



**OIL AND GAS  
REGIONALLY OWNED ENTERPRISES AND  
REGIONAL DEVELOPMENT IN POLICY,  
ENVIRONMENT, AND HEALTH  
ISBN 978-606-95069-0-5**



**Sekar Nur Wulandari, et al**

**Technium Press  
2024**

**OIL AND GAS  
REGIONALLY OWNED ENTERPRISES AND  
REGIONAL DEVELOPMENT IN POLICY,  
ENVIRONMENT, AND HEALTH**  
ISBN 978-606-95069-0-5



Sekar Nur Wulandari, et al

EDITORIAL OFFICE

TECHNIUM PRESS

E.U.



For citation purposes, cite as indicated below:

Sekar Nur Wulandari, et al, OIL AND GAS. REGIONALLY OWNED ENTERPRISES AND REGIONAL DEVELOPMENT IN POLICY, ENVIRONMENT, AND HEALTH; 978-606-95069-0-5, TECHNIUM PRESS, 2024..

FIRST EDITION 2024

ISBN 978-606-95069-0-5 (PDF)

© 2024 by the author. The book is Open Access and distributed under the Creative Commons Attribution license (CC BY-NC-ND), which allows users to download, copy and build upon published work non-commercially, as long as the author and publisher are properly credited. If the material is transformed or built upon, the resulting work may not be distributed.



**TECHNIUM**  
**BOOKS**

# **OIL AND GAS**

## **REGIONALLY OWNED ENTERPRISES AND REGIONAL DEVELOPMENT IN POLICY, ENVIRONMENT, AND HEALTH**



# OIL AND GAS REGIONALLY OWNED ENTERPRISES AND REGIONAL DEVELOPMENT IN POLICY, ENVIRONMENT, AND HEALTH

Sekar Nur Wulandari  
Herie Saksono  
Nurul Izzati  
Raymond Rayendra Elven  
Endriana Wahyu Alita  
Hadi Supratikta  
Aliffisya Ummu Raihan  
Tedy Kardana  
Risa Adelina Tarigan  
Amalia Ida Gunawati  
Andini Putri Titasari  
Kurnia Tri Hermawan  
Husnah Rahman  
Gema Bangsawan  
Charles Conrad Rambung  
Fitri Susiyanti  
Andi Tenri Awaru  
Hasniati  
Bachtari Alam Hidayat  
Mutiarra Kartika Dewi  
Romasta Napitupulu  
Rina Komala Dewi  
Asriani  
Indah Gilang Pusparani  
Miftahul Jannah Nasution  
Novid Gumelar  
Andjar Prasetyo  
Ira Amanda Hirbasari



# Foreword

## HEAD OF PLANNING, RESEARCH AND DEVELOPMENT AGENCY OF RIAU ISLANDS PROVINCE, INDONESIA

Assalamu'alaikum Warahmatullahi Wabarakatuh,  
Greetings to all of us,  
Dear authors, academics, practitioners, and all readers of this book,



First of all, let us give thanks to the presence of Allah SWT for all His mercy and grace so that the book entitled "**Oil and Gas Regionally Owned Enterprises and Regional Development in Policy, Environment, and Health**" can be published and presented as an important reference in understanding the role of Regionally Owned Enterprises (BUMD) in the oil and gas sector in the Riau Islands, in the context of policy, environment, and health. The Riau Islands, as one of the regions with great potential in the oil and gas sector, have a great responsibility to manage these natural resources wisely, sustainably, and oriented towards the welfare of the community. The presence of Oil and Gas BUMD is an important part of the regional development strategy that not only focuses on economic growth, but also prioritizes environmental protection and public health around the oil and gas work area.

This book, which consists of 14 comprehensive chapters, provides an in-depth analysis that is very relevant to the current condition of the Riau Islands. Chapter 1: Introduction begins by explaining the strategic role of oil and gas BUMDs in regional development, which is then followed by Chapter 2: National Policy on Oil and Gas Management and Environmental Health, which discusses national policies related to oil and gas management and its implications for environmental health. In the next chapter, this book also reviews Oil and Gas Potential and Management of Regionally Owned Enterprises (Chapter 3) and Policy Impact on Natural Resources Management (Chapter 4), which emphasizes the importance of policies in optimizing natural

resource management while still paying attention to environmental sustainability and impact on society.

Furthermore, I would like to emphasize the importance of Community Participation and Environmental Protection (Chapter 5), where community involvement is the key to the success of sustainable natural resource management. As explained in Chapter 6: Environmental Impacts of Oil and Gas Exploration and Exploitation, the environmental impacts of oil and gas exploration and exploitation must be managed properly, using Technology and Innovation for Environmental Protection reviewed in Chapter 7. Last but not least, the aspects of public health around oil and gas work areas are discussed in detail in Chapter 8: Public Health Around Oil and Gas Work Areas and Chapter 9: Health Management Strategies in the Operations of Oil and Gas Regionally-Owned Enterprises. This book provides valuable insights into how oil and gas BUMDs must manage health risks arising from industrial activities.

This book also discusses the Environmental and Health Risk Management strategy (Chapter 10) and Implications of Health and Environmental Policies on Investment (Chapter 11), which shows that investment in the oil and gas sector must be supported by strong health and environmental policies to maintain the economic and social survival of the community. Moreover, the application of the Blue Economy Principles (Chapter 12) emphasizes the importance of sustainable management of natural resources, especially in coastal areas such as the Riau Islands, which is carefully reviewed in this book. I would also like to highlight the importance of Multisectoral Collaboration (Chapter 13), where collaboration between the government, the private sector, the community, and academia is needed to implement sustainable development in the oil and gas sector. This book provides a strong foundation for all of us to move forward with evidence-based policies, especially in the aspects of environmental sustainability and public health. Finally, hopefully Chapter 14: Conclusions and Recommendations can provide clear guidance for stakeholders in the Riau Islands, as well as other regions, to take concrete steps in managing natural resources in a sustainable manner.

I believe that, this book is an important contribution to the literature and practices of responsible oil and gas management. Once again, I would like to thank all parties who have contributed to the preparation of this book. Hopefully this work will be useful for the development of our region, both in terms of policy, environment, and health.

Wassalamu'alaikum Warahmatullahi Wabarakatuh.

Misni, S.K.M, M.Si



**HEAD OF DEVELOPMENT PLANNING  
RESEARCH AND DEVELOPMENT AGENCY OF  
WAJO REGENCY, SOUTH SULAWESI PROVINCE, INDONESIA**

Assalamu'alaikum Warahmatullahi Wabarakatuh,  
Greetings to all of us,



First of all, let us give thanks to the presence of Allah SWT for all His mercy and gifts, so that we can witness the publication of this very valuable book, entitled "**Oil and Gas Regionally Owned Enterprises and Regional Development in Policy, Environment, and Health**".

This book is an important contribution in advancing our insight into the management of Regionally Owned Enterprises (BUMD) in the oil and gas sector in the context of sustainable regional development, especially in Wajo Regency. Wajo Regency, as one of the regions that has great potential in the oil and gas sector, has great challenges in managing this natural resource properly. The management must not only prioritize the economic aspect, but also must consider the impact of public policy, environmental sustainability, and community welfare, including health aspects. Through this book, we get a complete and comprehensive guide in facing these challenges.

This book consists of 14 chapters that are very relevant to the context of Wajo Regency. Chapter 1: Introduction explains the important role of oil and gas BUMDs in encouraging policy-based and sustainability-based regional development. Chapter 2: National Policy on Oil and Gas Management and Environmental Health discusses national policies related to oil and gas management and environmental health, which is the basic framework for the development of BUMDs in the regions. Then, Chapter 3: Oil and Gas Potential and Management of Regionally Owned Enterprises delves deeper into the oil and gas potential that can be utilized by BUMD to increase regional original income (PAD) while driving the local economy. The policies implemented have a direct impact on natural resource management, as reviewed in Chapter 4: Policy Impact on Natural Resources Management. In oil and gas management, local communities must be actively involved, as discussed in Chapter 5: Community Participation and Environmental Protection. The community must be involved in environmental protection efforts, especially considering the environmental impacts of oil and gas exploration and exploitation which are detailed in Chapter 6: Environmental Impacts of Oil and Gas Exploration and Exploitation. Along with technological developments, innovation in environmental management becomes crucial, as explained in Chapter 7: Technology and Innovation for Environmental Protection in Oil and Gas Management. This technology is expected to minimize negative impacts on the environment and maximize the efficiency of oil and gas



management in Wajo Regency. In addition, this book also pays great attention to Public Health Around Oil and Gas Work Areas in Chapter 8. Public health around oil and gas working areas should be a priority, and BUMDs should have a solid health strategy, as outlined in Chapter 9: Health Management Strategies in the Operations of Oil and Gas Regionally-Owned Enterprises. Risk management, both environmental and health risks, is also a very important issue and is discussed thoroughly in Chapter 10: Environmental and Health Risk Management in the Oil and Gas Sector. Oil and gas BUMDs must be able to identify these risks and implement effective mitigation strategies. Health and environmental policies not only have an impact on people's welfare, but also affect investment attractiveness, as reviewed in Chapter 11: Implications of Health and Environmental Policies on Investment in Regionally Owned Enterprises. Investment in the oil and gas sector must be aligned with policies that support long-term sustainability. One of the most important concepts in natural resource management today is the Implementation of Blue Economy Principles in Oil and Gas Management in Chapter 12. This concept provides a foundation for sustainable oil and gas management, taking into account the balance between resource exploitation and marine environment preservation in Wajo Regency. Not to forget, Chapter 13: Multisectoral Collaboration for Environmental Sustainability and Health emphasizes the importance of collaboration between various sectors, including government, private sector, and society, to achieve sustainable development goals and ensure environmental sustainability and public health. In closing, Chapter 14: Conclusions and Recommendations provides conclusions and recommendations that are very valuable for all of us, both in terms of BUMD management, policy strengthening, and protection of the environment and public health. I hope that this book can be a reference for stakeholders in Wajo Regency in managing oil and gas resources in a sustainable manner, which not only focuses on economic growth, but also prioritizes health and environmental sustainability. Hopefully our efforts in managing oil and gas can provide the greatest benefits for the people of Wajo and future generations.

Wassalamu'alaikum Warahmatullahi Wabarakatuh.

Andi Pallawarukka, S.IP



## Preface

We give thanks to the presence of God Almighty for the abundance of His grace and gifts, so that the preparation of this book with the title "Oil and Gas Regionally Owned Enterprises and Regional Development in Policy, Environmental Impact, and Health" can be completed properly. This book is designed to provide comprehensive insights into oil and gas management through BUMD, focusing on the interaction between public policy, environmental protection, and public health.

This book is divided into 14 chapters, starting with Chapter 1 which discusses the background of the importance of oil and gas management through BUMD, as well as the relevance of public policies in supporting environmental protection and public health. Chapter 2 explains national policies such as Law No. 22 of 2001 and regulations related to the 10% Participating Interest (PI), which is the legal basis for oil and gas management and environmental health. Chapter 3 reviews the potential of oil and gas resources in various regions, including the Riau Islands and South Sulawesi, as well as the role of BUMD in increasing regional original income (PAD). In Chapter 4, this book reviews the impact of policies on natural resource management, while Chapter 5 highlights the importance of community participation in oil and gas management and environmental protection. Chapters 6 and 7 discuss the environmental impacts of oil and gas exploration as well as innovative technologies for mitigation, such as waste management and carbon emission reduction. Furthermore, Chapter 8 and Chapter 9 explore the impact of public health around oil and gas areas and health management strategies, including corporate social responsibility (CSR) programs. Chapter 10 delves into environmental and health risk management, while Chapter 11 evaluates the influence of health and environmental policies on the feasibility of investment in the oil and gas sector.

The principles of the blue economy in oil and gas management in coastal areas are the focus of Chapter 12, while Chapter 13 highlights the importance of multisectoral collaboration between the government, communities, the private sector, and academia. The book ends with Chapter 14, which presents conclusions and recommendations for realizing sustainable oil and gas management, including policy improvements, the application of environmentally friendly technologies, and

the improvement of public health. We express our appreciation and gratitude to all parties who have contributed to the preparation of this book, both through data support, input, and constructive discussions. Hopefully this book can be a useful reference for stakeholders in managing the oil and gas sector responsibly and sustainably.

Authors



**Editor**



Amodu, Salisu Ameh PhD is a distinguished scholar and educator specializing in African Philosophy, with a Ph.D. in African Philosophy from the University of Nigeria, Nsukka, and advanced degrees from Prince Abubakar Audu University and Kogi State University, Anyigba. His academic expertise encompasses African metaphysics, epistemology, ethics, humanism, gender studies, and peace and conflict resolution, demonstrating a multidisciplinary approach to critical issues in African studies. Amodu currently serves as a lecturer in the Department of Philosophy and is a board member at the Center for Diploma and Pre-Degree Studies at Prince Abubakar Audu University. His dedication to advancing education is exemplified by initiatives like the Educate 500 Students on Quality Research program, showcasing his commitment to intellectual and professional development among students. As a prolific author and editor, Amodu has made significant contributions to African philosophical scholarship. His notable publications include *Land in African Ontology* and *Rational Proof of the Existence of God in Igala Ontology*, alongside co-edited works focusing on African philosophy, ethics, and sociocultural studies. Recognized for his impactful research and academic leadership, Amodu has received several accolades, including an Award of Excellence for his contributions to African studies. Amodu is an active member of prestigious academic organizations, such as the Association for the Promotion of African Studies (APAS) and the Association of Philosophy Professionals of Nigeria (APPON). He also serves as an editorial board member and manuscript reviewer for leading journals, furthering discourse in contemporary philosophy. Beyond academia, Amodu contributes to the enrichment of Africa's intellectual heritage by fostering critical engagement with African philosophical thought. Through his scholarly endeavors, community-focused initiatives, and professional service, Salisu Ameh Amodu continues to inspire the next generation of scholars and elevate the global understanding of African philosophy.



## Contributors



Dr. Herie Saksono, M.Si. is an Associate Expert Researcher (IV/c) with expertise in the field of Business and Management. He works at the Domestic Government Research Center, part of the Governance, Economy, and Community Welfare Research Organization at the Indonesian National Research and Innovation Agency. For his publications and scientific papers, Dr. Herie can be accessed through ORCID ID: <https://orcid.org/0000-0002-0464-5311>. Active in writing reputable scientific articles, as an editor at the Bina Praja Journal, Ministry of Home Affairs of Indonesia.



Dr. Bachtari Alam Hidayat, M.Si., born in Palembang on October 5, 1979, is a Young Expert Researcher with expertise in the field of Development Economics. He works at the Palembang City Government's Research and Development Development Agency and is registered as a member and administrator of the Indonesian Researchers Association of South Sumatra Province. In addition, he is a permanent lecturer at the Master of Government Science Postgraduate Program at Tamansiswa University Palembang and an extraordinary lecturer at the University of Muhammadiyah Palembang. Dr. Bachtari earned his Doctorate in 2018 from Padjadjaran University Bandung and participated in a Postdoctoral Fellowship at BRIN in 2023. He is also active in writing textbooks and references, with six ISBN books published between 2022-2023, covering topics such as political economy, governance, human resource management, and village development.



Andjar Prasetyo, SE, M. Si is a regional economic expert researcher, the writer lives in Magelang City, Central Java Province. Indonesia. Actively authors international scientific articles and books from several domestic and foreign publishers related to economics and regional issues related to various issues. Apart from that, it also conducts research collaborations across multi-disciplinary sciences.



Raymond Rayendra Elven, S.Si, M.A., M.S.E., with a strong academic background in economics and statistics. He earned a S1 degree in Statistics from Padjadjaran University in 2005, followed by two S2 degrees, namely in Economics from the University of Indonesia and Economics from Yokohama National University, both in 2018. At the provincial level, he received the Best Individual Working Paper Compiler Award at the Riau Islands Province Level IV Leadership Training in 2013, and was named the Fifth Best Participant in the same Training. At the national level, he won third place in 1992 at TVRI Bandung Station.



Sekar Nur Wulandari, S.E, M.Si, Young Expert Researcher of ASN Riau Islands Provincial Planning, Research and Development Agency SCOPUS ID: 57964343700, ORCHID ID: 0000-0002-9141-0384, PUBLONS ID: GLQ-6569-2022, has written two books: "Poverty Alleviation Strategies: A Study on Riau Islands Province" (2021) and "Fiscal Decentralization: Reformulation of General Allocation Fund Policy for Islands Regions", both published by Blue Ocean. He also collaborated in various researches, including as the head of the research team on the Feasibility Analysis of the Establishment of Riau Islands Energy Regionally Owned Enterprises and the Evaluation of the Riau Islands Provincial RPJMD 2016-2021. In addition, he is involved in the publication of proceedings at various international conferences such as SHIMBA 2023 and ICOSI-HESS 2022, as well as being an active member of the ICMI organization of Tanjungpinang City and the Alumni Association of the Bogor Agricultural Institute of Riau Islands Province. As a peer reviewer, he contributes to several international journals, such as the Australian Journal of Maritime & Ocean Affairs. Scientific Journal Publications: Sustainability (Q1), Bulletin of Electrical Engineering and Informatics (Q3), Bina Praja Journal (SINTA 2), Economics & Public Policy Journal (SINTA 2)



Risa Adelina Tarigan, has a Bachelor's degree in Statistics from the University of North Sumatra (2001-2006) and a Master's degree in Management from the University of Batam (2017-2019). He is involved in various research collaborations, such as a member of the Technical Team for the Preparation of the Regional Medium-Term Development Plan for the Riau Islands Province (2021-2026), a member of the Technical Team for the Study of Optimizing the Maritime Potential of the Riau Islands Province (2021), and a member of the Technical Team for the Preparation of the Study of Regency/City Strategic Areas in the Riau Islands Province (2021). In addition, he also serves as the editor of the Archipelago Journal at the Riau Islands Provincial Research and Development Planning Agency. In the academic field, he has been a lecturer at various institutions, such as STT Indonesia Tanjungpinang (2009-2011), STMIK IBBI Medan (2006-2009), STMIK Budi Darma Medan (2007-2009), and Amik Intel Com Global Medan (2006-2008), teaching Statistics, Matrix, and SPSS courses. In addition, he is active in the organization, as a member of the Indonesian Development Planners Association and serves as the Secretary of the PPPI Commissariat of Riau Islands Province.



Rina Komala Dewi, ST, graduated from S1 - Urban Regional Planning at Hatta Padang University in 2004, a Young Expert Planner at Bappeda Riau Islands Province since 2022, with previous experience as an Executor in the Planning and Evaluation Subdivision (2017-2021) and the Infrastructure and Environment Sector (2014-2016) at the same agency. Previously, he served as the Head of Sub-Division at Bappeda Natuna Regency in 2013-2014 and worked as the Executor for Infrastructure and Regional Development there from 2009 to 2013. He has participated in various trainings, including the Implementation of the Ministerial Regulation of the National Development Planning Agency in 2022, Sectoral Statistics Training (2022), and training related to Planning and Evaluation of Regional Medium-Term Development Plans and Regional Development Work Plans (2019). He also participated in training related to the Socialization of Government Performance Accountability Reports and the Preparation of Strategic Plans as well as Digital Map Data Management and GIS for spatial planning in Riau Islands Province.





Tedy Kardana, S.Sos, a graduate of the Raja Haji College of Social and Political Sciences with a Bachelor of Government Science degree in 2008, this employee has now held a functional position since December 31, 2021, and is projected to retire on September 1, 2044. He actively develops his competencies through various trainings, such as the Institutional and Policy Strategy Webinar in November 2022, as well as the Focus Group Discussion on Strengthening the Role of Functional Positions in July 2022. He has also completed Group III Pre-service Education and Training in June 2011.



Aliffisya Ummu Raihan, has worked as an ASN at the Riau Islands Provincial Planning, Research, and Development Agency since 2019. Previously, he had experience as a Sales Marketing Support at PT. Labtech Penta International from 2017 to 2019. In addition, he is active in research, including as a member of the research team at The International Conference on Social-Humanities in Maritime Border Area (SHIMBA 2023) with the topic of Riau Islands Province's strategy to face challenges as a border area. He is also involved in research related to the feasibility analysis of the establishment of Riau Islands Energy Regionally Owned Enterprises. Active in the organization of the Indonesian Muslim Scholars Association of Tanjung Pinang City and the Indonesian Researchers Association.



Asriani, S.PSI., M.A., graduated with a Master's degree in Psychology from Gadjah Mada University in 2017, and a Bachelor of Psychology from Makassar State University in 2007, this individual has extensive experience in the field of regional development planning and human resource development. Currently, he works as a researcher at the Wajo Regency Regional Development Planning, Research and Development Agency, and has served as the Head of the Innovation and Technology Utilization Subdivision. Previously, he also had experience in planning and reporting management at the Wajo Regency Civil Service Agency and was responsible for integrity analysis and enforcement of apparatus discipline.



Husnah Rahman, as a Young Expert Researcher at Bappelitbangda, Wajo Regency since 2021. Previously, he served as the Head of Subbid in various fields at Balitbangda Wajo Regency, including Dissemination of Research and Development and Assessment of Rules and Natural Resources (2017-2018), Regional, Physical, and Infrastructure Development (2018-2019), and Social and Government (2020-2021). He is a graduate of Puangrimaggalatung Sengkang University, Wajo Regency, in 2023.



Andi Tenri Awaru, works as a State Civil Apparatus with the position of Young Expert Researcher at the Regional Development Planning, Research, and Development Agency (Bappelitbangda) of Wajo Regency since 2021. Born in Soppeng on December 12, 1982. He has a Master's degree in Public Administration from the Puangrimaggalatung College of Administration, Sengkang. Previous experience includes the position of Head of Innovation and Technology Development Sub-Division at Balitbangda Wajo Regency (2017–2018), Head of Chemical Industry at the Wajo Regency Industry Office (2018–2020), and Head of Economy and Development Sub-Division at Bappelitbangda Wajo Regency (2020-2021).



Dr. Hadi Supratikta, MM is an academic and senior researcher with expertise in the field of public policy, particularly in development studies. Born in Trenggalek, East Java, on May 27, 1969, he studied formally at the University of Muhammadiyah Malang for S1, Muhammadiyah University of Jakarta for S2, and completed his doctoral program in Administrative Sciences at Brawijaya University Malang. Currently, he serves as the Principal Expert Researcher at the Domestic Government Research Center, BRIN. Dr. Hadi has long experience in various strategic positions since 1993, including as a researcher and head of field in government agencies. His dedication is reflected in various scientific research and publications, especially in the last five years, involving themes such as policy innovation, risk mitigation, and the development of knowledge management systems. Some of his research results have been published in prestigious international journals, such as *the Journal of International Review for Spatial Planning and Sustainable Development* and *Plos One*.



Miftahul Jannah Nasution, S.T., M.Ling. is a graduate of S1 Environmental Engineering from Diponegoro University, Semarang, and holds a Master's degree in Environmental Science from the University of Lampung, Bandar Lampung. He has work experience as a RIS PNPM Facilitator in 2010, then worked at the Lampung Provincial Regional Environmental Management Agency from 2011 to 2015. Furthermore, Miftahul had a career at Balitbangda Lampung Province as a staff until 2018, and since 2019 has served as the First Researcher at the Lampung Provincial Regional Research and Development Agency.



Romasta Napitupulu, ST, is a young researcher who graduated from Chemical Engineering, University of North Sumatra in 2011, started his career as an Administrative Staff at PT. Musimmas in 2010 to 2012. From 2013 to 2017, he worked as a Staff at the Musi Rawas Regency Industry and Trade Office, then joined the Musi Rawas Regency Research and Development Agency as a staff from 2017 to 2019. From 2019 to 2021, he served as Head of the Cooperation Subdivision at the same institution. Currently, since 2021, he has been working as a Young Expert Researcher at the Musi Rawas Regency Research and Development Agency.



Charles Conrad Rambung is a First Researcher at the Regional Research and Innovation Development Planning Agency of East Nusa Tenggara Province since February 2019. Previously, he served as a researcher at the Regional Research and Development Agency of East Nusa Tenggara Province from December 2015 to February 2019. His experience also includes the role of Pharmacy Supervisor at Prof. Dr. W.Z. Johannes Kupang General Hospital (2010-2015), as well as working in the R&D Department at a private pharmaceutical company, PT. Pertiwi Agung-Landson (2006-2010) and PT. Novartis (2005-2006). Charles holds a Master of International Public Health degree from the University of New South Wales, Australia, as well as a pharmacist degree from Sanata Dharma University, Yogyakarta. His expertise includes health research development, project management, and management of academic collaborative relationships.



Gema Bangsawan, a graduate of S1 Informatics Engineering from the Handayani Makassar College of Information and Computer Management and S2 Regional Government Administration from the University of East Indonesia Makassar, this individual has experience in various government positions. He has served as Expenditure Treasurer at the Gowa Regency Regional Disaster Management Agency (2013-2016), Financial Analyst at the Planning and Finance Section of the Gowa Regional Secretary (2016-2019), and currently works as a Young Expert Researcher at the Gowa Regency Regional Research and Development Agency. He has also participated in various Human Resource development trainings, including in the fields of accounting, procurement of goods and services, disaster contingency planning, and performance accountability systems.



Indah Gilang Pusparani, S.Sos., M.Sc. is a researcher at Regional Development Planning and Research Agency of Cirebon City (Bappelitbangda Kota Cirebon), specializing in public administration, policy, and development studies. She holds a Bachelor's degree in International Relations from Universitas Indonesia (2009-2014) and a Master's degree in Development Administration and Planning from University College London, United Kingdom (2014-2015). Her recent works focus on participatory development, creative economy, and regional innovations, published in national and international journals and proceedings. She has also presented her research at numerous international conferences and recently received a Best Presenter award from the National Institute of Public Administration-School of Administration. Her other works can be accessed at <https://orcid.org/0009-0002-5537-3755>.



Novid Gumelar, ST., M.Eng., is a researcher at the Regional Development Planning and Research Agency (Bappelitbangda Kota Cirebon) of Cirebon City. He holds a Bachelor's degree in Civil Engineering from the Bandung National Institute of Technology (2000) and a Master's degree in Natural Disaster Management from Gadjah Mada University (2012). With extensive experience as a civil servant in the Cirebon City Government since 2003, he has held various positions, including Head of the Water Resources Section in the Public Works Agency of Cirebon City. He actively presents his research at both national and international conferences, including ENDYNAMOSIS and ICoGPASS. His publications focus on flood risk management, urban planning, and sustainable development.



Kurnia Tri Hermawan, S.Sos., M.A.P., completed his Bachelor's degree in Public Administration at Sebelas Maret University (2011) and his Master's degree in Public Administration at Diponegoro University (2019). He has work experience as a data analyst at PT. Indonesian Consultant for Development and Empowerment (ICDE) (2018). He is currently serving at the Regional Development Planning and Research Agency of Cirebon City (Bappelitbangda Kota Cirebon), West Java, Indonesia, as a researcher. His research focuses on public policy, public management, management strategies, as well as innovation and technology. He also participates in international conferences. He has produced several publications related to the development of the creative economy, improvements in public service, policy evaluation for accelerating the reduction of stunting, and the development of regional tourism and culture. His publication information can be accessed at <https://orcid.org/0000-0001-8950-5280>.



Endriana Wahyu Alita, M.A.P., earned a Bachelor's degree from STISIP Muhammadiyah Madiun in 2000 and completed her S2 education at Sebelas Maret University of Surakarta in 2020. Currently, he works as a researcher at the Pacitan Regency Regional Research and Development Development Planning Agency since 2015. In professional development, he participated in various non-formal education, including the First Level I Researcher training at the Indonesian Science University in 2013 for 30 days, the National Scientific Paper Writing in 2019 for 7 days, and the Open Journal System training in the same year. Active in the publication of scientific articles both nationally and internationally.



Mutiara Kartika Dewi, ST., ME, graduated with a Bachelor of Chemical Engineering from the National Development University "Veteran" (2002) and a Master of Economics from Mulawarman University (2023), this individual has experience as the First Expert Researcher at Balitbangda, Kutai Kartanegara Regency, East Kalimantan, from 2015 to 2022. Currently, he serves as the First Expert Researcher at the Pekalongan City Regional Development Planning Agency since 2023.





Nurul Izzati, graduated from Lambung Mangkurat University in 2010 with a S1 degree in Public Health from Lambung Mangkurat University, and continued to the S2 Master's degree in Development Economics at the same university, which is planned to be completed in 2024. His work experience began as a Health and Benefit Officer at PT. Rahman Abdijaya from 2010 to 2015. Currently, he has been working as the First Researcher at Bappedalitbang, Tabalong Regency since 2010. In the field of research, he has been involved in various projects, including the preparation of the Economic Masterplan (2020), the Industrial Estate Masterplan, the Daerah Innovation System Roadmap, and the Prototype Management of the Tabalong Regency Tahfiz House (2021). In 2022, he was involved in the development of Macro Socio-Economic Indicators, Mining Governance, and Performance Trees in Tabalong. In 2023, he will continue with studies for the Tourism Masterplan, Agricultural Action Plan, and various analyses related to regional assets and economic growth.



Fitri Susiyanti, a graduate of the Environmental Science Study Program, Postgraduate of Gadjah Mada University (2016-2018), with an educational background from the Faculty of Biology, Gadjah Mada University (2009-2013) and SMAN 1 Demak (2006-2009), this individual has work experience in various fields. He has worked as a staff at the Demak Regency Environment Agency (2014-2016), a science teacher at Kurnia Excellent Course Demak (2015-2016), a researcher at PT Newmont Nusa Tenggara (2013), and an intern at the Jepara Brackish Water Aquaculture Fisheries Center (2011). In addition, he is also active in writing various studies, including The Impact of El Nino on Brebes Regency's Economic Growth (2023, in process), as well as a study on mapping the distribution of agricultural commodities in Brebes Regency (2022). His research also includes a study on environmental pollution in the Penaruban River due to gold mining and soil insect diversity on reclaimed land in Sumbawa.



Amalia Ida Gunawati, ST earned a Bachelor of Chemical Engineering degree from the University of Muhammadiyah Surakarta in 2002. Currently, he works as the First Expert Researcher at the Pekalongan City Regional Development Planning Agency, a position he has held since 2015.



Andini Putri Titasari, has been working as the First Researcher at the Tabalong Regency Research and Development Development Agency since 2015. Previously, he served as HRGA Admin at Yayasan Adaro Bangun Negeri/Adaro Foundation (2014-2015) and Safety Officer at PT Hasnur Jaya Utama (2013-2014). His experience also includes a position as a Safety Admin at PT United Tractors, Tbk, Site Adaro Tanjung (2013). In the world of research, the main focus is on economic and social development, such as the Economic Masterplan (2020), the Industrial Estate Masterplan (2021), to the Socio-Economic Macro Indicators and Tourism Studies in Tabalong Regency (2022-2023). The research covers various important topics including population development design, tahfiz house management prototypes, to the study of regional expenditure budgets and the needs of non-State Civil Apparatus employees.



Hasniati, SE, MM, born in 1973, is a dedicated professional with a strong academic and career background. She earned her Bachelor's degree in Accounting from Universitas Muhammadiyah Makassar and later pursued a Master's degree in Regional Governance Management at Institut Nobel Indonesia. Currently serving as a Civil Servant in the Research and Development Division of the Regional Development Planning, Research, and Development Agency (Bappelitbang) in Takalar Regency, South Sulawesi, Indonesia, Hasniati has established herself as a committed researcher. Her work focuses on fostering innovation and supporting sustainable development initiatives in the region.



Ira Amanda Hirbasari, S.E., M.Si, is a researcher with expertise in Development Economics, Agricultural Economics, Tourism Economics, and Environmental Economics. She holds a Master's degree in Economics and Development Studies from Universitas Sebelas Maret (UNS) and has contributed extensively to research on regional economic development. Currently serving as a First-Level Researcher at the Brebes Regional Planning, Research, and Development Agency, Ira is recognized for her work in statistical data analysis using SPSS and EViews. Her publications include books and proceedings that address economic challenges, tourism marketing strategies, and sustainable development initiatives.





# Acknowledgements

We give thanks to the presence of God Almighty for His grace and grace, so that the preparation of this book, which is the result of the merger of two feasibility study documents on establishment and investment in Regional-Owned Enterprises (BUMD) in the oil and gas sector, can be completed properly. This book would not have been possible without the support, hard work, and contributions from various parties directly or indirectly involved.

First of all, we would like to express our deepest gratitude to the Regional Development Planning, Research and Development Agency of Riau Islands Province and the Regional Development Planning, Research and Development Agency of Wajo Regency, who have given full support to this book. Oil and gas management in these two regions is an important focus in encouraging local economic growth, and the team of authors of this book highly appreciates the assistance and commitment from the study team of Riau Islands Province and Wajo Regency in providing data, insights, and guidance during the preparation process. Thank you to the central government, especially the Ministry of Energy and Mineral Resources, which with the 10% Participating Interest (PI) policy has provided opportunities for local governments to participate directly in the management of oil and gas resources. Without policies that allow BUMD involvement in the oil and gas industry, this book will not be able to have significant relevance for regional development.

Furthermore, I would like to express my gratitude to the team of researchers, consultants, and academics who have worked together in compiling and perfecting the various chapters in this book. The active participation of experts in the fields of energy economics, environment, health, and public policy has made a great contribution to the content of this book. Their contribution in providing in-depth and relevant analysis has added to the richness of the book's content.

Deep appreciation was also conveyed to local stakeholders, both from the government, private sector, and community in the Riau Islands and Wajo Regency, who have provided valuable input and are willing to collaborate in this research. The active participation of local communities in the field study process has enriched our perspective, especially regarding environmental and health issues that are directly related to oil and gas activities in their areas. Appreciation was specifically conveyed to the Feasibility Study team for the Establishment of Regionally Owned Enterprises

for Oil and Gas Energy in Riau Islands Province, including Supervisors: Misni, S.KM, M.Si, Director: Raymond Rayendra Elven, S.Si, M.A, M.S.E, Head of the Research Team: : Sekar Nur Wulandari, S.E., MM, Research Team Members: Tedy Kardana, S.Sos, Andi Gustomo, S.E, Maskur Perkasa, S.Ak, Rina Komala Dewi, S.T, Risa Adelina Br Tarigan, S.Si., M.M, Aliffisya Ummu Raihan, S.Mat, Drs. Gunarto, M.M, Ibnu Hiban, S.Sos, Fajar Hanung Basworo, S.T., Haris Muzakky, S.E., Budi Santoso, S.Pd, M.Ling, Junjung Sahala Tua Manik, S.Sos, M.A.P, Radja Sugianti, S.Sos, Sheptya Yusnita Putri, S.IP, and Dahliana, SE. Then he also specifically expressed his appreciation to the Regional Needs Study team in the Establishment of Regionally Owned Enterprises in Wajo Regency, in the work unit: Research and Development, with the Technical Implementation Team of the Activity, Chairman: Andi Tenri Awaru SP. M.Si, Resource persons: Dr. Herie Saksono, M.Si (Researcher of BPP Ministry of Home Affairs), Imam Radianto Anwar, S.T., M.M. (Researcher of BPP Ministry of Home Affairs), A. Elvira Fajarwati. P, S.H. (Bag. Law & Human Rights of the Wajo Regency Secretariat), Muh. Tahir Tajang, SP., M.Si (Disperindagkop, & SMEs of Wajo Regency), Daswinarta, S.Sos (PMPTSP Office of Wajo Regency), Andi Sahlan, SE., Ak., M.Si (BPKPD of Wajo Regency), H. Suriadi, S.H., S.IP., M.Si (Transportation Office of Wajo Regency), Dewi Noviany Kahar, S.E. (Economic Section of the Wajo Regency SETDA), and Abdul Malik, SP., M.Si (Agriculture and Food Security Office of Wajo Regency).

Not to forget, the team of authors of this book is grateful to the editorial team and publishers who have worked hard in ensuring that this book can be published with good quality and accessible to a wide audience. Their hard work in editing, compiling, and publishing this book deserves appreciation.

Finally, to all parties who may not be able to be mentioned individually, but have provided moral, technical, and logistical support during the process of compiling this book, we would like to express our sincere gratitude. Hopefully, this book can provide benefits for policymakers, academics, and practitioners in managing oil and gas resources in a sustainable manner, for the sake of economic development, environmental protection, and public health.

Thanks.

Author Team



# Contents

|                                                                                  |       |
|----------------------------------------------------------------------------------|-------|
| Cover Page .....                                                                 | i     |
| Book identity page .....                                                         | ii    |
| Foreword .....                                                                   | iii   |
| Preface .....                                                                    | vii   |
| Editor .....                                                                     | ix    |
| Contributors .....                                                               | x     |
| Acknowledgments .....                                                            | xx    |
| Contents .....                                                                   | xxii  |
| Tables .....                                                                     | xxvii |
| Figures .....                                                                    | xxix  |
| Abbreviations .....                                                              | xxxi  |
| Chapter 1 Introduction                                                           |       |
| <i>Herie Saksono, Nurul Izzati</i>                                               |       |
| 1.1. Introduction .....                                                          | 1     |
| 1.2. Purpose .....                                                               | 8     |
| 1.3. Systematics .....                                                           | 11    |
| Reference .....                                                                  | 13    |
| Chapter 2: National Policy on Oil and Gas Management and<br>Environmental Health |       |
| <i>Raymond Rayendra Elven, Endriana Wahyu Alita</i>                              |       |
| 2.1. Regulatory and Legal Framework .....                                        | 16    |
| 2.1.1. Environmental Responsibility and Corporate Reporting .....                | 16    |
| 2.1.2. Environmental Remediation: Bioremediation .....                           | 23    |
| 2.1.3. Environmental Incident Reporting .....                                    | 25    |
| 2.2. Participating Interest 10% .....                                            | 30    |
| 2.2.1. Granting Rights to Local Governments for 10% PI .....                     | 30    |
| 2.2.2. Environmental Transparency and Accountability .....                       | 33    |
| 2.2.3. Supervision of PI Implementation by Local Governments .....               | 34    |
| 2.2.4. Economic Benefits for the Region .....                                    | 36    |
| 2.3. Impact of Oil and Gas Management .....                                      | 37    |

|                                                             |    |
|-------------------------------------------------------------|----|
| 2.3.1. Environmental Impact of Oil and Gas Management ..... | 38 |
| 2.3.2. Impact on Public Health .....                        | 39 |
| 2.3.3. Sustainability and Energy Transition .....           | 40 |
| 2.3.4. Social and Economic Aspects .....                    | 41 |
| 2.3.5. Oversight and Transparency .....                     | 41 |
| 2.4. Conclusion .....                                       | 42 |
| Reference .....                                             | 44 |

### Chapter 3 Oil and Gas Potential and Management of Regionally Owned Enterprises

*Sekar Nur Wulandari, Hadi Supratikta*

|                                                                         |    |
|-------------------------------------------------------------------------|----|
| 3.1. Potential of Oil and Gas Resource .....                            | 53 |
| 3.1.1. Riau Island Province .....                                       | 53 |
| 3.1.2. Wajo Regency, South Sulawesi .....                               | 60 |
| 3.2. Relevance Of the Establishment of BUMD .....                       | 68 |
| 3.2.1. Riau Island Province .....                                       | 68 |
| 3.2.2. Wajo Regency Province .....                                      | 72 |
| 3.3. The influence Of Regional Policies in The Management of BUMD ..... | 77 |
| 3.4. Conclusion .....                                                   | 79 |
| Reference .....                                                         | 80 |

### Chapter 4 Policy Impact on Natural Resources Management

*Aliffisya Ummu Raihan, Tedy Kardana*

|                                                                                           |     |
|-------------------------------------------------------------------------------------------|-----|
| 4.1. Policy Framework for Oil and Gas Natural Resources Management ..                     | 84  |
| 4.2. Community Involvement in The Management of The Oil and Gas Industry .....            | 91  |
| 4.3. Adoption Of the United Nations Framework Classification .....                        | 94  |
| 4.4. Implementation of Environmental Policies in the oil and gas Sector....               | 96  |
| 4.5. Challenges, Obstacles and Recommendations for Natural Resources Sustainability ..... | 98  |
| 4.6. Conclusion .....                                                                     | 102 |
| Reference .....                                                                           | 105 |

### Chapter 5 Community Participation and Environmental Protection

*Risa Adelina Tarigan, Amalia Ida Gunawati*

|                                                            |     |
|------------------------------------------------------------|-----|
| 5.1. Community involvement in oil and gas management ..... | 111 |
| 5.1.1. Adaptive Management .....                           | 113 |
| 5.1.2. Collaborative Governance.....                       | 115 |
| 5.1.3. Stakeholder Theory and Sosial Capital .....         | 117 |
| 5.1.4. Consensus Participation Model .....                 | 119 |

|                                                                                     |     |
|-------------------------------------------------------------------------------------|-----|
| 5.1.5. Community – Based Natural Resource Management (CBNRM) .....                  | 121 |
| 5.1.6. Interconnection Between Theoretical Approaches to Community Engagement ..... | 123 |
| 5.2. Community Involvement in Environmental Impact Monitoring .....                 | 126 |
| 5.2.1. Participatory Governance .....                                               | 127 |
| 5.2.2. Systemic Approach .....                                                      | 129 |
| 5.3. Conclusion .....                                                               | 130 |
| Reference .....                                                                     | 131 |

## Chapter 6 Environmental Impacts of Oil and Gas Exploration and Exploitation

*Andini Putri Titasari, Kurnia Tri Hermawan*

|                                                                                                 |     |
|-------------------------------------------------------------------------------------------------|-----|
| 6.1. Environmental Impact of Oil and Gas Exploration and Exploitation ....                      | 138 |
| 6.1.1. Environmental Strategy Planning .....                                                    | 141 |
| 6.1.2. Implementation of Operational Processes .....                                            | 145 |
| 6.1.3. Environmental Strategy Supervision .....                                                 | 147 |
| 6.1.4. Evaluation of Environmental Strategy results .....                                       | 150 |
| 6.1.5. Continuous improvement Environmental Strategy .....                                      | 151 |
| 6.2. Review of environmental degradation cases in coastal areas and mitigation strategies ..... | 153 |
| 6.3. Conclusion .....                                                                           | 158 |
| Reference .....                                                                                 | 160 |

## Chapter 7 Technology and Innovation for Environmental Protection in Oil and Gas Management

*Husnah Rahman, Gema Bangsawan*

|                                                                                         |     |
|-----------------------------------------------------------------------------------------|-----|
| 7.1. Environmental Protection Technology and Innovation in Oil and Gas Management ..... | 169 |
| 7.1.1. Industrial Ecological Approach .....                                             | 170 |
| 7.1.2. Sustainable Innovation Theory Approach .....                                     | 173 |
| 7.1.3. Eco – Innovation Maturity Model Approach (Eco-M1) .....                          | 178 |
| 7.2. Green Technology in The Oil and Gas Sector .....                                   | 182 |
| 7.3. Application of Techonology and Innovation in The Oil and Gas Sector .....          | 184 |
| 7.4. Conclusion .....                                                                   | 188 |
| Reference .....                                                                         | 189 |

## Chapter 8 Public Health Around Oil and Gas Work Areas

*Charles Conrad Rambung, Fitri Susiyanti*

|                                                                              |     |
|------------------------------------------------------------------------------|-----|
| 8.1. Impact of oil and gas exploration and production on public health ..... | 195 |
| 8.2. Cumulative Environmental Impact Theory .....                            | 196 |
| 8.3. Environmental Justice Theory .....                                      | 201 |

|                                                                     |     |
|---------------------------------------------------------------------|-----|
| 8.4. Systemic Risk Analysis Theory .....                            | 205 |
| 8.5. Evidence-Based Assessment Theory .....                         | 207 |
| 8.6. Public Health Around Oil and Gas Work Areas .....              | 210 |
| 8.7. Mitigation Of Health Impact Due to Oil and Gas Operations..... | 214 |
| 8.8. Conclusion .....                                               | 216 |
| Reference .....                                                     | 217 |

## Chapter 9 Health Management Strategies in the Operations of Oil and Gas Regionally-Owned Enterprises

*Andi Tenri Awaru, Hasniati*

|                                                             |     |
|-------------------------------------------------------------|-----|
| 9.1. Health and Safety Operational Management.....          | 224 |
| 9.2. Risk Management in Hazardous or Remote Locations ..... | 228 |
| 9.3. Promotion and Maintenance of Workers' Health.....      | 231 |
| 9.4. Conclusion .....                                       | 244 |
| Reference .....                                             | 245 |

## Chapter 10 Environmental and Health Risk Management in the Oil and Gas Sector

*Bachtari Alam Hidayat, Mutiara Kartika Dewi*

|                                                                                                  |     |
|--------------------------------------------------------------------------------------------------|-----|
| 10.1. Identification of Environmental and Health Risks in Oil and<br>Gas Operations.....         | 252 |
| 10.2. Risk Assessment and Its Impact on the Environment and Health .....                         | 256 |
| 10.3. Standard Operating Procedures (SOPs) for Health and<br>Environmental Risk Management ..... | 260 |
| 10.4. Environmental and Health Risk Mitigation Strategies .....                                  | 265 |
| 10.5. Conclusion and Recommendations.....                                                        | 268 |
| Reference .....                                                                                  | 269 |

## Chapter 11 Implications of Health and Environmental Policies on Investment in Regionally Owned Enterprises

*Romasta Napitupulu, Rina Kumala Dewi*

|                                                                                            |     |
|--------------------------------------------------------------------------------------------|-----|
| 11.1. Introduction .....                                                                   | 277 |
| 11.2. Health and Environmental Policy .....                                                | 282 |
| 11.3. Implementation of Health and Environmental Policy in the Oil and<br>Gas Sector ..... | 282 |
| 11.4. Conclusions and Recommendations .....                                                | 298 |
| Reference .....                                                                            | 300 |



|                                                                                                         |     |
|---------------------------------------------------------------------------------------------------------|-----|
| Chapter 12 Implementation of Blue Economy Principles in Oil and Gas Management                          |     |
| <i>Asriani, Indah Gilang Pusparani</i>                                                                  |     |
| 12.1. Blue Economy Principles in the Context of Oil and Gas .....                                       | 309 |
| 12.2. Environmental Challenges in Oil and Gas Exploration and Production in Coastal Areas .....         | 312 |
| 12.3. Implementation of Environmentally Friendly Technology in Oil and Gas Activities .....             | 315 |
| 12.4. The Role of BUMD in Sustainable Oil and Gas Management.....                                       | 317 |
| 12.5. Synergy Between the Oil and Gas Sector and Marine Conservation...                                 | 321 |
| 12.6. Policy Recommendations to Support the Blue Economy in Oil and Gas.....                            | 324 |
| 12.7. Conclusion and Recommendations.....                                                               | 331 |
| Reference .....                                                                                         | 333 |
| Chapter 13 Multisectoral Collaboration for Environmental Sustainability and Health                      |     |
| <i>Miftahul Jannah Nasution, Novid Gumelar</i>                                                          |     |
| 13.1. The Role of the Government in Environmental and Health Management in the Oil and Gas Sector ..... | 343 |
| 13.2. Community Participation in Safeguarding the Environment and Health .....                          | 350 |
| 13.3. Private Sector Contribution to Sustainability .....                                               | 352 |
| 13.4. The Role of Academics in Improving Innovation and Advocacy .....                                  | 355 |
| 13.5. Case Study: Multisectoral Collaboration in Overcoming the Impact of Oil and Gas Activities.....   | 357 |
| 13.6. Strategies to Strengthen Collaboration for the Future .....                                       | 361 |
| 13.7. Conclusion and Recommendations.....                                                               | 364 |
| Reference.....                                                                                          | 365 |
| Chapter 14 Conclusions and Recommendations                                                              |     |
| <i>Andjar Prasetyo, Ira Amanda Hirbasari</i>                                                            |     |
| 14.1. Conclusion .....                                                                                  | 375 |
| 14.2. Recommendations .....                                                                             | 383 |
| 14.3. Implications and Steps Foreward.....                                                              | 389 |
| Reference.....                                                                                          | 392 |
| Index.....                                                                                              | 395 |



## Tables

|            |                                                                                                               |     |
|------------|---------------------------------------------------------------------------------------------------------------|-----|
| Table 2.1. | Implementation of CER in companies.....                                                                       | 18  |
| Table 2.2. | GRI Implementation .....                                                                                      | 19  |
| Table 2.3. | AMDAL in some countries .....                                                                                 | 22  |
| Table 2.4. | Bioremediation on petroleum contamination in some countries                                                   | 24  |
| Table 2.5. | PI Practices of Several Countries in Granting Rights to Local Governments .....                               | 32  |
| Table 2.6. | PI Practices in Environmental Transparency and Accountability .....                                           | 34  |
| Table 2.7. | Comparison of PI Implementation Supervision .....                                                             | 35  |
| Table 2.8. | Comparison of PI to Economic Benefits for Regions .....                                                       | 36  |
| Table 3.1. | Land Area and Sea Area of Riau Islands Province .....                                                         | 54  |
| Table 3.2. | Riau Island Province GDP on The Basis of The Year 2017-2021 (Million IDR) .....                               | 56  |
| Table 3.3. | Riau Island Province GDP on The Basis of Constant Prices for The 2010 base year 2017-2021 (billion IDR) ..... | 57  |
| Table 3.4. | LQ Analysis of The Industrial Sector (Business Field) Of Riau Island Province .....                           | 59  |
| Table 3.5. | Supporting Factors for The Relevance of The Establishment Of Energy BUMD In Riau Island Province .....        | 69  |
| Table 3.6. | Result Of Nominal Group Technique (NTG) Data Processing .....                                                 | 72  |
| Table 4.1. | Community Involvement in Oil and Gas Natural Resource Management .....                                        | 92  |
| Table 4.2. | UNFC Involvement in The Framework of Achieving the SDGs ..                                                    | 95  |
| Table 4.3. | Environmental Policy Implementation, Indicators and Impact                                                    | 97  |
| Table 4.4. | Digital Transformation Trends in The Oil and Gas Industry .....                                               | 101 |
| Table 5.1. | Collaborative Governance Implications and Indicators .....                                                    | 116 |
| Table 5.2. | Implementation Of the Stakeholder Theory and Social Capital Approach .....                                    | 118 |
| Table 5.3. | Implementation Consensus Participation Model .....                                                            | 120 |
| Table 5.4. | Implementation CBMRM .....                                                                                    | 122 |

|            |                                                                                 |     |
|------------|---------------------------------------------------------------------------------|-----|
| Table 5.5. | Interconnection initiatives in interstate integration .....                     | 125 |
| Table 5.6. | Implementation Of Participatory Governance Policies In ASEAN Countries .....    | 128 |
| Table 6.1  | Matrix of Stage and Performance Indicators of ISO 14001 Implementation .....    | 144 |
| Table 6.2  | KPI Quantitative Analysis Series .....                                          | 150 |
| Table 6.3  | Practice of Implementing Periodic Evaluations on Environmental Strategies ..... | 151 |
| Table 6.4  | Environmental Sustainability Implementation Practices.....                      | 152 |
| Table 6.5. | Mitigation Of Environmental Degradation in Coastal Areas .....                  | 155 |
| Table 6.6. | Mitigation Of Coastal Environmental Degradation .....                           | 157 |
| Table 7.1  | Industrial Symbiosis Effectiveness Practices.....                               | 171 |
| Table 7.2. | Internship Model CBMIP .....                                                    | 177 |
| Table 7.3. | Ex-Eco-Innovation Maturity Model (Eco-Me) .....                                 | 181 |
| Table 7.4. | CCS Simulation.....                                                             | 183 |
| Table 7.5  | Category : Innovation and Benefit of The Industrial Sector in 2022-2023 .....   | 185 |
| Table 8.1. | Implementation Of the CIA In Various Sector .....                               | 199 |
| Table 8.2. | CPS Model CPS Implementation Practices .....                                    | 204 |
| Table 8.3. | Advantages And Disadvantages .....                                              | 207 |
| Table 8.4  | Advantages and Disadvantages of EBA Theory .....                                | 209 |



## Figures

|             |                                                                                                                       |     |
|-------------|-----------------------------------------------------------------------------------------------------------------------|-----|
| Figure 1.1. | Contribution of the GDP Sector in Riau Islands Province in 2019 – 2023.....                                           | 5   |
| Figure 1.2. | Contribution of the oil and gas sector and sector growth in Wajo Regency .....                                        | 7   |
| Figure 2.1. | CER typology .....                                                                                                    | 16  |
| Figure 2.2. | Impact of Oil and Gas Management.....                                                                                 | 38  |
| Figure 3.1  | Contribution of The GDP Sector Per District in Wajo Regency in 2022 .....                                             | 61  |
| Figure 5.1  | Interconnection Between Theoretical approaches for Community Involvement In Oil and Gas Management Through BUMD ..... | 124 |
| Figure 6.1  | ISO 14001 Framework .....                                                                                             | 143 |
| Figure 7.1  | The Effectiveness of Industrial Symbiosis .....                                                                       | 170 |
| Figure 7.2  | CBMIP .....                                                                                                           | 174 |
| Figure 7.3  | Eco-Innovation Maturity Model .....                                                                                   | 178 |
| Figure 8.1  | CIA Process Flow .....                                                                                                | 197 |
| Figure 8.2  | Colloborative Problem-Solving Model.....                                                                              | 202 |



# Abbreviations

|       |                                                  |
|-------|--------------------------------------------------|
| ABIF  | ASEAN Banking Integration Framework              |
| ABVC  | ASEAN BioDiaspora Virtual Center                 |
| AHN   | ASEAN Highway Network                            |
| AI    | Artificial intelligence                          |
| AIIRA | Artificial Intelligence Incident & Risk Analysis |
| AMDAL | Analisis Mengenai Dampak Lingkungan              |
| APG   | ASEAN Power Grid                                 |
| APSC  | ASEAN Political and Security Community           |
| AR    | Augmented Reality                                |
| ASEAN | Association of Southeast Asian Nations           |
| ASR   | Abandonment and Site Restoration                 |
| ASW   | ASEAN Single Window                              |
| BBM   | Bahan Bakar Minyak                               |
| BCF   | Bio Carbon Fund                                  |
| BMI   | Body Mass Index                                  |
| BMN   | Barang Milik Negara                              |
| BoB   | Build-Operate-Boost                              |
| BP    | British Petroleum                                |
| BPBD  | Badan Penanggulangan Bencana Daerah              |
| BPMA  | Badan Pengelola Migas Aceh                       |
| BPMN  | Business Process Modeling and Notation           |
| BRI   | Belt and Road Initiative                         |
| BRICS | Brazil, Russia, India, China, South Africa       |
| BUMD  | Badan Usaha Milik Daerah                         |
| BUMN  | Badan Usaha Milik Negara                         |
| CAPM  | Capital Asset Pricing Model                      |
| CAR   | Cumulative Abnormal Return                       |
| CBM   | Condition-Based Maintenance                      |
| CBMIP | Cambridge Business Model Innovation Process      |
| CBNRM | Community-Based Natural Resource Management      |
| CCS   | Carbon Capture and Storage                       |

|       |                                                           |
|-------|-----------------------------------------------------------|
| CCUS  | Carbon capture, utilization, and storage                  |
| CDA   | Community Development Agreement                           |
| CEPA  | Comprehensive Economic Partnership Agreement              |
| CER   | Corporate Environmental Responsibility                    |
| CH    | Chemical Hazard                                           |
| CIA   | Cumulative Impact Assessment                              |
| CIPP  | Context, Input, Process, Product                          |
| CNG   | Compressed Natural Gas                                    |
| COBIT | Control Objectives for Information and Related Technology |
| CoF   | Consequences of failure                                   |
| CPS   | Collaborative Problem-Solving                             |
| CSR   | Corporate social responsibility                           |
| CSV   | Creating Shared Value                                     |
| DBH   | Dana Bagi Hasil                                           |
| DMO   | Domestic Market Obligation                                |
| E&P   | Exploration and Production                                |
| EATS  | Extractive Activities Transparency Standards              |
| EBA   | Ecosystem-based approach                                  |
| EBM   | Evidence-Based Medicine                                   |
| EGD   | European Green Deal                                       |
| EIA   | Environmental Impact Analysis                             |
| EiMIS | Eco-Innovation Management Information System              |
| EITI  | Extractive Industries Transparency Initiative             |
| EMS   | Environmental Management System                           |
| EOR   | Enhanced Oil Recovery                                     |
| EPA   | Environmental Protection Agency                           |
| EPZ   | Emergency planning zone                                   |
| ERM   | Enterprise Risk Management                                |
| ERP   | Emergency Response Plan                                   |
| ESDM  | Energi dan Sumber Daya Mineral                            |
| ESG   | Environmental Social Governance                           |
| ESR   | Effort Sharing Regulation                                 |
| ETA   | Event Tree Analysis                                       |
| ETS   | Emissions trading system                                  |
| EU    | European Union                                            |
| FDI   | Foreign direct investment                                 |
| FGD   | Flue Gas Desulfurization                                  |
| FMEA  | Failure Mode and Effect Analysis                          |
| FSA   | Facility Sharing Agreement                                |
| FTA   | Fault Tree Analysis                                       |

|        |                                                                         |
|--------|-------------------------------------------------------------------------|
| GCC    | Gulf Cooperation Council                                                |
| GCG    | Good Corporate Governance                                               |
| GDP    | Gross Regional Domestic Product                                         |
| GEM    | Global Entrepreneurship Monitor                                         |
| GHG    | Greenhouse Gases                                                        |
| GHRM   | Green Human Resource Management                                         |
| GIS    | Geographic Information Systems                                          |
| GMCR   | Graph Model for Conflict Resolution                                     |
| GRI    | Global Reporting Initiative                                             |
| GWP    | Global warming potential                                                |
| HAZID  | Hazard Identification                                                   |
| HAZOP  | Hazard and Operability                                                  |
| HIA    | Health Impact Assessment                                                |
| HIRA   | Hazard Identification and Risk Assessment                               |
| HR     | Human Resources                                                         |
| HRA    | Health Risk Assessment                                                  |
| HRO    | High Reliability Organizations                                          |
| HSE    | Health, Safety and Environment                                          |
| HSMS   | Health and Safety Management System                                     |
| ICS    | Incident Command System                                                 |
| IEA    | International Energy Agency                                             |
| IOGP   | International Association of Oil and Gas Producers                      |
| IoT    | Internet of Things                                                      |
| IPIECA | International Petroleum Industry Environmental Conservation Association |
| IRPA   | Individual Risk Per Annum                                               |
| KHDTK  | Kawasan Hutan Dengan Tujuan Khusus                                      |
| KKKS   | Kontraktor Kontrak Kerja Sama                                           |
| KPI    | Key Performance Indicator                                               |
| LCA    | Life cycle assessments                                                  |
| LNG    | Liquefied natural gas                                                   |
| LQ     | Location Quotient                                                       |
| MSME   | Micro, Small, and Medium Enterprises                                    |
| MSP    | Marine Spatial Planning                                                 |
| NGO    | Non Government Organizations                                            |
| NL     | Newfoundland and Labrador                                               |
| NPV    | Net Present Value                                                       |
| NTG    | Net to Gross                                                            |
| O&M    | Operating and maintenance                                               |
| OGI    | Optical Gas Imaging                                                     |



|        |                                                                                               |
|--------|-----------------------------------------------------------------------------------------------|
| OHS    | Occupational Health and Safety                                                                |
| OHSM   | Occupational health and safety management                                                     |
| OIMS   | Operational Integrity Management System                                                       |
| OPEC   | Organization of the Petroleum Exporting Countries                                             |
| OSH    | Occupational Safety and Health                                                                |
| PAD    | Pendapatan Asli Daerah                                                                        |
| PFAS   | Per- and Polyfluoroalkyl Substances                                                           |
| PI     | Participating Interest                                                                        |
| PIMS   | Pipeline Integrity Management Systems                                                         |
| PKBL   | Program Kemitraan dan Bina Lingkungan                                                         |
| PLN    | Perusahaan Listrik Negara                                                                     |
| PM     | Particulate matter                                                                            |
| POD    | Plan of Development                                                                           |
| PoF    | Probability of failure                                                                        |
| PP     | Peraturan Pemerintah                                                                          |
| PPE    | Personal protective equipment                                                                 |
| PPP    | Public-Private Partnership                                                                    |
| PSC    | Production Sharing Contract                                                                   |
| PSR    | Pressure-state-response                                                                       |
| PT     | Perseroan Terbatas                                                                            |
| PVN    | PetroVietnam                                                                                  |
| QRA    | Quantitative Risk Analysis                                                                    |
| R&D    | Research and development                                                                      |
| RBI    | Risk-Based Inspection                                                                         |
| RBM    | Risk-Based Management                                                                         |
| RDF    | Refuse Derived Fuel                                                                           |
| RUEN   | Rencana Umum Energi Nasional                                                                  |
| SAFETI | Software for Accident Frequency and Evaluation in Transportation and Industrial Installations |
| SCADA  | Supervisory Control and Data Acquisition                                                      |
| SCM    | Supply Chain Management                                                                       |
| SDG    | Sustainable development goals                                                                 |
| SEMS   | Safety and Environmental Management Systems                                                   |
| SES    | Systemic Expected Shortfall                                                                   |
| SEZ    | Special Economic Zone                                                                         |
| SKK    | Satuan Kerja Khusus                                                                           |
| SLCA   | Social Life Cycle Assessment                                                                  |
| SLRT   | Sustainable Landscapes Rating Tool                                                            |
| SME    | Small and medium-sized enterprises                                                            |
| SOFC   | Solid Oxide Fuel Cells                                                                        |

|       |                                                   |
|-------|---------------------------------------------------|
| SOP   | Standard Operating Procedures                     |
| SPA   | Sales And Purchase Agreement                      |
| SRCM  | Streamlined Reliability Centered Maintenance      |
| SSCM  | Sustainable Supply Chain Management               |
| STAMP | Systems-Theoretic Accident Model and Process      |
| STEM  | Science, Technology, Engineering, and Mathematics |
| SWOT  | Strengths, Weaknesses, Opportunities, Threats     |
| TAGP  | Trans-ASEAN Gas Pipeline                          |
| TBL   | Triple Bottom Line                                |
| TCZ   | Two Control Zones                                 |
| TPH   | Total Petroleum Hydrocarbon                       |
| TPST  | Tempat Pengolahan Sampah Terpadu                  |
| TWH   | Total Worker Health                               |
| UAE   | United Arab Emirates                              |
| UHC   | Universal Health Coverage                         |
| UN    | United Nations                                    |
| UNECE | United Nations Economic Commission for Europe     |
| UNEP  | United Nations Environment Programme              |
| UNFC  | United Nations Framework Classification           |
| UNGD  | Unconventional oil and gas development            |
| UNU   | United Nations University                         |
| US    | United States                                     |
| VR    | Virtual Reality                                   |
| WHRI  | Worker's Health Risk Index                        |
| WK    | Wilayah Kerja                                     |
| WNTS  | West Natuna Transportation System                 |
| WS    | Work System                                       |



# Introduction

Herie Saksono, Nurul Izzati

Oil and gas management by Regionally Owned Enterprises in Indonesia plays an important role in supporting regional economic growth, but the main challenges lie in environmental protection, sustainability, and local community health.

This book discusses oil and gas (oil and gas) management based on Regionally Owned Enterprises (BUMD) in the Riau Islands and Wajo Regency, with a focus on policy, environment, public health, and the importance of multisectoral collaboration and environmentally friendly technological innovation to achieve economic and ecosystem sustainability.

## 1.1. Introduction

Indonesia, as a country rich in natural resources, especially oil and gas, has a great responsibility in managing this energy potential optimally. Oil and gas management through Regionally Owned Enterprises (namely BUMD) not only functions as a source of national income, but also plays an important role in encouraging regional economic development. The management of the oil and gas sector by BUMDs allows regions such as the Riau Islands and Wajo Regency, South Sulawesi, to utilize their natural resources to improve the welfare of local communities and support regional economic growth. A study by (Qurbani et al., 2020) shows that the management of BUMDs in the oil and gas sector in Bojonegoro, which is one of the oil and gas producing areas, has made a significant contribution to regional economic growth. However, the benefits received by the local community have not been optimal, especially in terms of increasing employment. Better management is needed to ensure that the benefits of the oil and gas sector can be felt directly by local communities. (Wibowo, 2020) also emphasized the importance of BUMD as an agent driving local economic growth and as a source of Regional Original Revenue. BUMD not only plays a role as a public service provider, but also as an instrument to achieve economic justice through the decentralization of natural resource management in the regions. The existence of BUMDs is important in realizing

equitable and sustainable development throughout Indonesia. In addition, research by (Ibrahim & Pratama, 2024) highlights the role of Village-Owned Enterprises (namely BUMDes) in supporting local economic development, especially in rural areas rich in natural resources such as West Sumbawa Regency. This study shows that BUMDes have great potential to improve the welfare of rural communities by utilizing local resources sustainably.

Oil and gas management through BUMD plays a very important role in supporting public policies, ensuring environmental protection, and protecting public health. One way to achieve this goal is through the provision of a Participating Interest (PI) of 10% to local governments in upstream oil and gas operations. This PI gives local governments the right to participate in the management of oil and gas operations, which at the same time provides responsibility in ensuring that oil and gas activities comply with environmental regulations and encourage sustainability. Research by (Hasiholan et al., 2023) emphasizes that local government participation through PI ownership is very important in ensuring environmental compliance in the management of the oil and gas sector. This study highlights that with the allocation of PI, local governments have the responsibility to maintain safety, health, and environmental awareness in upstream oil and gas operations in accordance with applicable regulations. However, the implementation of this PI policy does not always run smoothly. (Yulianingsih & Algasahri, 2020) show that regulations on the distribution of PI of 10% still face obstacles in several areas, such as in Sampang Regency. They recommend a review of the regulation to increase the effectiveness of PI implementation through BUMDs and involve the private sector to increase regional participation. Furthermore, another study by (Wahyudi, 2022) revealed that PI policies in some regions, such as Aceh, have not provided optimal results. Although there are regulations that require PI to be offered to the regions, the supervision and implementation of the Aceh Oil and Gas Management Agency (namely BPMA) has not been effective, which results in the regions not fully receiving the benefits of PI. The absence of sanctions for violations of PI offers is also one of the causes of the ineffectiveness of this policy. The management of a 10% PI by local governments not only provides economic opportunities, but also demands great responsibility in ensuring that oil and gas operations practices do not harm the environment, and remain in line with public policies for environmental protection and public health.

Environmental protection in oil and gas management is often a very important issue, especially related to pollution and negative impacts on the environment. Research conducted in Azerbaijan and Ukraine reveals that small and medium-sized oil and gas companies face major challenges in managing the environmental impact of their activities. Poor environmental management in these companies contributes to increased pollution and decreased operational efficiency. In this regard, the study highlights the importance of implementing stronger

environmental taxation policies and environmental safety regulations to improve environmental management in the oil and gas sector (Sheydai et al., 2021). Another study in Ukraine also shows that environmental taxation has an important role in improving oil and gas companies' compliance with environmental protection. Environmental taxes not only serve as a fiscal tool, but also as an incentive for companies to adopt more environmentally friendly technologies. However, the implementation of these taxes is often ineffective due to weak enforcement and a lack of real incentives for companies to comply with environmental standards (Samusevych & Horodetska, 2023). Research by (Mas'ud et al., 2020) also shows that the implementation of an effective environmental tax compliance model in the oil and gas sector can help reduce air, water, and soil pollution. Increased regulation and the use of enforcement mechanisms are expected to improve compliance with environmental taxes, which will ultimately encourage cleaner production and reduce negative impacts on the environment. The recommendations of these studies emphasize the importance of strengthening environmental taxation policies and enforcing environmental safety regulations in the oil and gas sector, especially in developing countries, to ensure better operational efficiency and more effective environmental protection.

The implementation of an Environmental Management System in the oil and gas industry in Indonesia, including the ISO 14001 standard and the Environmental Impact Analysis, is critical in preventing environmental damage and protecting public health. Based on a literature review by (Muzanni et al., 2022), the implementation of Environmental Management System (EMS) by Indonesian oil and gas companies has shown an important role in reducing the negative environmental impact of upstream oil and gas operations. In this study, six key aspects of EMS implementation were identified, including strategic planning, project evaluation, execution, technical accuracy, consulting, and institutional trust. EMS helps ensure a company's compliance with environmental regulations while improving operational efficiency. Furthermore, the role of human resources in supporting the implementation of EMS is no less important. Research by (Sherly & Nawangsari, 2022) highlights that environmentally friendly human resource management (Green Human Resource Management, GHRM) is closely related to the successful implementation of ISO 14001 in the oil and gas sector. GHRMs help strengthen corporate policies in preserving the environment, ultimately increasing compliance with environmental standards such as ISO 14001. In addition, research by (Mahzun et al., 2020) shows that economic, social, and ecological factors significantly affect the successful implementation of ISO 14001 in heavy industries in Indonesia, such as shipyards. The results of the study show that the successful implementation of EMS depends on how companies manage these factors to minimize negative impacts on the environment while complying with existing regulations. The implementation of EMS in Indonesia's

oil and gas sector, especially through ISO 14001 and AMDAL standards, plays an important role in mitigating negative environmental impacts and increasing company awareness of the importance of sustainable environmental management.

The 10% PI policy, which is regulated in the Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016, provides a great opportunity for local governments to be directly involved in the management of oil and gas working areas. This opens the door for regions to get greater revenue from their natural resources through BUMD. However, the main challenge of this policy is to ensure that oil and gas management is carried out in a sustainable manner, by integrating aspects of environmental protection and public health. Research conducted by (Hasiholan et al., 2023) shows that local governments as holders of 10% PI have a great responsibility in ensuring compliance with environmental regulations in upstream oil and gas operations. They play an important role in encouraging sustainable oil and gas development, where environmental responsibility is an integral part of the management of these natural resources. Local governments are expected to be able to manage environmental impacts, including the risk of water and soil pollution due to oil and gas exploration and production activities. Furthermore, (Wahyudi, 2022) examined the effectiveness of monitoring the implementation of PI by BPMA and found that although PI is required to be offered to local governments, some regions have not received the full benefits. One of the main obstacles is the lack of strict sanctions for contractors who do not comply with the obligation to offer PI to local governments. This shows that strengthening regulations is needed to ensure more effective implementation of this policy. In addition, from a public health perspective, research by (Deziel, 2021) shows a relationship between oil and gas activities and negative impacts on health, especially weight loss of babies born to mothers who live close to drilling sites. Oil and gas drilling produces harmful emissions that can affect air and water quality, which in turn affects the health of local communities. This study highlights the importance of stricter environmental monitoring to reduce the adverse health impacts of oil and gas operations. The 10% PI policy provides a great opportunity for local governments to be involved in oil and gas management, but challenges related to environmental and public health risks must be seriously managed. Integrating a sustainability approach in every aspect of oil and gas management—both in terms of policy, investment, and operations—is essential to ensure that the exploitation of natural resources does not damage the environment and the well-being of local communities.

In the 2024 Riau Islands Province statistical report, the oil and gas (oil and gas) sector is discussed in the context of mining and quarrying in the Riau Islands Province. This subcategory includes crude petroleum, natural gas, and geothermal production activities, which are the main components of the province's GDP (Gross Regional Domestic Product). The contribution of the oil and gas subcategory to the Riau Islands

GDP shows a downward trend during the 2019-2023 period. In 2019, the oil and gas subcategory contributed 88.92 percent of the mining and quarrying sector, but this figure dropped to 82.95 percent in 2023. This indicates a decrease in oil and gas production which has an impact on the regional economy. Over the past five years, the oil, gas, and geothermal mining sector in the Riau Islands has faced various challenges. External factors, such as regulatory changes, especially the Mineral and Mineral Law that restricts the export of raw materials, also affect the performance of this sector. Nevertheless, this sector remains the largest contributor to mining and quarrying GDP.

The mining and quarrying sector, especially oil and gas (oil and gas), continues to dominate the economic structure of the Riau Islands Province (figure 1), with a significant contribution to the GDP. In 2019, the oil and gas sector accounted for 88.92% of the total contribution of the mining and quarrying sector. Despite experiencing a gradual decline of up to 82.95% in 2023, the oil and gas sector remains the largest contributor to the province's economy. This decline can be attributed to a variety of factors, including changes in energy policy and challenges in oil and gas production. In addition, the processing industry sector also plays an important role with a relatively stable contribution, which is around 12.60% to 13.45% during the 2019–2023 period. The electricity and gas sector, although its contribution is smaller, also shows a consistent role, ranging from 4.87% to 5.12%. On the other hand, the agriculture, forestry, and fisheries sectors only make a small contribution to GDP, which is around 1.55% to 1.67%. Overall, the Riau Islands economy is highly dependent on the oil and gas and energy sectors, while other sectors such as the processing industry and electricity-gas provide important support in the province's economic structure. Despite the decline in the contribution of the oil and gas sector, other subcategories such as metal ore mining showed positive growth in 2023 with an increase in contribution to 13.18 percent.

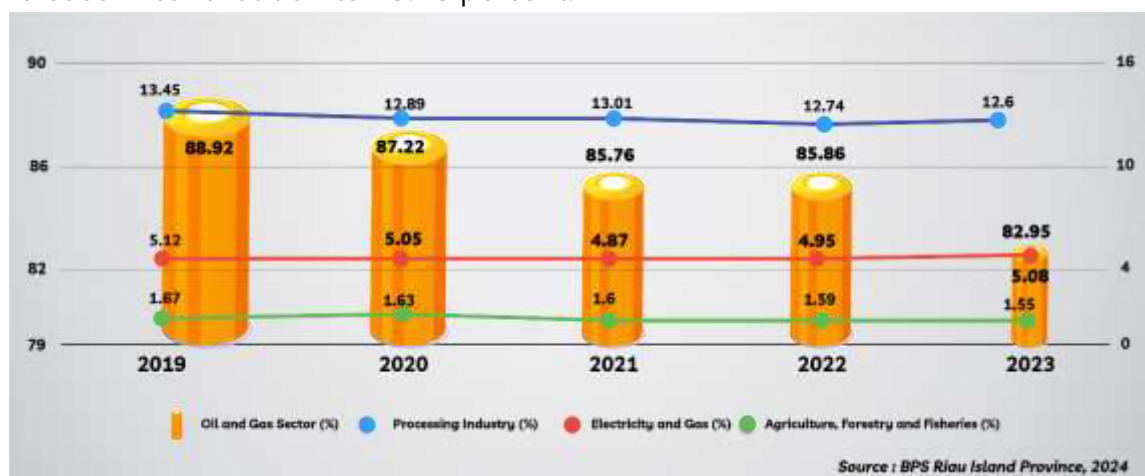


Figure 1.1. Contribution of the GDP Sector in Riau Islands Province in 2019-2023



Meanwhile in Wajo Regency, South Sulawesi Province, Indonesia's petroleum and natural gas is the two main energy sources that play an important role in the regional economy. Both are included in the mining and quarrying sectors, which significantly contribute to the Gross Domestic Product (GDP) in various regions, including Wajo Regency, as reflected in the Wajo Regency GDP report by business field 2018-2022. This sector includes the exploration and production of crude oil, natural gas, and other supporting activities. In the Wajo Regency GDP report, the mining and quarrying sector, including oil and gas, recorded an important contribution to regional economic growth. In 2022, the contribution of this sector continued to grow with the improvement of exploration technology and increased economic activity in the region. The following table illustrates the contribution of the mining and quarrying sector to the GDP in Wajo. Data sources from the GDP report indicate that the sector experienced a steady increase during the 2018-2022 period, driven by strong energy demand and volatile oil and gas commodity prices.

Petroleum is used as the main fuel for transportation, raw materials for the petrochemical industry, as well as in the production of electrical energy. Meanwhile, natural gas is widely used in heating, electricity production, as well as raw materials for chemical products. Globally, oil and gas production is affected by international market dynamics, new technologies such as fracking, and geopolitical issues that can affect the price and availability of these energy sources. Oil and gas exploitation is inseparable from environmental impacts, such as air, water, and soil pollution due to oil leaks or natural gas waste. In addition, the exploration of this resource often triggers social conflicts in the producing areas, due to differences in profit sharing or environmental damage that affects local communities.

Figure 2 is a line graph depicting the contribution of the oil and gas sector and the overall sector growth in Wajo Regency from 2018 to 2022. The contribution of the oil and gas sector (marked with a blue line) shows a consistent increase, starting from 5.80% in 2018, rising to 6.00% in 2019, then 6.20% in 2020, 6.50% in 2021, and reaching 6.70% in 2022. Meanwhile, overall sector growth (purple line) also increased, although the pace of increase was more moderate. Sector growth started from 3.40% in 2018, increased slightly to 3.60% in 2019, then rose to 4.00% in 2020, 4.20% in 2021, and finally 4.50% in 2022. The trend that can be identified from this graph is a consistent increase in the contribution of the oil and gas sector, which shows the strategic role of this sector in the economy of Wajo Regency. Meanwhile, overall sector growth also showed an upward trend, albeit at a slower pace compared to the oil and gas sector. This reflects that the oil and gas sector is increasingly playing a major role in the regional economy, while other sectors continue to grow steadily but not as fast as the contribution of the energy sector.

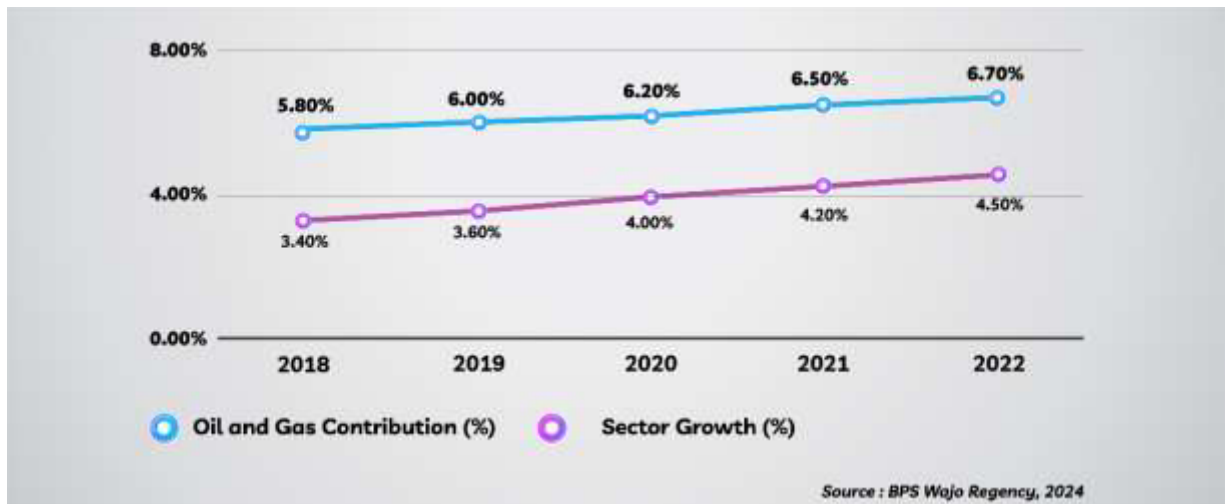


Figure 1.2. Contribution of the oil and gas sector and sector growth in Wajo Regency

These challenges include efforts to balance economic development with environmental sustainability and community welfare. The management of BUMD in the oil and gas sector must be oriented not only to economic benefits, but also to the protection of ecosystems and public health. Studies conducted in the Riau Islands show that large environmental potential, such as oil pollution in waters, is a major challenge. Research by (Ryan Anggria Pratama & Dhani Akbar, 2021) shows that oil waste has been polluting Bintan waters since the 1960s, and the government's efforts to address this problem are still not optimal. The study recommends a collaborative approach between various actors, including the government and local communities, to address such pollution in a sustainable manner. In addition, corporate social responsibility (CSR) also plays an important role in supporting sustainable development. Research by (Afrizal et al., 2021) highlights how PT Chevron Pacific Indonesia in Riau has implemented CSR programs that focus on social, economic, and environmental development. This program has had a positive impact on local communities, but its effectiveness still needs to be improved for long-term sustainability. On the other hand, Wajo also faces the same challenges related to environmental risk management. According to (Nelson & Zega, 2021), the management of Occupational Health and Safety (K3) in the oil and gas fabrication sector in Batam, Riau Islands, still needs to be improved. This is important because fabrication activities pose a high risk to the health and safety of workers, which can affect the well-being of the surrounding community. These two regions must continue to develop sustainable oil and gas management strategies by involving local governments, companies, and local communities in maintaining a balance between natural resource exploitation and environmental protection.

## **1.2. Purpose**

This book comes as a result of the merger of two main studies that focus on the feasibility of establishment and investment in Regionally Owned Enterprises (BUMD) in the oil and gas sector in the Riau Islands and Wajo Regency. The management of the oil and gas sector by BUMDs is not only seen from an economic and policy point of view, but also includes environmental and public health aspects that are often overlooked. Considering that Indonesia is one of the countries with the largest oil reserves, this management is an important instrument in maintaining a balance between the use of natural resources and environmental sustainability. Research conducted by (Nelson & Zega, 2021) in the Riau Islands revealed that although many oil and gas companies operate in this region, aspects of occupational safety and health are still a challenge, especially in the oil and gas-related fabrication industry. The results of this study demonstrate the importance of management commitment and safety culture to ensure the protection of workers in this sector. Furthermore, a study on the environmental impact of oil and gas activities in the Riau Islands shows the threat of oil spills that can pollute marine waters, as highlighted by (Ryan Anggria Pratama & Dhani Akbar, 2021) in their research in Bintan. They found that sludge oil pollution has been a long-standing problem in the area since the 1960s, and until now the treatment carried out is still not optimal. This study recommends a better institutional approach and active participation from various actors, including the government and local communities. In addition, studies related to investment in the oil and gas sector in Riau Province show that there are challenges in terms of regulatory uncertainty, especially related to regional spatial plans. Research by (Hasnati & Yalid, 2020) emphasizes that the uncertainty of the legal status of land causes investors to be reluctant to make new investments in the plantation and oil and gas sectors, even though this sector has great potential to increase regional income. From a public health perspective, a study by (Afrizal et al., 2021) on CSR in Riau Province shows that companies such as PT Chevron Pasifik Indonesia have made efforts to support sustainable development through CSR programs that focus on economic, social, and environmental aspects. However, the effectiveness of these programs still requires improvement in terms of long-term sustainability and deeper involvement from local communities. This book provides a comprehensive overview that covers various important aspects of oil and gas management, including public policy, environmental protection, and public health. This study offers strategic solutions to ensure that investment in the oil and gas sector can run sustainably, while maintaining community welfare and environmental sustainability in oil and gas producing areas such as the Riau Islands and Wajo Regency.

This book serves as a practical and theoretical guide for policymakers, oil and gas practitioners, and stakeholders at the regional and national levels. With 14

chapters covering various aspects ranging from national policies to the application of blue economy principles, this book is designed to provide guidance in more sustainable and long-term welfare-oriented oil and gas management. One of the important policies discussed is the implementation of the 10% PI, which gives local governments the opportunity to be involved in the management of oil and gas work areas, as well as emerging challenges related to environmental management and public health. Research shows that although these policies bring economic benefits, areas such as Riau still face environmental challenges such as oil pollution in waters, which requires a collaborative approach to their handling (Ryan Anggria Pratama & Dhani Akbar, 2021). In addition, the application of the blue economy concept is one of the strategies highlighted in this book. The blue economy emphasizes the importance of sustainable use of marine resources, which focuses not only on economic growth, but also on the protection of marine ecosystems. A study by (Sari & Muslimah, 2020) shows that blue economy policies can be a solution for better management of fishery resources in Indonesia, emphasizing the importance of marine conservation and sustainable management for the future. Public health aspects are also a concern in oil and gas management, especially the long-term impact of environmental pollution on health. The implementation of an EMS through ISO 14001 and AMDAL in the oil and gas sector is an important step in preventing pollution and maintaining the health of the surrounding community, as explained in a study by (Muzanni et al., 2022). This entire book emphasizes the importance of synergy between the government, industry, and the community in creating sustainable oil and gas management policies. It is hoped that this guide can help create a balance between economic growth, environmental protection, and social welfare in the management of Indonesia's abundant natural resources.

This book highlights the importance of multisectoral collaboration between local governments, the private sector, the community, and academics in responsible oil and gas management, especially in oil-rich areas such as the Riau Islands and Wajo Regency. Effective collaboration between these various stakeholders is not only expected to increase regional income, but also maintain environmental sustainability and the quality of life of the surrounding community. Research shows that collaboration between local governments, companies, and communities is a key element in ensuring sustainable natural resource management. For example, a study by (Wardana et al., 2023) in Riau shows that in the management of forest areas, collaboration between actors, including communities, is very important in achieving nature conservation goals. The participation of various parties increases transparency, trust, and shared commitment in managing natural resources in a sustainable manner. In addition, cross-sector collaboration has also proven to be effective in waste management and other environmental problems. (Adni, 2023) emphasized the importance of collaboration in forest and land fire management in

Riau. The results of his research show that collaboration between various government and non-government agencies is very important to control forest fires through a collaborative governance approach that involves trust and facilitative leadership. In Wajo Regency, the importance of collaboration between various stakeholders is also recognized in the management of the regional budget. (Bahri et al., 2020) recommended a collaborative model in the formulation of the Wajo Regional Revenue and Expenditure Budget, which involves active participation from the government, legislative, and community forums. This model increases consensus and shared commitment in public decision-making, which is important for transparency and accountability in regional resource management. This book emphasizes that a collaborative approach to oil and gas management, involving various sectors, is essential to achieve economic and environmental sustainability in the Riau Islands and Wajo Regency. The involvement of all parties not only ensures that the oil and gas potential can be utilized optimally, but also maintains the sustainability of the ecosystem and the quality of life of local communities.

The Riau Islands and Wajo Regency have great potential to become a successful oil and gas management model based on BUMD. Support from the right policies, effective risk management, and green technological innovations are essential in achieving these goals. BUMDs in the oil and gas sector have a strategic role in encouraging regional economic growth, as explained by (Wibowo, 2020) that BUMDs are not only a source of Regional Original Revenue, but also responsible as agents of local economic growth, especially in the oil and gas industry which has a large contribution to economic development. However, challenges in oil and gas management also include environmental and sustainability aspects. In Riau, the important role of BUMDs in environmental risk management has been identified as a crucial factor to maintain a balance between resource exploitation and ecosystem sustainability. A study by (Ryan Anggria Pratama & Dhani Akbar, 2021) emphasizes the importance of cross-sectoral collaboration to address sludge oil pollution in Bintan waters, which has been a serious problem since the 1960s. Joint efforts between the government, oil and gas companies, and the community are needed to effectively manage environmental impacts. Environmentally friendly technological innovation is also the key to success in oil and gas management. (Ariyanto et al., 2020) highlighted the importance of the adoption of palm oil farming technology in Riau, which shows that the use of more advanced technology can improve technical efficiency and productivity. The adoption of technology in the oil and gas sector can reduce negative impacts on the environment and improve the operational efficiency of BUMDs. With clear policy support and the implementation of technological innovations, BUMDs in the oil and gas sector are expected to be the driving force for inclusive and sustainable regional development. The involvement of all stakeholders – both governments, companies, and communities – is crucial in creating an oil and

gas management model that is not only oriented towards economic benefits, but also maintains environmental sustainability and the quality of life of local communities.

### **1.3. Systematics**

This book is compiled into 14 chapters that comprehensively discuss oil and gas (oil and gas) management and environmental health. Chapter 1 Introduction provides an overview of the importance of responsible oil and gas management and its impact on public health and the environment. This chapter also outlines the purpose of the writing and the scope of the discussion. Chapter 2 discusses the National Policy on Oil and Gas Management and Environmental Health, which covers the various regulations underlying the management of the oil and gas sector in Indonesia. This chapter highlights government policies in managing oil and gas resources in a sustainable manner and maintaining health and environmental balance. Chapter 3 explores the Potential of Oil and Gas and the Management of Regionally Owned Enterprises (BUMD). Here, it discusses how BUMD plays a role in managing oil and gas resources in the local area, including the development of regional oil and gas potential and effective management mechanisms.

Chapter 4 focuses on Policy Impact on Natural Resource Management, which reviews how oil and gas policies affect overall natural resource management, both from environmental and economic aspects. Chapter 5 highlights Community Participation and Environmental Protection, by discussing the importance of community involvement in environmentally friendly oil and gas management as well as environmental protection measures that must be implemented by companies and governments. Chapter 6 discusses the Environmental Impact of Oil and Gas Exploration and Exploitation, especially regarding the environmental damage that may occur due to oil and gas exploration and exploitation activities, as well as mitigation efforts that can be made to reduce its negative impacts. Chapter 7 reviews Technologies and Innovations for Environmental Protection in Oil and Gas Management, highlighting technological advances used in the oil and gas industry to minimize environmental impacts. This chapter also discusses innovations that contribute to greener management.

Chapter 8 discusses public health around oil and gas working areas, focusing on the impact of oil and gas activities on the health of people living around exploration and exploitation areas. This chapter also reviews the efforts made to protect public health. Chapter 9 focuses on Health Management Strategies in the Operations of Oil and Gas Regionally Owned Enterprises, which includes health strategies implemented by BUMDs in oil and gas operations to ensure the welfare of workers and the surrounding community. Chapter 10 reviews Environmental and Health Risk Management in the Oil and Gas Sector, explaining how environmental and health risks arising from oil and gas activities are properly managed to reduce their negative

impacts. Chapter 11 discusses the Implications of Health and Environmental Policies on Investment in Regional-Owned Enterprises, reviews how policies related to health and the environment affect the attractiveness of investment in the oil and gas sector, especially at the local level. Chapter 12 introduces the concept of Implementation of Blue Economy Principles in Oil and Gas Management, which discusses how blue economy principles can be applied in the oil and gas industry to maintain the sustainability of the ocean and surrounding ecosystems. Chapter 13 highlights the importance of Multisectoral Collaboration for Environmental and Health Sustainability, by discussing collaborative efforts between governments, companies, communities, and non-governmental organizations in achieving sustainability in the oil and gas sector. The final chapter, Chapter 14, presents Conclusions and Recommendations, summarizing the key points discussed in this book and providing recommendations for improving oil and gas management that is more sustainable, environmentally friendly, and focuses on public health. With the structure of the chapters, this book offers an in-depth view of socially and environmentally responsible oil and gas management, providing the policy, technology, and collaboration perspectives needed to achieve a balance between the use of natural resources and the protection of health and the environment.

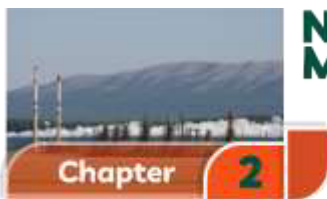
## Reference

- Adni, D. F. (2023). Controlling Forest and Land Fires in Riau Province using Collaborative Governance: Support for Smart Environment. *E3S Web of Conferences*, 440. <https://doi.org/10.1051/e3sconf/202344002006>
- Afrizal, A., Sujianto, S., Zulkarnain, Z., & Firdaus, F. (2021). Tanggung jawab sosial PT.Chevron Pasifik Indonesia di Provinsi Riau untuk pembangunan berkelanjutan. *Dinamika Lingkungan Indonesia*, 8(1). <https://doi.org/10.31258/dli.8.1.p.80-85>
- Ariyanto, A., Syaikat, Y., Hartoyo, S., & Sinaga, B. M. (2020). TECHNOLOGY ADOPTION AND TECHNICAL EFFICIENCY OF OIL PALM SMALLHOLDER PLANTATION IN RIAU AND WEST KALIMANTAN. *Jurnal Manajemen Dan Agribisnis*. <https://doi.org/10.17358/jma.17.3.239>
- Bahri, S., Rakhmat, Yunus, M., & Allorante, A. I. (2020). RECOMMENDATION for COLLABORATIVE GOVERNANCE MODEL in WAJO DISTRICT REGIONAL REVENUE and EXPENDITURES BUDGET FORMULATION. *Journal of Critical Reviews*, 7(13). <https://doi.org/10.31838/jcr.07.13.28>
- Deziel, N. C. (2021). Invited perspective: Oiland gas development and adverse birth outcomes: What more do we need to know? *Environmental Health Perspectives*, 129(7). <https://doi.org/10.1289/EHP9715>
- Hasiholan, A., Murwadji, T., & Sukarsa, D. E. (2023). Environmental Responsibilities of Local Governments as PI Holders in Upstream Oil and Gas Operations. *IOP Conference Series: Earth and Environmental Science*, 1270(1). <https://doi.org/10.1088/1755-1315/1270/1/012006>
- Hasnati, H., & Yalid, Y. (2020). Policy Impact Areas of Spatial Plan Investment Climate of Business Plantation in Riau Province. *IOP Conference Series: Earth and Environmental Science*, 469(1). <https://doi.org/10.1088/1755-1315/469/1/012072>
- Ibrahim, I., & Pratama, I. N. (2024). IMPRESI PRODUK DOMESTIK REGIONAL BRUTO TERHADAP TINGKAT KEMISKINAN DI KABUPATEN LOMBOK TENGAH. *Jurnal Ilmu Sosial Dan Ilmu Politik Malikussaleh (JSPM)*, 5(1), 1. <https://doi.org/10.29103/jspm.v5i1.10516>
- Mahzun, R., Thamrin, Bahrudin, & Nofrizal. (2020). Effect of ecological, economic and social factors on the implementation of ISO 14001 environmental management system in heavy industries in Indonesia. *International Journal of Energy Economics and Policy*, 10(6). <https://doi.org/10.32479/ijeep.8984>
- Mas'ud, A., Yusuf, R., Udin, N. M., & Al-Dhamari, R. (2020). Enforce environmental tax compliance model for the oil and gas industry. *International Journal of Energy Sector Management*, 14(6). <https://doi.org/10.1108/IJESM-11-2019-0005>



- Muzanni, A., Soesilo, T. E. B., Martono, D. N., Hamzah, U. S., Berkademi, W., & Febraldo, D. (2022). Review of Environmental Management System Implementation in the Oil and Gas Company in Indonesia. *IOP Conference Series: Earth and Environmental Science*, 1111(1). <https://doi.org/10.1088/1755-1315/1111/1/012018>
- Nelson, A., & Zega, Y. A. (2021). INFLUENCE OF OCCUPATIONAL HEALTH SAFETY (OHS) CULTURE, COMMITMENT MANAGEMENT, OHS TRAINING ON OHS PERFORMANCE IN OIL & GAS CONTRACTORS COMPANY IN BATAM ISLAND. *Journal of Business Studies and Mangement Review*, 4(2). <https://doi.org/10.22437/jbsmr.v4i2.12852>
- Qurbani, I., Sumarno, T., & Cassy, R. (2020). Regional Economic Development Strategy: Increasing Local Generated Domestic Revenue of the Regional-Owned Enterprises in the Oil and Gas Sector. *Brawijaya Law Journal*, 7(1), 70–81. <https://doi.org/10.21776/ub.blj.2020.007.01.05>
- Ryan Anggria Pratama, & Dhani Akbar. (2021). Transformasi Pemerintahan Kolaboratif dalam Pengendalian Pencemaran Limbah Sludge Oil untuk Pencapaian Blue Economy di Bintan. *Jurnal Administrasi Politik Dan Sosial*, 1(3). <https://doi.org/10.46730/japs.v1i3.32>
- Samusevych, Y., & Horodetska, M. (2023). Environmental taxation impact on the development of Ukrainian mining industry. *Economic Herald of SHEI USUCT*, 17(1), 98–107. <https://doi.org/10.32434/2415-3974-2022-17-1-98-107>
- Sari, D. A. A., & Muslimah, S. (2020). Blue economy policy for sustainable fisheries in Indonesia. *IOP Conference Series: Earth and Environmental Science*, 423(1). <https://doi.org/10.1088/1755-1315/423/1/012051>
- Sherly, S., & Nawangsari, L. C. (2022). The Role of Green Human Resources Management in Supporting the Implementation of the ISO 14001 Environmental Management System at Inspection Companies in Indonesia. *Inclusive Society and Sustainability Studies*, 2(2). <https://doi.org/10.31098/issues.v2i2.1153>
- Sheydai, T., Nykyforuk, O., Berezhnytska, U., Melnychuk, I., & Mandryk, I. (2021). Environmental management in small and medium-sized enterprises of oil and gas industry. *IOP Conference Series: Earth and Environmental Science*, 628(1). <https://doi.org/10.1088/1755-1315/628/1/012021>
- Wahyudi, W. (2022). Effectiveness And Supervision Of Participating Interest By The Bpma: A Legal Analysis. *Kanun Jurnal Ilmu Hukum*, 24(2). <https://doi.org/10.24815/kanun.v24i2.28237>

- Wardana, D., Wijaya, M., & Al Hafis, R. I. (2023). Enhancing Collaborative Governance in Managing Grand Forest Park in Riau, Indonesia. *Journal of Contemporary Governance and Public Policy*, 4(2). <https://doi.org/10.46507/jcgpp.v4i2.208>
- Wibowo, A. (2020). *The Development of Regionally Owned Enterprises (BUMD) in Indonesia*. <https://doi.org/10.2991/aebmr.k.200513.090>
- Yulianingsih, I., & Algasahri, M. R. Y. (2020). GOVERNMENT'S NEW POLICY ON THE ARRANGEMENTS OF PARTICIPATING INTEREST. *Trunojoyo Law Review*, 2(2). <https://doi.org/10.21107/tlr.v2i2.9500>



# National Policy on Oil and Gas Management and Environmental Health

Raymond Rayendra Elven, Endriana Wahyu Alita

In discussing national policies on oil and gas (oil and gas) management and environmental health, there are several important and strategic aspects that need to be elaborated. Topics in this chapter cover the close relationship between the management of energy resources (especially oil and gas) and their impact on the environment and public health.

## **2.1. Regulatory and Legal Framework**

Law No. 22 of 2001 concerning oil and gas is the main legal basis that regulates the management and exploitation of oil and gas in Indonesia. This law regulates the use of oil and gas resources for the welfare of the community, while ensuring that oil and gas companies are obliged to be responsible for the environment and public health. Second, it regulates compliance with environmental impact analysis (EIA) as a condition for oil and gas exploration and exploitation, including post-extraction environmental restoration to preserve the ecosystem.

The Utilization of Oil and Gas Resources for Community Welfare and Environmental Responsibility in the context of Law No. 22 of 2001 covers several important matters, especially in terms of environmental responsibility of oil and gas companies and related reporting.

### **2.1.1. Environmental Responsibility and Corporate Reporting**

Oil and gas companies in Indonesia are required to report their environmental responsibilities through Corporate Environmental Responsibility (CER) which follows the Global Reporting Initiative (GRI) reporting standards. This standard is used to ensure that oil and gas companies reduce the negative impact of their operations on the environment. However, studies show that the level of compliance of oil and gas companies with GRI standards is still low, reflecting limited openness in environmental impact reporting.

CER is a company's commitment to manage the environmental impact of its operational activities. CER aims to reduce negative effects on the environment and promote sustainable practices. CER is part of Corporate Social Responsibility (CSR) which focuses on environmental aspects, such as reducing carbon emissions, waste

management, and using environmentally friendly resources described in the CER typology (figure 2.1).



Figure 2.1. CER typology

The CER mechanism involves integrating environmental considerations into a company's strategy and operations. This can include investments in green innovation, the implementation of environmental standards, environmental performance assessments, and stakeholder engagement in sustainability efforts. For example, companies often use strategic management frameworks to include environmental responsibility at various stages of their life cycle, so that environmental responsibility becomes part of decision-making (Kasych et al., 2020). In addition, compliance with environmental regulations and disclosure policies is also an important tool to improve CER and reduce pollution (Wang et al., 2021). CER is urgently needed because it addresses environmental degradation caused by business operations, promotes sustainable development, and aligns with global trends in environmental conservation. Since businesses are a major contributor to environmental pollution, their proactive involvement in reducing damage is indispensable to achieving sustainability goals. In addition, CER also improves a company's reputation, strengthens regulatory compliance, and can improve financial performance through efficiency and innovation (Liu et al., 2022; Peng et al., 2021). CER involves a wide range of stakeholders, including companies, governments, non-governmental organizations (NGOs), investors, and the community. CER practices are sustainable and are implemented as part of the company's long-term strategy. Companies typically integrate CERs at different stages of their development, continuously improving environmental performance over time. Its implementation also responds to external factors such as regulatory changes or environmental crises that encourage

companies to take stronger action (Xue et al., 2022). CERs are an important component of the responsibility of modern companies that address environmental impacts while promoting sustainable practices. It involves multiple stakeholders and requires long-term strategic implementation to achieve sustainability goals. The implementation of CER, its impact, and the causes that trigger the implementation of CER in these companies with the implementation that has been carried out in several countries (Table 2.1).

Table 2.1. Implementation of CER in companies

| CER                                                                             | Impact                                                                                                                                                     | Causes of CER                                                                                                  |
|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Mandatory Environmental Responsibility Disclosure in China (Wang et al., 2021)  | Reduce environmental pollution and increase corporate responsibility. A non-linear relationship is found between environmental regulation and performance. | Government regulations that require disclosure of environmental responsibility.                                |
| Environmental Responsibility in Chemical Companies in China (Peng et al., 2021) | CER improves the company's environmental performance, although the impact is not significant overall. Industry competition amplifies the impact of CER.    | Pressure from industry competition to improve environmental standards and maintain the company's image.        |
| Environmental Responsibility in Supply Chains in China (Luo & Xie, 2021)        | Increased implementation of CER by suppliers and customers through vertical spillover effects.                                                             | It is the strength in the supply chain that drives companies to meet their environmental responsibilities.     |
| Environmental Strategy and Green Innovation in Malaysia (Kraus et al., 2020)    | Green innovation and environmental strategies improve the company's environmental performance.                                                             | The drive to innovate in an effort to achieve sustainability and improve the competitiveness of the company.   |
| Involvement in the United Nations Global Compact (J. Li & Wu, 2020)             | Private companies experienced a significant reduction in negative ESG incidents; Public companies tend not to have a significant impact.                   | Pressure from stakeholders to comply with international standards such as the UNGC.                            |
| Management of CER in the Energy industry in Poland (Wolniak et al., 2021)       | Investments in ISO 14001 and environmental education activities improve corporate image and ecological innovation.                                         | Pressure from national environmental regulations and a push to maintain sustainability in the energy industry. |

Source: Author's search, 2024

CER is standardized in the GRI, which is a global standard that aims to help organizations report their economic, environmental, and social impacts transparently. GRI facilitates sustainability reporting based on the triple bottom line, which includes economic, environmental, and social aspects. This standard is used by organizations around the world to support sustainable development and public accountability for its sustainability performance (Narula et al., 2021). The GRI mechanism involves applying the guidelines and principles set out in the GRI standards to measure and report on the impact of the organization on the economy, the environment, and society. This reporting process includes accurate and relevant data collection, impact assessment, and comparative and timely reporting. In addition, GRI also encourages the use of industry 4.0 technologies in the sustainability

reporting process, such as the digitization of supply chain management and organizational communication strategies to increase transparency (Narula et al., 2021). The implementation of GRI involves a wide range of stakeholders, including company management, regulators, shareholders, and the wider community. International organizations such as the United Nations, national governments, and large and small companies are also involved in the implementation of this standard. GRI provides a framework that allows companies to communicate with their stakeholders regarding their social, environmental, and economic impacts (Schnitger et al., 2021). GRI is implemented on an ongoing basis, with companies around the world using this standard in their annual sustainability reports. Every organization that uses GRI is expected to continuously update and adjust their reports based on policy changes and recent developments in the field of global sustainability (Halkos & Nomikos, 2021). GRI plays a critical role in guiding organizations to report on their sustainability impacts, increase transparency, and help achieve sustainable development goals. GRI involves many parties and is applied continuously to create a positive impact on society and the environment. The implementation of GRI, its impact, the causes of implementation have been carried out, which can be informed in table 2.2.

Table 2.2. GRI Implementation

| GRI Implementation                                                             | Impact                                                                                                                                                                                                                  | Causes of Implementation                                                                                                                         |
|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| The use of industry 4.0 technology in GRI (Narula et al., 2021)                | 85% of environmental standards, 65% of economic standards, and 50% of social standards in GRI are significantly affected by industry 4.0 technologies. It improves economic performance, energy, and emission reduction | Increased demand for transparency in sustainability reporting, as well as adoption of cutting-edge technologies for efficiency                   |
| GRI Reporting on the CAC40 Exchange Market in France (Ben Ismail et al., 2021) | The implementation of GRI increases the amount of information disclosed regarding life cycle assessments, encouraging companies to better manage their environmental performance                                        | There is a demand from the market and stakeholders for greater transparency about environmental impacts                                          |
| GRI Reporting in the Infrastructure Sector (Ferrarez et al., 2020)             | 42 valid indicators were found to measure the sustainability of infrastructure projects, including 21 new indicators to be included in GRI reporting                                                                    | Demand for massive infrastructure sustainability evaluations due to impacts on the environment, public health, and local economies               |
| GRI and Reporting Challenges in Developing Countries (Taurigana, 2021)         | GRIs have had a limited impact on the increased adoption of sustainability reporting in developing countries due to challenges such as market pressures and awareness                                                   | The need to increase transparency in developing countries and help organizations face international pressures regarding sustainability reporting |

*Source : Author's search, 2024*

The GRI is a reporting standard designed to help organizations report their economic, environmental, and social impacts in a measurable and transparent manner. This standard focuses on three main pillars, namely economic,

environmental, and social, which are often referred to as the triple bottom line. The GRI reporting model consists of several important steps that make it easier for organizations to compile relevant and measurable reports. The first step in the implementation of GRI is the identification of material aspects, organizations must identify the economic, environmental, or social issues that are most relevant to their operations. This process involves dialogue with stakeholders to determine topics that are considered important and have a significant impact on the sustainability of the organization. Furthermore, GRI provides a flexible modular reporting structure, with a mechanism for organizations to choose modules that suit their business needs, such as indicators for greenhouse gas emissions or resource use, which are then measured and reported consistently on an annual basis (Narula et al., 2021).

GRI also emphasized the importance of stakeholder involvement in the reporting process, with the aim of increasing corporate transparency and accountability. Stakeholders are involved in determining sustainability priorities that are important to companies and the public (Afolabi et al., 2023). The GRI standard is based on the principle of materiality, which requires companies to only report issues that are considered to have a significant impact on sustainability and are relevant to stakeholders (Pizzi et al., 2023). The GRI's reporting structure includes economic, environmental, and social sections. The economics section highlights the direct economic impact as well as the value created for the community, while the environmental section reports on emissions, water use, and waste management. The social part includes aspects of health, occupational safety, and community development. With this measurable and transparent model, organizations can demonstrate their performance in achieving sustainability goals and mitigate the negative impact of their operations on the environment and society ((Zharfpeykan & Akroyd, 2023).

In line with CER and GIR in Indonesia, several scientific references have had interesting highlights, for example through research by (Nabila Qothrunada & Wuri Handayani, 2023) showing that oil and gas companies in Indonesia have a low level of compliance with CER reporting based on the GRI 300 standard, which focuses on environmental impact. The use of content analysis in annual reports and sustainability reports shows that many companies meet only a small fraction of the GRI requirements, especially regarding the environmental impact of their activities. A study on PT Pertamina shows that although sustainability reporting began in 2011, the average report disclosure during the 2017-2018 period only reached 28-37%. The increase in environmental incidents, such as oil spills, is triggering an increase in sustainability reporting, as companies seek to improve their public image through greater openness (Purwanti & Lestari, 2022). Further research on companies in other sectors, such as manufacturing, also shows that although the use of GRI standards increased after the enactment of mandatory environmental disclosure regulations in

2012, such reporting is still limited. Only 13.95% of companies implemented GRI standards before 2012, which then increased to 30.90% in 2013, but most of the reports are still limited to companies with low or moderate carbon emissions (Yaya et al., 2018). Another study found that social and environmental responsibility disclosures based on GRI standards had an influence on market reactions. This study analyzes energy companies listed on the Indonesia Stock Exchange, where the application of CSR reporting based on the GRI influences market reaction through the measurement of Cumulative Abnormal Return (Maharani & Rozzaid, 2022). Although the GRI standard has been widely applied in the oil and gas sector and other industries in Indonesia, the implementation of environmental responsibility reporting by oil and gas companies still requires significant improvements in terms of openness and full compliance with international standards.

An important issue related to CER and GIR is compliance with the EIA as a condition for oil and gas exploration and exploitation, aiming to ensure that oil and gas exploration and exploitation activities do not cause excessive environmental damage and that post-extraction environmental restoration can be carried out properly to preserve the ecosystem. AMDAL is an evaluation process that must be carried out before a major project begins, especially for sectors that have the potential to cause a major impact such as the oil and gas industry (Zhang, 2021). The EIA mechanism begins with an initial assessment of the potential impact of exploration and exploitation activities on the environment, including soil, water, air, and ecosystem life. This stage is followed by the formulation of a mitigation plan to reduce the negative impacts that have been identified. In addition, there is an obligation for companies to carry out continuous environmental monitoring during the exploitation process and after the production phase to ensure there is no further contamination. The use of methodologies such as geochemistry, sedimentation, and biophysical indicators is often used to monitor the environmental impact of offshore oil and gas operations (Musci & Da Cunha, 2023). Compliance with the EIA is needed to prevent irreparable environmental damage, maintain the health of local communities, and meet national and international environmental legal and regulatory obligations. In many countries, failure to comply with the AMDAL can lead to severe sanctions as well as damage to a company's reputation. In addition, the implementation of a good EIA can also help reduce the cost of post-exploitation environmental restoration and maintain long-term operational sustainability (Arthur, 2020). The AMDAL process involves a wide range of stakeholders, including oil and gas companies, governments, local communities, and environmental organizations. The company is responsible for conducting environmental impact studies and implementing mitigation measures. The government acts as a watchdog, ensuring that companies meet their obligations as per regulations. Local communities and NGOs are often involved in public consultation to ensure that their interests are



accommodated in mitigation plans (Zhuravska et al., 2023). The EIA is implemented at an early stage before exploration begins and continues throughout the project life cycle, including the post-exploitation environmental monitoring phase. Environmental restoration is carried out after extraction activities are completed to ensure ecosystem restoration and prevent further damage (Mein et al., 2021).

Table 2.3. Environmental Impact Analysis (AMDAL) in some countries

| Description                                                                                       | Environmental Impact Indicators                      | Cause                                                    | Post-Extraction Environmental Recovery                                                                                 |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Oil and Gas Exploration Offshore in Brazil (Musci & Da Cunha, 2023)                               | Seawater pollution and oil spills                    | Pipe leaks, transportation accidents                     | Marine sediment monitoring uses sediment geochemistry to detect pollution                                              |
| Oil and Gas Exploration in Santos Basin (Mein et al., 2021)                                       | Hydrocarbon pollution, soil degradation              | Offshore drilling, production activities                 | Vegetation restoration, hazardous waste management, and long-term monitoring                                           |
| Oil and Gas Exploration from Delta Niger in Nigeria (Azi et al., 2023)                            | Ecosystem damage, river water pollution              | Oil spill due to pipe leak                               | Ecosystem restoration with reforestation and improved monitoring infrastructure                                        |
| Oil and Gas Exploration Onshore (Komi, Rusia) (Vora et al., 2021)                                 | Soil and water pollution, erosion, permafrost damage | Road drilling and construction                           | Ecosystem rehabilitation, vegetation replanting, and drainage system improvement                                       |
| Oil and Gas Extraction with Enhanced Oil Recovery (EOR) in the European Union (Vora et al., 2021) | Greenhouse gas emissions, water and soil pollution   | Use of oil recovery technology with water and chemicals  | Implementation of sustainable recovery through wastewater management and emission reduction with the latest technology |
| Oil and Gas Exploration in Indonesia (Achmad et al., 2022)                                        | Environmental degradation, air and water pollution   | Chemical use and oil spills                              | Land reclamation, wastewater management, restoration of local ecosystems                                               |
| Oil and Gas Exploitation in Malaysia (Zeraibi et al., 2021)                                       | Water pollution and greenhouse gas emissions         | Burning fossil fuels in the production process           | Reducing greenhouse gas emissions with environmentally friendly technology                                             |
| Oil and Gas Exploration in Thailand (S. P. Nathaniel, 2021)                                       | Deforestation and land degradation                   | Land clearing for oil and gas infrastructure development | Replanting vegetation on degraded land, sustainable waste management                                                   |
| Oil and Gas Exploitation in Vietnam (Rehman & Holý, 2022)                                         | Groundwater pollution and land use change            | Oil pipeline leaks, oil spills                           | Groundwater recovery, improved waste management and infrastructure improvement                                         |
| Oil and Gas Infrastructure Development in the Philippines (S. Nathaniel & Khan, 2020)             | Soil erosion and water pollution                     | Excavation and construction of oil and gas facilities    | Soil restoration, construction of drainage to prevent further erosion                                                  |

Source : Author's search, 2024

AMDAL practices that can be a reference from several countries as described in table 2.3 with oil and gas exploration and exploitation, complete with indicators of impacts, causes, and environmental recovery. EIA plays an important role in minimizing the negative impact of oil and gas exploration and exploitation on the environment, especially in the ASEAN region. In countries such as Indonesia, Malaysia, Vietnam, and Thailand, oil and gas activities often cause air and water pollution, soil degradation, and greenhouse gas emissions. For example, in Indonesia and Thailand,

EIAs are used to identify exploitative impacts such as deforestation and oil spills. This activity requires efforts to restore the environment through reforestation, wastewater management, and emission reduction with environmentally friendly technology (Achmad et al., 2022; S. P. Nathaniel, 2021). In addition, the implementation of AMDAL encourages post-extraction environmental recovery to mitigate ecosystem damage. In Malaysia and Vietnam, mitigation efforts are focused on reducing greenhouse gas emissions through the use of advanced technology and waste monitoring. This shows that the AMDAL not only protects the environment, but also forces companies to adopt green technologies and long-term sustainability strategies. This process involves various stakeholders, from companies to governments, to ensure that environmental restoration is carried out thoroughly after the extraction activities are completed (Rehman & Holý, 2022).

AMDAL has proven to be an important instrument in managing the environmental impact of the oil and gas sector. With proper implementation, the AMDAL helps to balance economic growth and environmental sustainability, as well as encourages technological innovation to protect ecosystems from further damage. The effective implementation of the AMDAL also encourages oil and gas companies in ASEAN to continue to improve their environmental governance and strengthen sustainable management practices in the industry.

### **2.1.2. Environmental Remediation: Bioremediation**

Bioremediation is an environmental treatment method that utilizes living organisms, especially microorganisms such as bacteria, to decompose harmful substances such as petroleum into compounds that are not harmful to the environment. This technique is considered one of the environmentally friendly and cost-effective solutions to deal with hydrocarbon contamination, such as oil spills, which often cause damage to terrestrial and aquatic ecosystems (Khan et al., 2022). The bioremediation mechanism involves the decomposition of hydrocarbons by microorganisms that use these compounds as energy sources. This process can be optimized by controlling various factors such as oxygen levels, pH, nutrient availability, and ambient temperature. In some cases, the addition of special microbes (bioaugmentation) or supporting substances such as biosynthetic surfactants (biostimulation) can improve the efficiency of petroleum decomposition. For example, studies show that bacteria of the genus *Bacillus* are able to decompose crude oil significantly, with a degradation rate of up to 97.5% under optimal conditions (Deng et al., 2020). Bioremediation is needed because traditional methods such as burning or the use of chemicals often risk further damaging the environment and are expensive. On the other hand, bioremediation offers a safer and more environmentally friendly solution because it uses natural biological processes that do not produce additional pollution. In addition, this technique is also important for

reducing negative impacts on human health and ecosystems, especially in areas that are frequently exposed to oil spills (Alvernia et al., 2021). Parties involved in bioremediation include oil companies, governments, and the scientific community. Governments play a role in ensuring that environmental standards are adhered to, while companies are responsible for implementing bioremediation as part of their social and environmental responsibilities. The implementation of bioremediation is usually carried out as soon as contamination is detected, and continues until the level of hydrocarbon pollution is reduced to a safe level in accordance with applicable environmental standards. This process can take anywhere from a few weeks to several months depending on the level of contamination and environmental conditions (Xu et al., 2020).

Table 2.4. Bioremediation on petroleum contamination in some countries

| Description                                                                                                | Environmental Impact Indicators                   | Bioremediation Methods                                                                         | Environmental Restoration                                                     |
|------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Bioremediation of crude oil-contaminated soil in China (Deng et al., 2020)                                 | Soil pollution, reduction of microbial diversity  | Bioaugmentation with bacterial strains <i>Bacillus cereus</i> and <i>Bacillus halotolerans</i> | Microbial diversity recovery up to 97.5% degradation of crude oil             |
| Oil-contaminated tillage with bioaugmentation (Q. Li et al., 2020)                                         | Soil quality deterioration, groundwater pollution | Addition of hydrocarbon-degrading bacterial strains and APG biosurfactants                     | Soil restoration with the decomposition of 59% hydrocarbons in 30 days        |
| Bioremediation of petroleum sludge using local bacteria (Mora et al., 2020)                                | Contaminasi hydrocarbon polycyclic aromatic       | Combination of oxidative permanganate and local microbial biostimulation                       | PAH reduction of up to 92% within two months                                  |
| Use of bioremediation with <i>Pseudomonas luteola</i> in contaminated soil (Gayathri & Krishnaprema, 2023) | Crude oil contamination in the ground             | Immobilization of <i>Pseudomonas luteola</i> bacteria with a banana peel-like medium           | Crude oil degradation of more than 80% in five days                           |
| Bioremediation in the upstream oil and gas industry in Indonesia (Rayhan et al., 2023)                     | Oil contamination in soil and water               | Bioaugmentation using hydrocarbon-degrading bacteria                                           | Environmental restoration according to profit-sharing contract with SKK Migas |
| Soil pollution by oil in Indonesia (Murti Sujadi et al., 2020)                                             | Increased levels of hydrocarbons in the soil      | Bioaugmentation and biostimulation using local bacteria                                        | Reduction of TPH levels by up to 53%                                          |
| Bioremediation of oil spills off the coast of Vietnam (Gao et al., 2023)                                   | Increased levels of hydrocarbons in seawater      | Bioaugmentation with the bacterium <i>Pseudomonas aeruginosa</i>                               | Hydrocarbon content recovery up to 50.94% in 50 days                          |
| Oil bioremediation in old oil mines in Philippines (Alvernia et al., 2021)                                 | Increased TPH in soil, groundwater contamination  | Combination of biostimulation and bioaugmentation                                              | Reduction of TPH by local microbial methods and nutritional supplements       |

Source: Author's search, 2024

Bioremediation is an efficient and sustainable environmental management technique to overcome petroleum contamination, offers safer solutions for ecosystems and human health and has become a scientific concern as in table 2.4

which summarizes the application of bioremediation to petroleum contamination, with indicators of impact, method, environmental recovery. Several important things that can be used related to the application of bioremediation in petroleum contamination management, bioremediation has proven to be effective in reducing hydrocarbon levels in contaminated soil, water, and ecosystems. For example, bioaugmentation and biostimulation methods in various countries such as Indonesia and Malaysia have succeeded in reducing Total Petroleum Hydrocarbons (TPH) by 88% in a relatively short time, showing that decomposing microorganisms can cope well with oil spills (Alvernia et al., 2021).

Bioremediation is an environmentally friendly treatment method and is cheaper than physical or chemical methods. The use of natural microorganisms to decompose contaminants allows for processes that do not damage ecosystems and are more energy-efficient, compared to burning or the use of harmful chemicals. For example, bioremediation in Indonesia uses local bacteria as a sustainable approach to effectively reduce TPH (Rayhan et al., 2023). The use of local microbes adapted to local environmental conditions is helpful in increasing the effectiveness of bioremediation. In Vietnam, the use of *Pseudomonas aeruginosa* in bioaugmentation successfully lowered hydrocarbon levels by up to 50.94% in 50 days, suggesting that the right selection of microbes can accelerate the environmental recovery process (Gao et al., 2023). Bioremediation provides long-term solutions for the environment affected by petroleum, especially in ASEAN countries that are rich in natural resources but vulnerable to oil spills. With the application of this technology, we can reduce the negative impact of petroleum pollution, protect local ecosystems, and support environmental and economic sustainability. In addition, the use of methods such as bioaugmentation and biostimulation allows for the acceleration of the remediation process with the addition of nutrients and decomposing bacteria (Murti Sujadi et al., 2020). Through the studies presented, it can be seen that bioremediation can be implemented quickly after an oil spill, as shown in the Philippines and Malaysia, where oil spills can be addressed with timely treatment using decomposing bacteria and good monitoring techniques. This is important to minimize the direct impact on the surrounding community and marine ecosystem. The main benefit of implementing bioremediation is its effectiveness in addressing petroleum contamination in an environmentally friendly and cost-effective manner. With the selection of appropriate methods, such as bioaugmentation and biostimulation, and the use of local microorganisms, bioremediation can be a long-term solution to preserve the environment from damage caused by petroleum pollution.

### **2.1.3. Environmental Incident Reporting**

In the context of upstream oil and gas activities in Indonesia, bioremediation is the preferred method because it is environmentally friendly and regulated in a

cooperation contract with SKK Migas. Cooperation between the government, SKK Migas, and oil and gas companies is regulated through profit-sharing contracts and Regulation of the Minister of Energy and Mineral Resources No. 15 of 2018, which includes funds for Abandonment and Site Restoration. This ensures that the company is responsible not only during the production process, but also after the operation is completed, including environmental restoration (Waspiah et al., 2023). Bioremediation is an effective solution in overcoming the negative impact of upstream oil and gas activities on the environment in Indonesia, through cooperation between the government and companies and the implementation of environmentally friendly technology. Oil and gas companies in Indonesia still face major challenges in terms of compliance with environmental reporting in accordance with GRI standards. Although bioremediation has been implemented to restore the post-extraction environment, full compliance with social and environmental responsibility still requires significant improvement.

Compliance with environmental reporting in accordance with GRI standards in the context of the oil and gas industry can be designed by utilizing data-driven technology and content analysis from the company's sustainability reports. These simulations can measure the level of compliance and performance of companies in terms of environmental impact reporting, such as waste management, emissions, and natural resource use. Compliance with environmental reporting is carried out using a content-based approach (content analysis) from the company's sustainability report. Data is collected from annual reports and sustainability reports, where oil and gas companies are required to comply with GRI 300 guidelines for environmental reporting. In the simulation, each indicator of compliance with the GRI is evaluated, such as reports related to greenhouse gas emissions, water use, waste management, and impacts on biodiversity. With these simulations, companies can find out where they are not meeting GRI standards and make regular improvements.

Compliance is necessary to ensure that oil and gas companies not only comply with local regulations but also meet global standards related to sustainability reporting. This is important because GRI is a framework that helps companies to maintain transparency and accountability in their operations. Studies show that many companies in the oil and gas sector, especially in Indonesia, still have a low level of compliance in terms of environmental reporting based on GRI standards, which has an impact on corporate reputation and social responsibility (Nabila Qothrunada & Wuri Handayani, 2023). Parties involved in the implementation of this simulation include oil and gas companies, external auditors, the government, and environmental supervisory bodies such as Special Task Force for Upstream Oil and Gas Business Activities (namely SKK Migas). Governments and regulators will use the results of these simulations to ensure companies comply with applicable regulations and contribute to long-term environmental sustainability. This compliance is carried out

annually as part of the company's performance evaluation. Through these periodic evaluations, companies can monitor the progress of their compliance with GRI standards, allowing them to identify areas of improvement that need to be made in their operations. Relevant research shows that the increased use of industry 4.0 technologies in the reporting process can accelerate compliance with GRI standards. With the use of technologies such as data analysis and automation, 85% of GRI's environmental standards can be positively impacted by industry 4.0 technologies, improving the reporting of the company's economic, environmental, and social performance (Narula et al., 2021).

Compliance with environmental reporting in accordance with GRI standards can be seen through its implementation in the oil and gas sector in Indonesia, such as:

- a. Greenhouse gas emissions (GRI 305), this report measures CO<sub>2</sub> emissions produced during the exploration and production process, can evaluate how well companies comply with GRI standards in reducing emissions and their impact on climate change. The data analyzed included total emissions reported per year, as well as emissions reduction strategies implemented.

The measurement of greenhouse gas (GHG) emissions through the GRI 305 standard in the oil and gas exploration and production sector includes several key parameters. This parameter includes the total annual CO<sub>2</sub> emissions generated during the operational process, including production and distribution. GHG evaluations are often carried out using detailed emissions reporting methodologies, such as in the EOR oil industry, where the CO<sub>2</sub> used comes from sources such as fossil fuel power plants, significantly reducing net emissions from this process (Azzolina et al., 2016). Emission reduction strategies include techniques that are systematically designed to identify and mitigate major emission sources, such as flaring (gas combustion), efficient use of energy, and improved emission detection technologies such as Optical Gas Imaging and the use of drones for methane emission monitoring in the oil and gas industry (Singh, 2023). By implementing this GRI 305 standard, companies can identify and evaluate the most effective strategies to reduce their carbon emissions and improve environmental sustainability.

- b. Water Use (GRI 303), oil and gas companies are required to report on water use, especially in areas experiencing water scarcity, will monitor water withdrawal from local sources and how companies manage water resources in a sustainable manner.

The management of water use by oil and gas companies in water-scarce areas is becoming increasingly important, especially in the context of the GRI 303 standard report. In this case, the main parameters include water withdrawal from local sources, the use of water produced, and management strategies to minimize the impact on water resources. The use of produced water, the oil and

gas industry produce water that is reused or managed as waste. Reuse of this water for internal activities such as fracking, injection, or EOR is a common approach, especially in water-scarce areas (Feder, 2020). Desalination and Water Treatment, in the arithmetic, production water is processed through desalination to produce water of appropriate quality for agriculture or industrial purposes, helping to support sustainability and reduce dependence on fresh water (Adham et al., 2018). Water Management and Storage in Water-Scarce Areas, large volumes of water produced also increase logistical and energy challenges, especially for transportation and storage. Studies in New Mexico show that the reuse of produced water can become more energy-efficient, reduce the demand for fresh water, as well as the environmental risks associated with deep well disposal (Zemlick et al., 2018). By monitoring and implementing these strategies, oil and gas companies can improve operational sustainability in areas prone to water scarcity, in line with the GRI 303 standard for water resource management.

- c. Waste Management (GRI 306), will evaluate how companies manage hazardous waste, including toxic waste generated from drilling and production. The indicators assessed are the waste processing method, the amount of waste recycled, and the company's efforts in minimizing the impact of waste on the environment.

Hazardous waste management in the oil and gas industry, as per the GRI 306 standard, includes several key approaches and indicators that focus on reducing the environmental impact of toxic waste. Here are some relevant methods based on recent research. Reduction and management of toxic waste, the approach to managing hazardous waste in this industry includes the use of technology for the treatment of waste and the handling of heavy metals found in drilling mud as well as the water produced. Some of these management methods include incineration, chemical, and landfill management that are specifically designed to reduce the health risks and environmental impacts of heavy metals such as cadmium, lead, and mercury (Samaila et al., 2023). Recycling and reuse of waste, the waste produced can be recycled or reprocessed to reduce the amount of toxic waste produced. One technique is to use Refuse Derived Fuel made from a mixture of hazardous waste and biomass as a substitute for coal in cement production, significantly reducing CO<sub>2</sub> emissions and operational costs (Karpan et al., 2021). Optimization of oil sludge waste management, oil sludge containing heavy metals such as lead and mercury is treated as hazardous waste. Fuzzy-based mathematical models to optimize sludge management help in reducing environmental costs and improving safety, by involving health, safety, and environmental factors in the management of these wastes (Roudneshin & Azadeh, 2019). By implementing innovative hazardous waste management

technologies, oil and gas companies can minimize the impact of toxic waste on the environment and improve the sustainability of their operations.

- d. Biodiversity (GRI 304), oil and gas companies often operate near sensitive ecosystems. Compliance will check whether the company has taken the necessary steps to protect biodiversity, such as the conservation of local species and habitat restoration after operations are completed.

In the oil and gas industry, the GRI 304 standard promotes the protection of biodiversity, which includes measures for the conservation of local species and post-operative habitat restoration. In addition, research shows that habitat restoration is important for restoring biodiversity and ecosystem function, especially in freshwater environments that are vulnerable to degradation due to extractive activities (Piczak et al., 2024). At the policy level, conservation measures that focus on habitat restoration are proven to be more effective for maintaining long-term biodiversity. Efforts that include stakeholder engagement at the local level help drive support for long-term conservation, especially through restoration conservation that targets specific threatened species or ecosystems (Boiral & Heras-Saizarbitoria, 2017). The implementation of habitat restoration-based conservation policies, which involve an integrated approach between species protection and ecosystem restoration, provides optimal outcomes for biodiversity and supports more sustainable habitat management in the oil and gas sector (Possingham et al., 2015).

- e. CSR disclosure (GRI 400), includes reporting on CSR, such as the social impact of their operations on local communities, including human rights issues, and investment in the well-being of surrounding communities.

CSR disclosures in the oil and gas industry cover a wide range of social, environmental, and human rights aspects, which are frequently monitored against the GRI 400 standard guidelines. In a study of oil and gas companies in Sub-Saharan Africa, for example, CSR disclosures were made to achieve social legitimacy through compliance with GRI indicators, such as membership of the Extractive Industries Transparency Initiative (EITI), as well as investments in social projects to support the well-being of local communities (Reeve & Kabiawu, 2020). In addition, research shows that social responsibility in this sector is also linked to commitment to human rights. Companies like Petronas have implemented human rights commitments in their supply chains, including training to avoid excessive use of violence and fair labor practices, as part of a long-term effort to improve the sustainability of its operations (Carpenter, 2020). However, some studies also reveal that CSR disclosures in the oil and gas sector are sometimes limited to reporting without substantive efforts to address the negative social and environmental impacts generated by their operations. In Indonesia, for example,



there is a discrepancy between reported CSR standards and actual practices, especially regarding human rights violations and corruption in the industry (Kwarto et al., 2021). CSR disclosure is an important element of a company's sustainability strategy, a major challenge remains in consistently implementing and upholding this commitment to protect social well-being and human rights in the communities surrounding their operations.

Each indicator is measured based on the company's annual report. The results of this simulation will show how well the company is following the GRI standards, as well as provide recommendations on areas that need improvement. For example, research in Indonesia shows that many oil and gas companies still have low compliance levels in emissions reporting and waste management, which requires further improvement (Qothrunada & Handayani, 2023).

## **2.2. Participating Interest 10%**

Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016 concerning 10% Participating Interest (PI) provides opportunities for local governments through Regional-Owned Enterprises (BUMD) to be involved in the management of oil and gas resources. This policy focuses on increasing transparency and accountability in environmental management and ensuring that oil and gas operations comply with health and environmental standards. The following is a detailed explanation of the aspects covered by this policy:

### **2.2.1. Granting Rights to Local Governments for 10% PI**

Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016 concerning the 10% PI provides the right for local governments to be actively involved in the management of oil and gas resources through BUMD. This policy allows local governments to have up to 10% interest in upstream oil and gas projects operating in their territory. In practice, this involvement aims to encourage local economic development, expand transparency, and ensure that revenues from the oil and gas sector can contribute to the welfare of the local area (Yulianingsih & Algasahri, 2020). The 10% PI mechanism involves a process in which BUMDs or other local government entities can obtain a certain percentage of the revenue generated from oil and gas exploration and production activities in their area. This income is channeled through a cooperation contract mechanism between oil and gas companies and BUMDs, where BUMDs play the role of interest owners, even though they do not act as the main operator. Studies show that although this mechanism has great potential, financial challenges are often a major obstacle for regions that want to participate in sizable initial investments, such as the case in the Cepu Block, East Java, where BUMDs use public-private partnership schemes to meet initial financing needs (Priadi, 2021). The importance of this policy lies in efforts to provide opportunities for local

governments to manage the natural resources in their areas, which are often controlled by the central government and multinational corporations. With the 10% PI, the region is expected to get direct economic benefits that also increase local accountability in environmental management. This participation is considered important to provide greater control over the social and environmental impacts caused by oil and gas exploration activities (Hasiholan et al., 2023). The parties involved in the implementation of the 10% PI include the Ministry of Energy and Mineral Resources which sets regulations, oil and gas companies that carry out exploration and production activities, and BUMD as representatives of local governments. In some regions, the supervision and implementation of this policy also involves special agencies such as SKK Migas which facilitates cooperation between BUMD and private oil and gas companies or SOEs. The implementation of the 10% PI policy began since the enactment of the Minister of Energy and Mineral Resources Regulation No. 37 of 2016, with various regions starting to take advantage of this right, especially in areas rich in natural resources such as East Java and Kalimantan. However, implementation in some regions is only fully underway a few years after this regulation is enacted, in line with the resolution of funding problems and the improvement of institutional readiness at the local level.

Table 2.5 shows the various PI approaches in several countries to increase local involvement in the oil and gas industry. Each country has a scheme that tailors its local policy needs and objectives, but in general, the goal of PI is to optimize the socio-economic benefits for local communities and increase the environmental accountability of the industry. Nigeria through the Local Content Policy, Nigeria prioritizes the participation of local communities in the oil and gas sector. The policy is designed to encourage local investment and create jobs, as well as to transfer technology from multinational companies to local communities. Success indicators include increased investment and technology that benefits the local economy. Tanzania, the country emphasizes the importance of transparency and community involvement in natural gas management. The main objective is to ensure that local communities experience the direct benefits of the exploitation of energy resources, which is measured through transparency in contracts and the improvement of the livelihoods of local communities. GCC (Gulf Cooperation Council) – Qatar and the UAE, IPIECA guidelines are used to increase transparency in the sustainability reporting of oil and gas companies. This allows governments and communities to monitor the company's commitment to sustainable practices. The quality of the sustainability report is used as the main indicator in this evaluation. Russia relies on international collaboration to strengthen energy stability and cooperation in the global oil market. Energy supply stability and research cooperation are the main focuses, where Russia cooperates with European and Asian countries through Organization of the

Petroleum Exporting Countries (OPEC). Success indicators lie in the stability of energy supply and the progress of research collaboration.

Table 2.5. PI practices of several countries in granting rights to local governments

| Country                                         | PI scheme                                                       | Parties involved                                                              | Purpose of PI                                                                   | Success indicators                                           |
|-------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------|
| Nigeria<br>(Edward T. Bristol-Alagbariya, 2020) | Local Content Policy                                            | Local governments, multinational oil and gas companies, and local communities | Ensuring local participation in the oil and gas sector for economic development | Increased local investment, jobs, and technology transfer    |
| Tanzania<br>(Bishoge et al., 2022)              | Transparency and public participation in natural gas management | Governments, local communities, and foreign energy companies                  | Increase local community participation to ensure economic and social benefits   | Contract transparency, improvement of local living standards |
| GCC (Qatar, UAE)<br>(Aljanadi & Alazzani, 2023) | IPECA guidelines for sustainability reporting                   | Oil and gas companies, government regulators                                  | Increase transparency and accountability in sustainability reporting            | Quality sustainability indicators in annual reports          |
| Rusia<br>(Larchenko et al., 2020)               | International collaboration for economic and energy interests   | Russian governments, European and Asian countries, OPEC                       | Strengthening energy security and international cooperation                     | Supply stability, research cooperation                       |
| Malaysia<br>(Lingard et al., 2020)              | Production Sharing Contract (PSC)                               | Government, international oil and gas companies, BUMD                         | Optimize local profits and technology transfer                                  | Local investment, human resource improvement                 |
| Brunei<br>(Ariyon et al., 2023)                 | Production Sharing Contract                                     | Government, Shell Brunei and local companies                                  | Increasing local economic independence and oil and gas management               | Local PI percentage, economic stability                      |
| Vietnam<br>(Pandey, 2022)                       | Energy Collaboration                                            | Government, foreign companies, local companies                                | Securing energy supplies and supporting local revenues                          | Energy security, increased local contribution                |
| Thailand<br>(Safrina & Utama, 2023)             | Joint Venture Cooperation Contract                              | Government, BUMD, private oil and gas companies                               | Supporting local development through natural resource contributions             | Local involvement, contribution of regional revenue          |

Source : Author's search, 2024

Meanwhile, in the ASEAN region, it illustrates how ASEAN countries other than Indonesia use the PI scheme to increase local involvement and support the economic stability of the oil and gas sector. Each country adapts the PI approach according to their needs and conditions. Malaysia uses the PSC system, which prioritizes local profits through the involvement of national and multinational companies and technology transfer. Indicators of success are local investment and upskilling of the workforce. Brunei implements production-sharing contracts that focus on local economic stability through the involvement of local and foreign companies. Economic stability and an increasing percentage of local PIs are key indicators of success. Vietnam prioritizes collaboration in the energy sector to support energy security as well as local economic contributions. Success indicators are measured by guaranteed

energy security and the contribution of local income. Thailand uses joint venture contracts that allow the government, private companies, and state-owned enterprises (BUMDs) to collaborate on the use of resources. Success is measured through local involvement and revenue contribution to the region. PI practices in these countries demonstrate a range of indicators that include transparency, accountability, and socio-economic benefits that are important for measuring the success of PI policies.

### **2.2.2. Environmental Transparency and Accountability**

Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016 concerning 10% PI in Indonesia gives responsibility to local governments to play a significant role in ensuring oil and gas operations are in accordance with environmental standards. In this context, local governments that receive the 10% PI right are responsible for actively carrying out environmental monitoring, both in the production process, exploration, and in environmental restoration after the project is completed. As found by (Hasiholan et al., 2023), local governments that hold PI are obliged to ensure that oil and gas companies carry out social and environmental responsibilities in accordance with oil and gas cooperation contracts and applicable environmental regulations. This responsibility mechanism includes the active involvement of BUMDs in the operational supervision of oil and gas companies in their regions, including EIA assessments and the application of sanctions for non-compliance. In practice, local governments can use the resources obtained from PI to fund environmental restoration programs and environmental education for surrounding communities, which is one of the important elements to maintain ecosystem sustainability. This policy is necessary to ensure that oil and gas operations not only bring economic impacts but also contribute to environmental protection. Thus, local governments can directly monitor the impact of oil and gas operations, increasing corporate accountability to the community and the environment. The parties involved include the Ministry of Energy and Mineral Resources as the main regulator of policies, local governments that hold 10% PI rights, oil and gas companies that conduct exploration and production, and BUMDs that represent local governments in managing PI. This policy has been implemented since the issuance of the regulation in 2016 and continues with implementation tailored to the financial and infrastructure capabilities of each region. PI practices in these countries aim to increase transparency, accountability, and involvement of local communities in energy management. Nigeria, Norway, Mexico, and Canada have adopted different approaches according to their local contexts (table 2.6). Each country uses a specific scheme that includes public reporting, direct engagement with communities, and management of energy gains to ensure long-term benefits for society.

Table 2.6. PI practices in environmental transparency and accountability

| Country                                      | PI scheme                                             | Parties involved                                               | Purpose of PI                                                       | Success indicators                                      |
|----------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------|
| Nigeria (Edward T. Bristol-Alagbariya, 2020) | Nigerian EITI (NEITI)                                 | Government, oil and gas companies, local communities           | Increasing transparency and local involvement in the energy sector  | Annual public reporting, community engagement           |
| Malaysia (Lingard et al., 2020)              | PSC                                                   | Government, local and international oil and gas companies      | Ensuring transparency and economic benefits for the local community | Local involvement in operations, sustainability reports |
| Brunei (Ariyon et al., 2023)                 | Joint Venture between the government and Shell Brunei | Brunei government, Shell, local energy company                 | Improving environmental accountability and local economic benefits  | Environmental procedures, local economic development    |
| Vietnam (Phoumin et al., 2021)               | Energy partnerships managed by PVN                    | Vietnamese Government, PVN, International Companies            | Ensuring energy security and maximizing local benefits              | Energy diversification, contract transparency           |
| Thailand (Safrina & Utama, 2023)             | Petroleum Concession System                           | Thai government, private companies and state-owned enterprises | Supporting environmental accountability and sustainable development | Local engagement, environmental audits                  |

Source: Author's search, 2024

The practice of PI in ASEAN demonstrates the commitment of various countries to transparency, environmental accountability, and economic benefits for the local. Malaysia uses Production Sharing Contracts to guarantee transparency and increase local engagement, while Brunei focuses on accountability with energy companies such as Shell. Vietnam maximizes energy security through partnerships with national company PVN, and Thailand ensures robust environmental audits in their Petroleum Concession System.

### 2.2.3. Supervision of PI Implementation by Local Governments

Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016 provides opportunities for local governments in Indonesia to participate in the management of oil and gas resources through a 10% PI. However, the effectiveness of supervision of the implementation of PI still needs to be improved, especially in Aceh, where some regions have not yet obtained PI rights, even though the Aceh Oil and Gas Management Agency (BPMA) is responsible for this supervision. Research by (Wahyudi, 2022) shows that although BPMA has supervisory rights, the absence of strict sanctions for companies that do not implement PI provisions causes the effectiveness of supervision to be limited. This supervision mechanism involves direct monitoring by BPMA of oil and gas companies' compliance with PI allocations, especially in terms of profit-sharing and the application of environmental standards.

BPMA evaluates contracts and compliance with social and environmental obligations, but the weak sanctions mechanism makes it difficult for BPMA to ensure that the company carries out its commitments. The need for this supervision is important to ensure that local governments get economic benefits from PI and so that the environmental impact of oil and gas activities can be managed properly. Without effective supervision, the interests of the region and the surrounding community cannot be optimally guaranteed, reducing the benefits of the PI policy for local development. Parties involved in this supervision include BPMA as the main supervisor in Aceh, oil and gas companies as the implementer of oil and gas activities, and the central government which plays a role in determining regulations and provisions related to PI. Supervision by BPMA is supported by regulations from the Ministry of Energy and Mineral Resources and BPMA works directly with local governments to ensure compliance. The implementation of this policy began since this regulation was issued in 2016, but it still experiences obstacles in its implementation, especially in terms of the distribution of PI to several regions that have not been fulfilled. This shows the need to strengthen regulations and supervision so that regional rights in the PI can be realized effectively.

Table 2.7. Comparison of PI Implementation Supervision

| Country                                      | PI scheme                                | Parties involved                                            | Purpose of PI                                                          | Success indicators                                          |
|----------------------------------------------|------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------|
| Ghana (Tetteh et al., 2024)                  | Local Content Policy                     | Governments, international oil companies, local communities | Increasing local participation and economic sustainability             | Corporate compliance, local participation, community income |
| Nigeria (Edward T. Bristol-Alagbariya, 2020) | Nigerian EITI (NEITI)                    | Government, oil companies, local communities                | Promoting transparency and accountability in the energy sector         | Annual public reporting, community engagement               |
| Kanada (Hannouf et al., 2020)                | First Nations Oil and Gas Management Act | Government, Indigenous communities, energy companies        | Involving Indigenous communities in the management of energy resources | Land-based partnerships, community consent                  |

*Source : Author's search, 2024*

Table 2.7 shows how the PI scheme is used to integrate economic benefits, transparency, and environmental accountability in resource management. Ghana and Nigeria, for example, adopted policies of local participation and transparency, while Canada engaged Indigenous communities to improve social and environmental accountability. Norway demonstrated the implementation of PI with the management of public funds for long-term profits, ensuring public involvement in the supervision of energy profits.

#### 2.2.4. Economic Benefits for the Region

Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016 concerning 10% PI in the oil and gas sector has succeeded in increasing regional revenue in oil and gas producing areas such as the Cepu Block in East Java. PT Petrogas Jawa Timur Utama Cendana, one of the Regionally Owned Enterprises (BUMD) that manages this PI, has managed to obtain significant benefits from the PI rights, which are used to develop other local businesses, thus showing the great potential of local government involvement in energy resource management. With the PI system, regions have the opportunity to participate in the management of the oil and gas sector and maximize local economic benefits through direct participation in oil and gas projects without having to be an operator (Priadi, 2021). The mechanism for implementing the 10% PI involves a cooperation contract between the central government, oil and gas companies, and local BUMDs, where BUMDs play the role of shareholders without operational obligations. To implement PI, local governments through BUMDs usually require initial capital, which in the case of PT Petrogas Jawa Timur Utama Cendana, is obtained through public-private partnerships. PI allows local governments to obtain a portion of direct profits from oil and gas production, which can then be used to fund other local projects, both oil and gas-related and those that have an impact on regional economic development.

Table 2.8. Comparison of PI to Economic Benefits for Regions

| Country                                      | PI scheme                                | Parties involved                                     | Purpose of PI                                                             | Success indicators                                        |
|----------------------------------------------|------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------|
| Ghana (Tetteh et al., 2024)                  | Local Content Policy                     | Government, oil and gas companies, local communities | Increasing local participation in the energy industry                     | Increase in local labor participation and regional income |
| Tanzania (Bishoge et al., 2022)              | Partnerships for natural gas management  | Government, energy companies, local communities      | Ensuring transparency and economic benefits for the surrounding community | Contract transparency, local community involvement        |
| Brasil (Bologna Pavlik, 2019)                | Resource Transparency Act                | Government, community, extraction company            | Increase transparency in the distribution of resource revenue             | Community participation in revenue monitoring             |
| Nigeria (Edward T. Bristol-Alagbariya, 2020) | Nigerian EITI (NEITI)                    | Government, oil and gas companies, local communities | Promoting transparency and accountability in the energy sector            | Annual public reporting, community engagement             |
| Kanada (Hannouf et al., 2020)                | First Nations Oil and Gas Management Act | Government, Indigenous communities, energy companies | Involving Indigenous communities in the management of energy resources    | Land-based partnerships, community consent                |

Source : Author's search, 2024

This policy is needed to ensure that oil and gas producing regions benefit directly from the resources available in their regions, which are often operated by national or international companies. Without PI, more revenue from the oil and gas sector goes

into the national treasury, and direct benefits to local communities are often limited. PI provides incentives for local governments to support this industry while providing more equitable economic opportunities. The parties involved include the Ministry of Energy and Mineral Resources as policy makers, local governments and BUMDs as PI holders, and oil and gas companies as the main operators. Supervision and implementation of PI is carried out by BPMA in several regions such as Aceh, to ensure that the company meets its obligations in providing PI and follows the established operational and environmental standards. The implementation of PI in the Cepu Block has been implemented since this regulation came into effect in 2016, and has shown a positive impact in increasing local income, as shown by the success of PT Petrogas Jawa Timur Utama Cendana in East Java. This success illustrates the potential of PI as a model of economic success that can be adapted in other oil and gas producing regions in Indonesia.

Table 2.8. shows how countries outside Indonesia use PI schemes or transparency and accountability policies to strengthen community engagement in the energy and natural resources sectors. Tanzania is increasing contract transparency through energy partnerships with local communities. Brazil has a specific law for resource transparency that involves the public in revenue monitoring, and Spain implements public participation in energy investments to ensure accountability and broader economic benefits.

The Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016 concerning the 10% PI provides an opportunity for local governments to play an active role in the management of oil and gas resources, with a focus on transparency, accountability, and environmental responsibility. However, the implementation of this policy still needs to be improved to be more effective in all regions.

### **2.3. Impact of Oil and Gas Management**

Oil and gas management has a direct impact on the environment, including air pollution, water and soil pollution, and ecosystem degradation. Air pollution is mainly generated from the burning and processing of oil and gas which increases carbon emissions and toxic greenhouse gases such as methane and nitrogen oxides. Mitigation of these impacts includes carbon capture technologies and energy transition policies to reduce harmful industrial emissions. Water and soil pollution occurs through spills and industrial waste that pollute ecosystems, especially surrounding water bodies and soils, damaging habitat quality and the health of local ecosystems. Environmental policies such as hazardous waste management regulations and habitat restoration are needed to reduce these impacts and restore the quality of the environment that has been polluted. This policy mechanism involves the implementation of strict emission standards and technical requirements for waste management, implemented by environmental and public health agencies at



the national and international levels. In practice (figure 2.2), oil and gas companies work closely with regulatory bodies to comply with these regulations, including periodic environmental audits and the use of environmentally friendly technologies such as biochar that have the capacity to absorb pollutants in soil and water.



Figure 2.2. Impact of Oil and Gas Management

This policy is important because it protects biodiversity threatened by oil and gas exploration activities, such as in mangrove forests and coral reefs which have an essential role in maintaining ecosystem balance and climate mitigation. Stakeholders, including governments, international organizations such as WHO and United Nations Environment Programme (UNEP), as well as local communities and the oil and gas industry, are involved in the implementation and monitoring of these policies, which have been continuously improved since 2020 as awareness of the global climate crisis increases. This policy aims to ensure the sustainability of the oil and gas industry while protecting the environment and human health.

### 2.3.1. Environmental Impact of Oil and Gas Management

The management of the oil and gas sector has a significant impact on the environment through air pollution, water and soil pollution, as well as ecosystem and biodiversity degradation. This impact has been identified in various international studies and underscores the importance of environmental mitigation policies in the oil and gas industry. Oil and gas burning and processing produces carbon emissions and toxic gases that contribute to global climate change. This pollution causes increased levels of harmful compounds such as sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and aromatic hydrocarbons that pollute the atmosphere and negatively impact human health and ecosystems. One form of mitigation carried out is the

application of carbon capture technology and the use of low-emission fuels. In the United States, for example, the implementation of fuel efficiency standards and emission reduction in the transportation sector has succeeded in reducing the impact of air pollution from the energy industry (Frumkin & Myers, 2020). Toxic waste, such as hydrocarbons and heavy metals produced from oil and gas exploration activities, pollutes waters and soil. This pollution can damage soil and water quality, affect flora and fauna, and pose health risks to humans. Significant examples of water pollution occur in the Middle East region, where groundwater contamination has had an impact on local agriculture and the quality of clean water sources. The implementation of hazardous waste management policies, such as monitoring heavy metal levels in the area around the refinery, is urgently needed to reduce the impact of this pollution (Al-Thani & Yasseen, 2023). Oil and gas activities, particularly exploration and land clearing, contribute to habitat degradation and biodiversity loss, especially in sensitive areas such as mangrove forests and coral reefs. Studies show that biodiversity can increase ecosystem resilience to the negative impacts of the oil and gas industry. In oil spill incidents, such as those on the Gulf Coast of Mexico, areas with high biodiversity have been shown to have better recovery capacity. Therefore, the implementation of environmental conservation and habitat rehabilitation policies is crucial to protect affected ecosystems (Zerebecki et al., 2022). The implementation of environmental policies that focus on mitigating the impact of gas emissions, hazardous waste management, and ecosystem conservation and rehabilitation is urgently needed to maintain the sustainability of the oil and gas industry and protect the health of the global ecosystem.

### **2.3.2. Impact on Public Health**

The impact of the oil and gas sector on public health is mainly seen through air pollution containing toxic compounds such as sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>). These emissions can increase the risk of respiratory diseases such as asthma and bronchitis, as well as cause serious cardiovascular disease. For example, in Iran, an increase in SO<sub>2</sub> concentrations over 26 years shows a strong association with rising cases of cardiovascular and respiratory diseases, emphasizing the need for sustainable national policies for reducing emissions from fossil fuels (Rabiei et al., 2020). In the United States, research on the oil and gas sector shows that air pollution from NO<sub>2</sub> contributes to 7,500 excess deaths, 2200 new cases of asthma in children, and 410,000 asthma exacerbations, which require policy intervention to reduce harmful emissions in order to maintain public health (Buonocore et al., 2023). Implementations to reduce this impact include the application of de-SO<sub>2</sub> and de-NO<sub>x</sub> technologies in the fuel combustion process, which reduces SO<sub>2</sub> and NO<sub>x</sub> levels in emissions. This method uses oxidation, reduction, and adsorption to capture toxic gases efficiently, as reviewed by (Chen et al., 2021) who discuss technological

advances in eliminating SO<sub>2</sub> and NO<sub>x</sub> pollution simultaneously in the industrial sector. In addition, the implementation of policies to use low-sulfur fuels, such as in Canada through North American Emissions Control Area (NA ECA) regulations, has also succeeded in significantly reducing air pollution in Canadian port cities with a reduction in SO<sub>2</sub> by up to 83% in some locations, having a direct positive impact on air quality and public health (Anastasopoulos et al., 2021). Health services for oil and gas workers are also a priority because they face direct exposure to hazardous chemicals and the risk of work accidents. A study by (Benson et al., 2021) shows that workers in the oil and gas industry often experience health problems due to exposure to pollutants such as toxic gases, leading to long-term respiratory problems. Strict occupational health protections, such as the provision of personal protective equipment and routine health checks, have been implemented in the Nigerian oil and gas sector to mitigate this risk. The implementation of strict mitigation policies and comprehensive health services is urgently needed to maintain the health of the public and workers who are directly exposed to the oil and gas industry.

### **2.3.3. Sustainability and Energy Transition**

Reducing dependence on oil and gas (oil and gas) through diversification of energy sources is a step that many countries are increasingly prioritizing to achieve sustainability and reduce environmental impact. Renewable energy, such as solar, wind, and bioenergy, is a key pillar in reducing carbon emissions and increasing energy security. In Europe, for example, energy diversification policies have increased the contribution of renewable energy to 22% in 2021. This is part of the target to achieve 55% renewable energy by 2030 and reduce greenhouse gas emissions by 55% across all sectors of the economy by 2050 (Androniceanu & Sabie, 2022). The implementation of technologies such as solar panels and wind turbines is further strengthened by policy support and large government investments around the world. In terms of transitioning to a low-carbon economy, countries such as Pakistan have also developed transition strategies from an oil and gas-based economy to the full use of renewable energy. Research shows that Pakistan is targeting the use of 81.3% renewable energy by 2053 and zero CO<sub>2</sub> emissions by 2060. This transition includes bioenergy as one of the main energy sources, which is projected to grow to reach 78% of the total national energy supply by 2053 with minimal carbon emission levels (Raza et al., 2023). In Europe, the transition to a low-carbon economy also includes the use of carbon capture, utilization, and storage technologies to reduce emissions from heavy industrial sectors such as steel and cement, as well as from fossil fuel power plants (Babachenko et al., 2022). The implementation of this energy diversification and transition policy reflects a global commitment to sustainability. Each step of this energy transition requires the integration of technology, policy

support, and the involvement of various sectors to ensure long-term sustainability and energy security.

#### **2.3.4. Social and Economic Aspects**

Revenue from the oil and gas sector can support the welfare of local communities and economic development through the 10% PI policy which allows local governments to get a share of oil and gas revenues. This policy, which is implemented in some areas such as the Cepu Block in East Java, creates opportunities for local governments to manage this revenue through various sustainable social and infrastructure programs. For example, PT Petrogas Jawa Timur Utama Cendana, the manager of PI in Cepu, uses the profits from PI to finance local business projects aimed at improving the economy of the surrounding community. Research by (Priadi, 2021) shows that PI management in Cepu effectively increases regional revenue through public-private partnership schemes, which support the overall development of the local economy. The implementation of CSR from oil and gas companies also supports the welfare of the community. CSR programs such as those implemented in Kolaka, Southeast Sulawesi, have focused on improving the quality of life of the community through infrastructure development, health, and education. Although local governments hold the power to manage CSR funds, the effectiveness of this management is still constrained by administrative weaknesses that can hinder the optimization of CSR funds for the surrounding community (Matala, 2022). The management of oil and gas funds allocated to local governments can be used to improve public infrastructure and health services. In Jambi, oil and gas revenue sharing funds are used for capital expenditures focused on education and health, which shows that fund allocation can effectively improve people's quality of life and the human development index (HDI) ((Ramli & Safitri, 2023). However, more decisive policies are needed to ensure that these funds are truly allocated to priorities that support the economic and social sustainability of local communities. The 10% PI policy and the allocation of oil and gas funds at the local level play an important role in supporting sustainable development and community welfare around oil and gas operating areas.

#### **2.3.5. Oversight and Transparency**

Supervision and transparency in the management of the oil and gas sector are crucial aspects to ensure a fair distribution of benefits and reduce the risk of corruption. The implementation of good governance in the oil and gas sector requires transparency in the management and active participation of the community, including through independent supervisory agencies. A study emphasizes the importance of transparency and public participation in ensuring sustainable development in the oil and gas sector. Transparency allows the public to monitor oil

and gas revenue streams and ensure that the funds obtained are used for the public interest. This implementation, for example, is carried out through the EITI, which encourages governments and companies in more than 50 countries to disclose information related to income from natural resource extraction, with evidence that EITI participating countries have better accountability and a more equitable distribution of profits (Sovacool, 2020). Public participation in environmental decision-making is also a key component in ensuring that local communities understand the social and environmental impacts of oil and gas projects. Research suggests that active community participation in environmental policies, including in the public consultation and advocacy stages, is important to protect local interests and reduce conflicts. The application of the principles of transparency and public participation in oil and gas management helps to create good governance, maintain accountability, and ensure that decisions taken take into account the social and environmental interests of local communities.

National policies on oil and gas management and environmental health must include comprehensive regulations, mitigation of environmental and health impacts, and energy transition strategies towards sustainability. In addition, it is also important to ensure that the welfare of local communities and transparency in resource management are top priorities, with the implementation of policies such as the 10% PI that supports regional participation in oil and gas management and sustainable environmental development.

## **2.4. Conclusion**

This chapter highlights the importance of environmental responsibility in Indonesia's oil and gas (oil and gas) policy, especially the obligation of oil and gas companies to comply with CER and GRI standards. This standard requires companies to report their operational environmental impacts transparently, even though the company's compliance level with GRI is still low. In addition, regulations related to EIA require oil and gas companies to carry out mitigation and post-exploitation recovery to protect the ecosystem. Good implementation of AMDAL has proven to be effective in reducing long-term environmental impacts in several countries. In the context of local participation, the 10% PI policy allows regional involvement through BUMD that have 10% ownership in oil and gas projects. The 10% PI initiative provides direct economic benefits for the region and increases corporate accountability for social and environmental impacts.

This chapter also identifies bioremediation as an effective and environmentally friendly solution to deal with contamination due to oil spills. This method, which uses microorganisms to break down contaminants, has been shown to be successful in reducing hydrocarbon levels in polluted soil and water in various countries. In addition, other findings highlight the impact of the oil and gas sector on public health,

particularly through the emission of harmful gases such as SO<sub>2</sub> and nitrogen oxides NO<sub>x</sub> which can increase the risk of respiratory diseases. Emission reduction policies and the implementation of control technologies such as de-SO<sub>2</sub> and de-NO<sub>x</sub> are considered important to mitigate these health impacts.

As for suggestions for future improvements, this document recommends improving companies' compliance with GRI standards by leveraging Industry 4.0 technologies, such as data analysis and reporting automation, to improve the transparency and accountability of their environmental reporting. In addition, it is recommended that the government provide financial support for regions that want to implement the 10% PI, especially for BUMDs in areas that have financial limitations for initial investment. In terms of environmental remediation, further development of bioremediation technology and the use of local microorganisms is expected to accelerate the recovery process in polluted areas. Independent oversight involving local communities is also a recommendation to increase corporate accountability in managing the impact of oil and gas operations. Transparency in the oil and gas industry can be strengthened through initiatives such as the Extractive Industries Transparency Initiative that will support better public engagement and decision-making in the sector. These findings and suggestions provide a foundation for more sustainable management of the oil and gas sector and focus on community welfare and environmental conservation.

## Reference

- Achmad, Y., Syahnur, S., & Seftarita, C. (2022). The Effect of the Exploration and Exploitation of Oil and Gas on Indonesian Economic Growth. *International Journal of Quantitative Research and Modeling*, 3(3). <https://doi.org/10.46336/ijqrm.v3i3.342>
- Adham, S., Hussain, A., Minier-Matar, J., Janson, A., & Sharma, R. (2018). Membrane applications and opportunities for water management in the oil & gas industry. In *Desalination* (Vol. 440). <https://doi.org/10.1016/j.desal.2018.01.030>
- Afolabi, H., Ram, R., & Rimmel, G. (2023). Influence and behaviour of the new standard setters in the sustainability reporting arena: implications for the Global Reporting Initiative's current position. *Sustainability Accounting, Management and Policy Journal*, 14(4). <https://doi.org/10.1108/SAMPJ-01-2022-0052>
- Aljanadi, Y., & Alazzani, A. (2023). Sustainability reporting indicators used by oil and gas companies in GCC countries: IPIECA guidance approach. *Frontiers in Environmental Science*, 11. <https://doi.org/10.3389/fenvs.2023.1069152>
- Al-Thani, R. F., & Yasseen, B. T. (2023). Possible Future Risks of Pollution Consequent to the Expansion of Oil and Gas Operations in Qatar. *Environment and Pollution*, 12(1). <https://doi.org/10.5539/ep.v12n1p12>
- Alvernia, P., Utomo, S., Soesilo, T. E. B., & Herdiansyah, H. (2021). The use of bioremediation technology on oil-contaminated soil. *IOP Conference Series: Earth and Environmental Science*, 755(1). <https://doi.org/10.1088/1755-1315/755/1/012061>
- Anastasopoulos, A. T., Sofowote, U. M., Hopke, P. K., Rouleau, M., Shin, T., Dheri, A., Peng, H., Kulka, R., Gibson, M. D., Farah, P. M., & Sundar, N. (2021). Air quality in Canadian port cities after regulation of low-sulphur marine fuel in the North American Emissions Control Area. *Science of the Total Environment*, 791. <https://doi.org/10.1016/j.scitotenv.2021.147949>
- Androniceanu, A., & Sabie, O. M. (2022). Overview of Green Energy as a Real Strategic Option for Sustainable Development. In *Energies* (Vol. 15, Issue 22). <https://doi.org/10.3390/en15228573>
- Ariyon, M., Sukendi, S., Manda Putra, R., Kausarian, H., & Santika, B. (2023). Comparison of oil and gas fiscal policies in Southeast Asian Countries: Indonesia, Malaysia and Brunei Darussalam. *BIO Web of Conferences*, 70. <https://doi.org/10.1051/bioconf/20237006007>
- Arthur, J. L. (2020). Mitigating the Environmental Effects of Oil and Gas Exploitation: Issues of Compliance, Cost of Production, and Community Awareness. *Journal*

*of Power and Energy Engineering*, 08(09).  
<https://doi.org/10.4236/jpee.2020.89005>

- Azi, M. B., Pius, W. W., Sule, B., Gbemileke, N. A., Bala, A. M., & Haruna, B. D. (2023). THE IMPACT OF OIL AND GAS EXTRACTION IN NIGER DELTA: A NEED FOR ENVIRONMENTAL SAFETY AND SUSTAINABILITY IN KOLMANI, NIGERIA. *African Journal of Health, Safety and Environment*, 4(1).  
<https://doi.org/10.52417/ajhse.v4i1.397>
- Azzolina, N. A., Peck, W. D., Hamling, J. A., Gorecki, C. D., Ayash, S. C., Doll, T. E., Nakles, D. V., & Melzer, L. S. (2016). How green is my oil? A detailed look at greenhouse gas accounting for CO<sub>2</sub>-enhanced oil recovery (CO<sub>2</sub>-EOR) sites. *International Journal of Greenhouse Gas Control*, 51.  
<https://doi.org/10.1016/j.ijggc.2016.06.008>
- Babachenko, O. I., Nesterov, O. S., & Garmash, L. I. (2022). Decarbonization and the energy crisis. *Fundamental and Applied Problems of Ferrous Metallurgy*, 36, 35–48. <https://doi.org/10.52150/2522-9117-2022-36-35-48>
- Ben Ismail, N., Alcouffe, S., Galy, N., & Ceulemans, K. (2021). The impact of international sustainability initiatives on Life Cycle Assessment voluntary disclosures: The case of France's CAC40 listed companies. *Journal of Cleaner Production*, 282.  
<https://doi.org/10.1016/j.jclepro.2020.124456>
- Benson, C., Dimopoulos, C., Argyropoulos, C. D., Varianou Mikellidou, C., & Boustras, G. (2021). Assessing the common occupational health hazards and their health risks among oil and gas workers. *Safety Science*, 140.  
<https://doi.org/10.1016/j.ssci.2021.105284>
- Bishoge, O. K., Kombe, G. G., & Mvile, B. N. (2022). Community perspectives on natural gas management in Tanzania. *Energy and Environment*, 33(6).  
<https://doi.org/10.1177/0958305X221076047>
- Boiral, O., & Heras-Saizarbitoria, I. (2017). Managing Biodiversity Through Stakeholder Involvement: Why, Who, and for What Initiatives? *Journal of Business Ethics*, 140(3). <https://doi.org/10.1007/s10551-015-2668-3>
- Bologna Pavlik, J. (2019). Access to Information Laws and Voter Behavior: Does Transparency Increase Participation? *SSRN Electronic Journal*.  
<https://doi.org/10.2139/ssrn.3448770>
- Buonocore, J. J., Reka, S., Yang, D., Chang, C., Roy, A., Thompson, T., Lyon, D., McVay, R., Michanowicz, D., & Arunachalam, S. (2023). Air pollution and health impacts of oil & gas production in the United States. *Environmental Research: Health*, 1(2).  
<https://doi.org/10.1088/2752-5309/acc886>
- Carpenter, C. (2020). Human Rights as a Sustainability Goal. *Journal of Petroleum Technology*, 72(05). <https://doi.org/10.2118/0520-0018-jpt>



- Chen, R., Zhang, T., Guo, Y., Wang, J., Wei, J., & Yu, Q. (2021). Recent advances in simultaneous removal of SO<sub>2</sub> and NO<sub>x</sub> from exhaust gases: Removal process, mechanism and kinetics. In *Chemical Engineering Journal* (Vol. 420). <https://doi.org/10.1016/j.cej.2020.127588>
- Deng, Z., Jiang, Y., Chen, K., Gao, F., & Liu, X. (2020). Petroleum Depletion Property and Microbial Community Shift After Bioremediation Using *Bacillus halotolerans* T-04 and *Bacillus cereus* 1-1. *Frontiers in Microbiology*, 11. <https://doi.org/10.3389/fmicb.2020.00353>
- Edward T. Bristol-Alagbariya. (2020). The Concept, Principle, Law and Developmental Practice of Environmental Democracy towards Sustainable Development in Resources-rich Communities of Developing Countries: Focus on Nigeria's Oil Producing Delta Region. *Journal of Law, Policy and Globalization*. <https://doi.org/10.7176/jlpg/94-07>
- Feder, J. (2020). Reuse of Produced Water Grows in the Oil and Gas Industry. *Journal of Petroleum Technology*, 72(12). <https://doi.org/10.2118/1220-0060-jpt>
- Ferrarez, R. P. F., Vargas, R. V., Alvarenga, J. C., Chinelli, C. K., Costa, M. de A., de Oliveira, B. L., Haddad, A. N., & Soares, C. A. P. (2020). Sustainability indicators to assess infrastructure projects: Sector disclosure to interlock with the global reporting initiative. *Engineering Journal*, 24(6). <https://doi.org/10.4186/ej.2020.24.6.43>
- Frumkin, H., & Myers, S. S. (2020). Planetary health and the 2020 US election. In *The Lancet* (Vol. 396, Issue 10257). [https://doi.org/10.1016/S0140-6736\(20\)32038-9](https://doi.org/10.1016/S0140-6736(20)32038-9)
- Gao, Y., Cai, M., Shi, K., Sun, R., Liu, S., Li, Q., Wang, X., Hua, W., Qiao, Y., Xue, J., & Xiao, X. (2023). Bioaugmentation enhance the bioremediation of marine crude oil pollution: Microbial communities and metabolic pathways. *Water Science and Technology: A Journal of the International Association on Water Pollution Research*, 87(1). <https://doi.org/10.2166/wst.2022.406>
- Gayathri, V., & Krishnaprema, K. (2023). Bioremediation of Crude Oil using Hydrocarbon degrading *Pseudomonas luteola* by Immobilization methods. *Ecology, Environment and Conservation*, 29. <https://doi.org/10.53550/eec.2023.v29i01s.017>
- Halkos, G., & Nomikos, S. (2021). Corporate social responsibility: Trends in global reporting initiative standards. *Economic Analysis and Policy*, 69. <https://doi.org/10.1016/j.eap.2020.11.008>
- Hannouf, M., Assefa, G., & Gates, I. (2020). From social hotspots to policies for successful implementation of environmentally better technologies? The example of social life cycle assessment of oil and gas technologies in Alberta, Canada.

- Hasiholan, A., Murwadi, T., & Sukarsa, D. E. (2023). Environmental Responsibilities of Local Governments as PI Holders in Upstream Oil and Gas Operations. *IOP Conference Series: Earth and Environmental Science*, 1270(1). <https://doi.org/10.1088/1755-1315/1270/1/012006>
- Karpan, B., Abdul Raman, A. A., & Taieb Aroua, M. K. (2021). Waste-to-energy: Coal-like refuse derived fuel from hazardous waste and biomass mixture. *Process Safety and Environmental Protection*, 149. <https://doi.org/10.1016/j.psep.2021.03.009>
- Kasych, A., Suler, P., & Rowland, Z. (2020). Corporate environmental responsibility through the prism of strategic management. *Sustainability (Switzerland)*, 12(22). <https://doi.org/10.3390/su12229589>
- Khan, S., Tripathi, A. K., Srivastava, R., Saleem, M. S., Yeremenko, S., & Sydorenko, V. (2022). Bioremediation of Petroleum Contamination: A Short Review. In *Ecological Questions* (Vol. 33, Issue 2). <https://doi.org/10.12775/EQ.2022.012>
- Kraus, S., Rehman, S. U., & García, F. J. S. (2020). Corporate social responsibility and environmental performance: The mediating role of environmental strategy and green innovation. *Technological Forecasting and Social Change*, 160. <https://doi.org/10.1016/j.techfore.2020.120262>
- Kwarto, F., Nurafiah, N., Suharman, H., & Dahlan, M. (2021). *Sustainability Reporting in the Upstream Oil and Gas Industry Between Awards and Violations: A Systematic Literature Review, Evidence From Indonesia*. <https://doi.org/10.20944/preprints202109.0186.v1>
- Larchenko, L. V., Kolesnikov, R. A., & Mukhametova, L. (2020). Russian oil and gas industry as a sphere of international interests and economic cooperation. *E3S Web of Conferences*, 161. <https://doi.org/10.1051/e3sconf/202016101006>
- Li, J., & Wu, D. (2020). Do corporate social responsibility engagements lead to real environmental, social, and governance impact? *Management Science*, 66(6). <https://doi.org/10.1287/mnsc.2019.3324>
- Li, Q., Huang, Y., Wen, D., Fu, R., & Feng, L. (2020). Application of alkyl polyglycosides for enhanced bioremediation of petroleum hydrocarbon-contaminated soil using *Sphingomonas changbaiensis* and *Pseudomonas stutzeri*. *Science of the Total Environment*, 719. <https://doi.org/10.1016/j.scitotenv.2020.137456>
- Lingard, N., Morgan, P., Apostolova, K., & Tan, J. (2020). Cost recovery in production sharing contracts: A comparative review of Southeast Asian jurisdictions. *Journal of World Energy Law and Business*, 13(5–6). <https://doi.org/10.1093/jwelb/jwaa033>

- Liu, R., Zhao, M., & Ren, J. (2022). The Influence Mechanism of Corporate Environmental Responsibility on Corporate Performance: The Mediation Effect of Green Innovation. *Sustainability* (Switzerland), 14(17). <https://doi.org/10.3390/su141710975>
- Luo, T., & Xie, R. (2021). Supply chain power and corporate environmental responsibility: Mediation effects based on business performance. *International Journal of Environmental Research and Public Health*, 18(17). <https://doi.org/10.3390/ijerph18179264>
- Maharani, A. M., & Rozzaid, Y. R. (2022). GRI Standars Based Corporate Social Responsibility Disclosure Toward Market Reaction In Energy Companies Listed in Indonesia Stock Exchange. *International Social Sciences and Humanities*, 1(1). <https://doi.org/10.32528/issv1i1.19>
- Matala, A. (2022). Reviewing the Performance Of Local Governments In Managing Corporate Social Responsibility Program. *AKADEMIK: Jurnal Mahasiswa Humanis*, 2(2). <https://doi.org/10.37481/jmh.v2i2.469>
- Mein, T. F., Gimenes, A. L. V., Dias, E. M., Rebello Pinho Dias Scoton, M. L., & Udaeta, M. E. M. (2021). Environmental vulnerability in pre-salt oil and gas operations. *Energies*, 14(3). <https://doi.org/10.3390/en14030732>
- Mora, V. C., Morelli, I. S., & Rosso, J. A. (2020). Co-treatment of an oily sludge and aged contaminated soil: permanganate oxidation followed by bioremediation. *Journal of Environmental Management*, 261. <https://doi.org/10.1016/j.jenvman.2020.110169>
- Murti Sujadi, F., Yahya, Y., Kurniawan, A., & Aziz Amin, Abd. (2020). Lubricant Oil Bioremediation by Rhodococcus erythropolis Bacteria and Indigenous Bacteria Isolated from Water Contaminated with Lubricant Oil. *Research Journal of Life Science*, 7(1). <https://doi.org/10.21776/ub.rjls.2020.007.01.7>
- Musci, M., & Da Cunha, T. S. (2023). Assessment of environmental impacts in the offshore industry through sedimentary geochemistry. *CONTRIBUCIONES A LAS CIENCIAS SOCIALES*, 16(11). <https://doi.org/10.55905/revconv.16n.11-175>
- Nabila Qothrunada, & Wuri Handayani. (2023). DOES ENVIRONMENTAL DISCLOSURE OF THE OIL AND GAS INDUSTRY COMPLY WITH THE GRI? EVIDENCE FROM INDONESIA. *Journal of Business Management and Accounting*, 13(2). <https://doi.org/10.32890/jbma2023.13.2.1>
- Narula, S., Puppala, H., Kumar, A., Frederico, G. F., Dwivedy, M., Prakash, S., & Talwar, V. (2021). Applicability of industry 4.0 technologies in the adoption of global reporting initiative standards for achieving sustainability. *Journal of Cleaner Production*, 305. <https://doi.org/10.1016/j.jclepro.2021.127141>

- Nathaniel, S., & Khan, S. A. R. (2020). The nexus between urbanization, renewable energy, trade, and ecological footprint in ASEAN countries. *Journal of Cleaner Production*, 272. <https://doi.org/10.1016/j.jclepro.2020.122709>
- Nathaniel, S. P. (2021). Environmental degradation in ASEAN: assessing the criticality of natural resources abundance, economic growth and human capital. *Environmental Science and Pollution Research*, 28(17). <https://doi.org/10.1007/s11356-020-12034-x>
- Pandey, P. (2022). Billions of Barrels at Risk in Southeast Asia Due to Sour Gas. *Offshore Technology Conference Asia, OTCA 2022*. <https://doi.org/10.4043/31335-MS>
- Peng, B., Chen, S., Elahi, E., & Wan, A. (2021). Can corporate environmental responsibility improve environmental performance? An inter-temporal analysis of Chinese chemical companies. In *Environmental Science and Pollution Research* (Vol. 28, Issue 10). <https://doi.org/10.1007/s11356-020-11636-9>
- Phoumin, H., Kimura, F., & Arima, J. (2021). Asean's energy transition towards cleaner energy system: Energy modelling scenarios and policy implications. *Sustainability (Switzerland)*, 13(5). <https://doi.org/10.3390/su13052819>
- Piczak, M. L., Perry, D., Cooke, S. J., Harrison, I., Benitez, S., Koning, A., Peng, L., Limbu, P., Smokorowski, K. E., Salinas-Rodriguez, S., Koehn, J. D., & Creed, I. F. (2024). Protecting and restoring habitats to benefit freshwater biodiversity. *Environmental Reviews*, 32(3). <https://doi.org/10.1139/er-2023-0034>
- Pizzi, S., Principale, S., & de Nuccio, E. (2023). Material sustainability information and reporting standards. Exploring the differences between GRI and SASB. *Meditari Accountancy Research*, 31(6). <https://doi.org/10.1108/MEDAR-11-2021-1486>
- Possingham, H. P., Bode, M., & Klein, C. J. (2015). Optimal Conservation Outcomes Require Both Restoration and Protection. *PLoS Biology*, 13(1). <https://doi.org/10.1371/journal.pbio.1002052>
- Priadi, S. N. (2021). *The Success of Managing Participating Interest (PI) in Cepu Block in Increasing Regional Revenue In East Java*. <https://doi.org/10.29118/ipa21-bc-99>
- Purwanti, M., & Lestari, Y. D. (2022). Praktik Pengungkapan Sustainability Report dan Environmental Incidents: Studi pada Sustainability Report Perusahaan BUMN PT. Pertamina (Persero) Tahun 2017-2018. *Portofolio: Jurnal Ekonomi, Bisnis, Manajemen, Dan Akuntansi*, 18(1). <https://doi.org/10.54783/portofolio.v18i1.211>
- Rabiei, K., Sarrafzadegan, N., Ghanbari, A., Shamsipour, M., Hassanvand, M. S., Amini, H., Yunesian, M., & Farzadfar, F. (2020). The burden of cardiovascular and respiratory diseases attributed to ambient sulfur dioxide over 26 years. *Journal*

- of Environmental Health Science and Engineering*, 18(1).  
<https://doi.org/10.1007/s40201-020-00464-1>
- Ramli, F., & Safitri, Y. (2023). Analysis of the Effect of Natural Resources on the Quality of Human Development through Jambi Province Capital Expenditures. *Sustainability (STPP) Theory, Practice and Policy*, 2(2).  
<https://doi.org/10.30631/sdgs.v2i2.1454>
- Rayhan, A., Ramadhan, M. U. C., & Prakasa, T. B. Y. (2023). Bioremediation in Upstream Oil and Gas Enterprises: Indonesian Environmental Law Perspectives. *UNIFIKASI: Jurnal Ilmu Hukum*, 10(2).  
<https://doi.org/10.25134/unifikasi.v10i2.8592>
- Raza, M. A., Aman, M. M., Tunio, N. A., Soomro, S. A., Shahid, M., Ara, D., Jumani, T. A., & Haider, R. (2023). Energy transition through bioelectricity in Pakistan: Implications for limiting global mean temperature below 1.5°C. *Environmental Progress and Sustainable Energy*, 42(4). <https://doi.org/10.1002/ep.14189>
- Reeve, K., & Kabiawu, D. (2020). Corporate Social Responsibility as Legitimacy in the Oil and Gas Industry in Sub-Saharan Africa. *Proceedings of the International Association for Business and Society*, 31, 100–111.  
<https://doi.org/10.5840/iabsproc20203110>
- Rehman, S., & Holý, O. (2022). Is green and sustainable technological innovation a potential driver of environmental performance? an empirical investigation across the ASEAN region. *Frontiers in Environmental Science*, 10.  
<https://doi.org/10.3389/fenvs.2022.958203>
- Roudneshin, M., & Azadeh, A. (2019). A novel multi-objective fuzzy model for optimization of oil sludge management by considering Health, Safety and Environment (HSE) and resiliency indicators in a gas refinery. *Journal of Cleaner Production*, 206. <https://doi.org/10.1016/j.jclepro.2018.09.142>
- Safrina, R., & Utama, N. A. (2023). ASEAN energy transition pathway toward the 2030 agenda. In *Environmental Progress and Sustainable Energy* (Vol. 42, Issue 4).  
<https://doi.org/10.1002/ep.14101>
- Samaila, B., Kalgo, Z. M., & Maidamma, B. (2023). Exposure to heavy metals in oil and gas wastes: A systematic review on health hazards assessment and mitigation in Nigeria. *Advanced Research in Medical and Health Sciences*, 1(1).  
<https://doi.org/10.57040/armhs.v1i1.370>
- Schnitger, A., Holle, F., & Kockrow, M. (2021). Tax and Transparency: Reporting in Accordance with the Global Reporting Initiative. *Intertax*, 49(8–9).  
<https://doi.org/10.54648/taxi2021069>
- Singh, A. (2023). Overview of Emerging Technologies for Methane Measurement, Monitoring and Reduction in US Onshore Upstream Oil & Gas Industry. *Society*

- of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/216088-MS>
- Sovacool, B. K. (2020). Is sunshine the best disinfectant? Evaluating the global effectiveness of the Extractive Industries Transparency Initiative (EITI). *Extractive Industries and Society*, 7(4). <https://doi.org/10.1016/j.exis.2020.09.001>
- Tauringana, V. (2021). Sustainability reporting challenges in developing countries: towards management perceptions research evidence-based practices. *Journal of Accounting in Emerging Economies*, 11(2). <https://doi.org/10.1108/JAEE-01-2020-0007>
- Tetteh, L. A., Agyenim-Boateng, C., & Simpson, S. N. Y. (2024). A difficult journey from enactment to implementation of local content policy: instigating factors and accountability mechanisms for achieving sustainable development. *Journal of Applied Accounting Research*, 25(2). <https://doi.org/10.1108/JAAR-02-2023-0043>
- Vora, M., Sanni, S., & Flage, R. (2021). An environmental risk assessment framework for enhanced oil recovery solutions from offshore oil and gas industry. *Environmental Impact Assessment Review*, 88. <https://doi.org/10.1016/j.eiar.2020.106512>
- Wahyudi, W. (2022). Effectiveness And Supervision Of Participating Interest By The Bpma: A Legal Analysis. *Kanun Jurnal Ilmu Hukum*, 24(2). <https://doi.org/10.24815/kanun.v24i2.28237>
- Wang, M., Liao, G., & Li, Y. (2021). The relationship between environmental regulation, pollution and corporate environmental responsibility. *International Journal of Environmental Research and Public Health*, 18(15). <https://doi.org/10.3390/ijerph18158018>
- Waspiah, W., Arifin, R., Baiquni, M. I., & Adiyatma, S. E. (2023). Abandonment and Site Restoration (ASR) Funding Scheme in the Context of Environmental Protection after Upstream Oil and Gas Business Activities from an Economic Law Perspective. *IOP Conference Series: Earth and Environmental Science*, 1248(1). <https://doi.org/10.1088/1755-1315/1248/1/012034>
- Wolniak, R., Wyszomirski, A., Olkiewicz, M., & Olkiewicz, A. (2021). Environmental corporate social responsibility activities in heating industry—Case study. *Energies*, 14(7). <https://doi.org/10.3390/en14071930>
- Xu, J., Du, J., Li, L., Zhang, Q., & Chen, Z. (2020). Fast-stimulating bioremediation of macro crude oil in soils using matching Fenton pre-oxidation. *Chemosphere*, 252. <https://doi.org/10.1016/j.chemosphere.2020.126622>

- Xue, Y., Jiang, C., Guo, Y., Liu, J., Wu, H., & Hao, Y. (2022). Corporate Social Responsibility and High-quality Development: Do Green Innovation, Environmental Investment and Corporate Governance Matter? *Emerging Markets Finance and Trade*, 58(11). <https://doi.org/10.1080/1540496X.2022.2034616>
- Yaya, R., Wibowo, S. A., Ulfaturrahmah, & Jalaludin, D. (2018). Environmental disclosure practices after mandatory disclosure policy in Indonesia. *Journal of Business and Retail Management Research*, 12(4). <https://doi.org/10.24052/jbrmr/v12is04/art-09>
- Yulianingsih, I., & Algasahri, M. R. Y. (2020). GOVERNMENT'S NEW POLICY ON THE ARRANGEMENTS OF PARTICIPATING INTEREST. *Trunojoyo Law Review*, 2(2). <https://doi.org/10.21107/tlr.v2i2.9500>
- Zemlick, K., Kalhor, E., Thomson, B. M., Chermak, J. M., Sullivan Graham, E. J., & Tidwell, V. C. (2018). Mapping the energy footprint of produced water management in New Mexico. *Environmental Research Letters*, 13(2). <https://doi.org/10.1088/1748-9326/aa9e54>
- Zeraibi, A., Balsalobre-Lorente, D., & Murshed, M. (2021). The influences of renewable electricity generation, technological innovation, financial development, and economic growth on ecological footprints in ASEAN-5 countries. *Environmental Science and Pollution Research*, 28(37). <https://doi.org/10.1007/s11356-021-14301-x>
- Zerebecki, R. A., Heck, K. L., & Valentine, J. F. (2022). Biodiversity influences the effects of oil disturbance on coastal ecosystems. *Ecology and Evolution*, 12(1). <https://doi.org/10.1002/ece3.8532>
- Zhang, X. (2021). Analysis of Environmental Impact Assessment Indexes of Oil and Gas Resources. *IOP Conference Series: Earth and Environmental Science*, 781(3). <https://doi.org/10.1088/1755-1315/781/3/032046>
- Zharfpeykan, R., & Akroyd, C. (2023). Evaluating the outcome effectiveness of the global reporting initiative transitions. *Sustainability Accounting, Management and Policy Journal*, 14(6). <https://doi.org/10.1108/SAMPJ-07-2022-0365>
- Zhuravska, N., Stefanovych, I., Stefanovych, P., & Nehrii, T. (2023). ENVIRONMENTAL SAFETY IN THE OIL AND GAS INDUSTRY. *Naukovyi Visnyk Donetskoho Natsionalnoho Tekhnichnoho Universytetu*, 1, 63–68. <https://doi.org/10.31474/2415-7902-2023-1-63-68>



# Oil and Gas Potential and Management of Regionally Owned Enterprises

Sekar Nur Wulandari, Hadi Supratikta

Establishment of Regionally Owned Enterprises (BUMD) as an Economic Booster: Oil and gas BUMDs can make a significant contribution to Regional Original Income, create jobs, and optimize natural resource management at the local level.

Collaborative Infrastructure Development: Shared infrastructure such as the Facility Sharing Agreement (FSA) in the Duyung Block allows for investment efficiency and accelerates gas production, which can serve as an example for the rest of the region.

Local Participation through 10% Participating Interest (PI): Through the PI scheme, producing regions can participate in oil and gas production, so that the economic impact is more directly felt by the local community.

Utilization of Technology for Efficiency: The use of modern technology in oil and gas exploration and production, such as Enhanced Oil Recovery (EOR), is indispensable to improve the efficiency and sustainability of oil and gas management.

## **3.1. Potential of oil and gas resources**

### **3.1.1. Riau Islands Province**

Riau Islands Province officially became the 32nd province in Indonesia based on Law Number 25 of 2002. Based on the law, the territorial boundary of Riau Islands Province is the South China Sea to the north; to the east it borders Malaysia and West Kalimantan Province; to the south it borders South Sumatra Province and Jambi Province; and to the west bordering Singapore, Malaysia, and Riau Province. Meanwhile, according to Regional Regulation Number 1 of 2017 concerning the Spatial Plan of the Riau Islands Province for 2017-2037, the territorial boundaries are Vietnam and Cambodia in the north; to the east it borders the State of Malaysia and West Kalimantan Province; to the south it borders Bangka Belitung Province and Jambi Province; and to the west it borders Singapore, Malaysia, and Riau Province.

Administratively, Riau Islands Province consists of two cities, namely Tanjungpinang City as the provincial capital and Batam City, as well as five districts, namely Karimun Regency, Bintan Regency, Natuna Regency, Lingga Regency, and Anambas Islands Regency. Based on the Regulation of the Minister of Home Affairs Number 18 of 2005 concerning Codes and Data of Government Administrative Areas,



with the update through Permendagri Number 56 of 2015, the land area of Riau Islands Province is recorded at 8,201.72 km<sup>2</sup>. Meanwhile, according to technical calculations by the Bakosurtanal Geomatics Study Center in 2007—which sets aside the 12-mile sea management boundary—the area of the waters of Riau Islands Province reached 417,012.97 km<sup>2</sup>. Until now, the area of the sea area has not been officially determined through the Regulation of the Minister of Home Affairs. Further details about the area of waters per district/city in the Riau Islands were obtained from the results of technical calculations of the Bakosurtanal Geomatics Study Center in 2007 (table 3.1). Geomorphologically, Riau Islands Province is part of the continental region known as the "Sunda Exposure" or part of the Asian continental plate. The types of rocks in this region include altered rocks, such as mica gneiss and meta siltstone; volcanic rocks, such as tufts, lithic tufts, and tuff sandstones scattered in the eastern region of the Riau Islands; intrusion rocks, such as muskovite granite found in the eastern part of Kundur Island; as well as sedimentary rocks, such as shale, sandstone, and metabasite, which are scattered on Batam Island, Bintan Island, and Buru Island. In addition, there are also old alluviums in the form of clay, sand, and gravel, as well as young alluviums consisting of mud, silt, and gravel.

Table 3.1 Land Area and Sea Area of Riau Islands Province

| No. | Regency/City            | Land Area (km <sup>2</sup> ) | Sea Area Area (km <sup>2</sup> ) |
|-----|-------------------------|------------------------------|----------------------------------|
| 1.  | Karimun Regency         | 912.75                       | 4.698,09                         |
| 2.  | Bintan Regency          | 1.318,21                     | 102.964,08                       |
| 3.  | Natuna Regency          | 2.009,04                     | 216.113,42                       |
| 4.  | Lingga Regency          | 2.266,77                     | 43.339,00                        |
| 5.  | Anambas Islands Regency | 590.14                       | 46.074,00                        |
| 6.  | Batam City              | 960.25                       | 3.675,25                         |
| 7.  | Tanjungpinang City      | 144.56                       | 149.13                           |
|     | Total                   | 8.201,72                     | 417.012,97                       |

Land Area Source: Permendagri Number 56 of 2015  
Wide Source of the Ocean: Bakosurtanal Geomatics Study Center in 2007

From the hydrological aspect, the Riau Islands has two water sources, namely surface water and groundwater (hydrogeology). To meet the needs of clean water, people can use surface water such as rivers, springs, waterfalls, reservoirs, and underwater. Shallow groundwater (hydrogeology) is obtained through the digging of shallow wells. Kolong is a pond formed from former bauxite, tin, and sand mining that is used as a source of clean water and also developed into a tourist area. The river area in the Riau Islands Province has been stipulated in the Regulation of the Minister of Public Works and Public Housing Number 04/PRT/M/2015 concerning Criteria and Determination of River Areas. The Riau Islands WS covers 2,408 islands that make up the territory of this province, consisting of Natuna Regency, Anambas Islands

Regency, Lingga Regency, Karimun Regency, Bintan Regency, Batam City, and Tanjungpinang City.

The Domestic Product Regional Gross (GDP) is one of the indicators to understand the economic condition of a region in a certain period. Basically, GDP is calculated as the amount of added value produced by all business units in the region or as the total value of goods and services produced by all economic units. The preparation of GDP data requires careful attention to various key factors and data processing mechanisms. Based on research, the main factors affecting GDP include fixed capital investment, household consumption, as well as education levels and the number of productive workers in a given region. The identification of these factors is essential so that the data used in the calculations are truly relevant and able to reflect the dynamic regional economic conditions (Kuzmin & Zinoviev, 2020). To get more accurate results, several methods such as linear regression, key factor analysis, or machine learning-based models can be applied. Research shows that neural network models or genetic algorithms for predicting GDP can improve the accuracy of predictions compared to traditional methods, especially in responding to changes in data quickly and efficiently (Zhang et al., 2022). This preparation process involves several stakeholders, such as the Central Statistics Agency responsible for basic data collection and initial analysis, as well as research institutions and academics who play a role in the development of prediction models. This cross-sector collaboration allows for more optimal data validation and refinement, so that the data prepared is not only accurate but also in line with the latest economic developments (Jamolov, 2021).

GDP can be calculated based on the prevailing price (price in the year of calculation) or constant price (price in the year used as the base year). Since 2014, the calculation of GDP on the basis of constant prices for Riau Islands Province uses the base year 2010. In 2021, the GDP of Riau Islands Province on the basis of prevailing prices reached 275,636,327.71 million IDR, an increase compared to 2020 which was recorded at 254,253,285.10 million IDR. The details of the GDP value are presented based on each business sector. In the structure of the GDP of Riau Islands Province, economic sectors showed mixed contributions during the period 2017 to 2021 (table 3.2). The processing industry sector (C) has the highest contribution, with a value that continues to increase from 84,404,227.84 million IDR in 2017 to 115,852,489.04 million IDR in 2021. This reflects the role of this sector as the main driver of the provincial economy. The mining and quarrying sector (B) also had a significant contribution, albeit fluctuating, with a value of 32,061,779.41 million IDR in 2017 which rose to 34,696,081.02 million IDR in 2021, after a decline in 2020. The construction sector (F) also plays a major role, as seen from the significant increase, reaching 53,159,158.01 million IDR in 2021, showing its important role in the physical development of the region.

Table 3.2. Riau Islands Province GDP on the basis of the price valid for the year 2017-2021 (million IDR)

| BF*1    | 2017           | 2018           | 2019           | 2020           | 2021           |
|---------|----------------|----------------|----------------|----------------|----------------|
| A       | 7.981.525,77   | 8.100.215,60   | 8.223.770,10   | 8.061.287,20   | 8.471.006,79   |
| B       | 32.061.779,41  | 35.148.524,00  | 34.964.435,80  | 28.391.325,00  | 34.696.081,02  |
| C       | 84.404.227,84  | 91.792.574,10  | 100.705.378,60 | 105.899.714,30 | 115.852.489,04 |
| D       | 2.689.974,52   | 2.644.609,60   | 2.763.729,30   | 2.603.102,40   | 2.733.325,06   |
| E       | 282.713,05     | 288.735,60     | 291.287,10     | 281.458,40     | 279.639,13     |
| F       | 41.409.192,35  | 46.628.248,30  | 52.239.254,80  | 49.317.721,90  | 53.159.158,01  |
| G       | 19.653.105,04  | 22.074.794,10  | 24.314.345,40  | 21.561.951,70  | 22.474.866,12  |
| H       | 7.471.819,99   | 7.648.632,40   | 7.219.023,70   | 4.111.948,10   | 3.826.971,45   |
| I       | 5.061.473,37   | 5.585.876,50   | 6.208.870,50   | 3.391.339,90   | 3.171.660,89   |
| J       | 4.485.789,72   | 5.016.209,30   | 5.603.091,10   | 6.483.543,90   | 7.078.070,19   |
| K       | 6.254.648,42   | 6.781.343,50   | 7.271.530,20   | 6.991.384,70   | 7.191.818,68   |
| L       | 3.415.727,76   | 3.467.236,80   | 3.563.184,70   | 3.195.114,30   | 3.116.422,26   |
| M, N    | 11.341,95      | 12.475,70      | 11.378,50      | 5.823,40       | 6.634,30       |
| Or      | 5.914.071,69   | 6.385.002,90   | 6.791.467,50   | 7.347.301,60   | 6.697.960,15   |
| P       | 3.415.199,47   | 3.708.434,70   | 3.849.230,80   | 3.896.178,90   | 3.878.478,89   |
| Q       | 2.119.212,96   | 2.228.235,60   | 2.305.965,20   | 2.277.838,80   | 2.571.774,69   |
| R,S,T,U | 1.075.073,68   | 1.311.084,60   | 1.332.300,40   | 436.250,60     | 429.971,02     |
| PDRB    | 227.706.877,03 | 248.822.233,10 | 267.658.243,70 | 254.253.285,10 | 275.636.327,71 |
| PDRB**  | 197.794.334,22 | 217.694.227,40 | 236.591.379,60 | 229.513.003,10 | 245.879.720,25 |

Wholesale and retail trade (G) contributed consistently with a value of 22,474,866.12 million IDR in 2021, which shows its role in the province's trade activities. The information and communication sector (J) showed a sharp increase from 4,485,789.72 million IDR in 2017 to 7,078,070.19 million IDR in 2021, in line with the development of information technology. Other sectors such as health services (Q), education services (P), and financial services (K) also showed a stable contribution. The financial services sector, for example, increased from 6,254,648.42 million IDR in 2017 to 7,191,818.68 million IDR in 2021. Although the accommodation and food and beverage sector (I) has declined since 2019 due to the impact of the pandemic, its value remains significant for the regional economy. Other sectors such as government administration (O) and real estate (L) continue to contribute continuously, albeit at a lower level than the industrial and mining sectors. Overall, the total GDP on the basis of prevailing prices increased from 227,706,877.03 million IDR in 2017 to 275,636,327.71 million IDR in 2021, indicating economic growth supported by various sectors, especially the processing, construction, and mining industries. The development of ADHK's GDP can be seen in the following table.

<sup>1</sup> \*BF: Business Field; A: Agriculture, Forestry and Fisheries; B: Mining and Quarrying; C: Processing Industry; D: Electricity and Gas Procurement; E: Water Procurement, Waste Management, Waste, and Recycling; F: Construction; G: Wholesale and Retail Trade; Car and Motorcycle Repair and Maintenance; H: Transportation and Warehousing; I: Provision of Accommodation and Food and Beverages; A: Information and Communications; K: Financial Services and Insurance; L: Real Estate; M,N: Corporate Services; O: Government Administration, Defense and Compulsory Social Security; Q: Educational Services; Q: Health Services and Social Activities; R,S,T,U: Other Services; \*\*NON-OIL AND GAS PDRB

Table 3.3. Riau Islands Province GDP on the basis of constant prices for the 2010 base year 2017-2021 (billion IDR)

| BF*1    | 2017           | 2018           | 2019           | 2020           | 2021           |
|---------|----------------|----------------|----------------|----------------|----------------|
| A       | 5.945.614,56   | 5.757.782,20   | 5.717.726,30   | 5.466.778,60   | 5.322.051,79   |
| B       | 25.648.826,82  | 25.995.357,90  | 26.037.643,00  | 24.951.044,50  | 24.748.824,45  |
| C       | 62.436.275,20  | 65.018.044,50  | 69.079.808,10  | 71.325.791,90  | 75.925.345,99  |
| D       | 1.621.700,22   | 1.600.284,10   | 1.653.050,60   | 1.580.657,20   | 1.648.930,50   |
| E       | 222.655,41     | 225.029,90     | 224.902,30     | 218.654,80     | 218.681,16     |
| F       | 29.042.762,62  | 31.345.831,70  | 33.924.659,00  | 31.752.166,90  | 33.256.030,33  |
| G       | 13.665.031,43  | 14.523.505,50  | 15.408.880,00  | 13.449.606,60  | 13.592.975,14  |
| H       | 4.654.491,90   | 4.696.771,90   | 4.280.152,30   | 2.558.454,10   | 2.514.937,06   |
| I       | 3.536.015,49   | 3.895.599,70   | 4.283.338,30   | 2.526.908,70   | 2.357.945,39   |
| J       | 3.736.381,99   | 4.136.735,10   | 4.626.508,90   | 5.392.392,50   | 5.909.454,29   |
| K       | 4.466.528,76   | 4.724.106,90   | 4.951.671,70   | 4.798.291,00   | 4.833.245,99   |
| L       | 2.549.267,98   | 2.539.776,70   | 2.542.823,30   | 2.330.974,40   | 2.247.923,44   |
| M, N    | 8.879,10       | 9.486,20       | 8.649,40       | 5.027,10       | 5.737,79       |
| Or      | 3.750.526,90   | 4.013.016,40   | 4.073.850,20   | 4.398.445,20   | 4.028.294,03   |
| P       | 2.418.955,47   | 2.450.779,10   | 2.461.456,00   | 2.259.576,20   | 2.183.171,54   |
| Q       | 1.618.900,27   | 1.668.139,20   | 1.714.535,80   | 1.679.459,60   | 1.886.035,12   |
| R,S,T,U | 758.861,59     | 898.504,40     | 906.208,80     | 282.473,80     | 272.858,67     |
| PDRB    | 166.081.675,71 | 173.498.751,40 | 181.895.864,00 | 174.976.703,10 | 180.952.442,66 |
| PDRB**  | 142.160.814,19 | 150.851.373,50 | 159.246.616,60 | 153.233.019,60 | 159.424.388,58 |

Source: Riau Islands Province in 2022

In the period 2017 to 2021 (table 3.3), various economic sectors in the Riau Islands Province showed an important role in the structure of the GDP. The processing industry sector (C) emerged as the largest contributor to the provincial economy with a consistent increase from 62,436,275.20 million IDR in 2017 to 75,925,345.99 million IDR in 2021. This confirms the position of this sector as the main pillar of the economy. The construction sector (F) also has a large contribution and continues to grow to reach 33,256,030.33 million IDR in 2021, reflecting the importance of this sector in supporting physical development. The mining and quarrying sector (B) is another important sector, although it has experienced slight fluctuations, with a contribution of 24,748,824.45 million IDR in 2021. The large and retail trade (G) sectors have consistently played a role in GDP with a stable value, namely 13,592,975.14 million IDR in 2021. The information and communication sector (J) showed growth from 3,736,381.99 million IDR in 2017 to 5,909,454.29 million IDR in 2021, reflecting the rapid development of this sector in line with technological advances. In addition, the financial services (K) and other services sector, such as government administration (O), showed a stable contribution throughout the year, with the financial sector reaching 4,833,245.99 million IDR in 2021. The health services sector (Q) also showed a gradual increase to reach 1,886,035.12 million IDR in the same year, followed by the education sector (P) which plays an important role in supporting social welfare although its contribution is relatively smaller. Although several sectors such as accommodation and food and beverage (I) have declined since

2019 due to the impact of the pandemic, this sector still has a significant contribution to the regional economy. The total GDP on the basis of applicable prices for the Riau Islands Province showed growth from 166,081,675.71 million IDR in 2017 to 180,952,442.66 million IDR in 2021, which was supported by strong contributions from key sectors, especially the processing, construction, and mining industries. In the period 2017 to 2021, the processing, construction, and mining industry sectors became the main contributors to the GDP in the Riau Islands Province, reflecting the importance of strategic preparation and management of these sectors to support regional economic growth. Based on studies, the construction sector has a significant impact in developing physical infrastructure that encourages urbanization and regional development. The management of this sector can be optimized by applying correlation and regression models to map the linkages of the construction sector with other sectors, as has been implemented in Malaysia (Alaloul et al., 2021). The manufacturing industry sector, as the main pillar of GDP, plays an important role in supporting other sectors. A study conducted in Samarkand, Uzbekistan, shows that investment remains a vital role in increasing the potential of the industry, which is relevant to direct the development of the processing sector in the Riau Islands to remain competitive (Yakhshilikov, 2020). In addition, the mining sector, despite its volatility, remains an important supporter of industrial development and construction. An analysis in China shows that energy efficiency in the mining sector can be improved through industrial agglomeration, an approach that can be applied in the Riau Islands to improve the competitiveness of the mining sector (Lin & Zhu, 2021). Data and policy preparation for these sectors requires the role of various parties, including local governments, statistical institutions, and academics who can work together in developing prediction and planning models. For example, the implementation of data-driven policies involving input-output analysis in the construction sector can provide insights for better economic planning (Meglin et al., 2022).

Location Quotient (LQ) analysis is very important because it provides an in-depth view of a region's comparative advantages within a particular sector compared to other regions. Using LQ, policymakers and analysts can identify sectors that have the potential to be key drivers of regional economic growth, such as those applied in Qinghai Province to map dominant industries and suggest adjustments to the industrial structure based on the results of LQ analysis (Yu, 2020). This analysis is also important in designing policies that focus on key sectors to maximize the multiplier effect of the economy, especially when combined with more accurate multivariable approaches such as the Multivariable LQ Index which includes more variables for more comprehensive outcomes (Meyer & Niyimbanira, 2021). The results of the LQ analysis can then be implemented by directing investment and policy support to sectors with high LQ values. For example, in regions with high LQ in the manufacturing

or construction sectors, the government can increase support in the form of subsidies, infrastructure development, and workforce training, aiming to strengthen the sector's position as the base of the local economy. Studies in South Africa show that the use of LQ to identify key sectors regionally helps create targeted economic policies, enabling increased efficiency and sustainable economic growth (Meyer & Niyimbanira, 2021). Thus, a precise and detailed LQ analysis not only allows for the identification of leading sectors but also serves as a basis for the development of economic policies focused on the specific potential of the region.

Table 3.4. LQ Analysis of the Industrial Sector (Business Field) of Riau Islands Province

| Category | 2017 | 2018 | 2019 | 2020 | 2021 | LQ RATARATA | BASIS/NON-BASIS |
|----------|------|------|------|------|------|-------------|-----------------|
| A        | 0.27 | 0.25 | 0.24 | 0.23 | 0.22 | 0.25        | Non-Basis       |
| B        | 1.89 | 1.88 | 1.86 | 1.86 | 1.78 | <b>1.85</b> | <b>Basis</b>    |
| C        | 1.70 | 1.71 | 1.75 | 1.91 | 1.96 | <b>1.81</b> | <b>Basis</b>    |
| D        | 0.92 | 0.86 | 0.86 | 0.86 | 0.85 | 0.87        | Non-Basis       |
| E        | 1.60 | 1.54 | 1.44 | 1.37 | 1.30 | <b>1.45</b> | <b>Basis</b>    |
| F        | 1.69 | 1.72 | 1.77 | 1.75 | 1.78 | <b>1.74</b> | <b>Basis</b>    |
| G        | 0.60 | 0.61 | 0.62 | 0.57 | 0.55 | 0.59        | Non-Basis       |
| H        | 0.66 | 0.62 | 0.53 | 0.38 | 0.37 | 0.51        | Non-Basis       |
| I        | 0.68 | 0.71 | 0.74 | 0.50 | 0.45 | 0.62        | Non-Basis       |
| J        | 0.43 | 0.44 | 0.45 | 0.49 | 0.50 | 0.46        | Non-Basis       |
| K        | 0.64 | 0.66 | 0.65 | 0.62 | 0.61 | 0.64        | Non-Basis       |
| L        | 0.51 | 0.49 | 0.46 | 0.42 | 0.40 | 0.46        | Non-Basis       |
| M, N     | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00        | Non-Basis       |
| Or       | 0.66 | 0.66 | 0.64 | 0.71 | 0.65 | 0.67        | Non-Basis       |
| P        | 0.46 | 0.44 | 0.42 | 0.38 | 0.37 | 0.41        | Non-Basis       |
| Q        | 0.85 | 0.82 | 0.78 | 0.70 | 0.71 | 0.77        | Non-Basis       |
| R,S,T,U  | 0.26 | 0.28 | 0.26 | 0.08 | 0.08 | 0.19        | Non-Basis       |
| Total    | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00        |                 |

Source: Riau Islands Province in 2022

Analysis of the LQ for Riau Islands Province in the period 2017-2021 (table 3.4), shows that some sectors have LQ values above 1, which indicates that these sectors are the base or flagship sectors in this province. The mining and quarrying sector (B) has an average LQ of 1.85, indicating its strong role as a key sector that supports the regional economy. In addition, the processing industry sector (C) with an average LQ of 1.81 is also the base sector, indicating that this sector is one of the mainstays of the economy that has high competitiveness compared to other regions. The electricity, gas, and water sector (E) with an average LQ of 1.45, and the construction sector (F) with an average of 1.74, also play a role as the base sector, which means that both have comparative advantages and great potential for further development.

The existence of these base sectors indicates the potential of the Riau Islands Province in sectors related to industry, energy, and construction, which are economic pillars and can encourage future growth. On the other hand, most other sectors, such

as agriculture (A), wholesale and retail trade (G), transportation and warehousing (H), accommodation and food and beverage provision (I), and financial services (K), have LQ values below 1, making them non-base sectors. This shows that these sectors have a relatively smaller and less specific role for the Riau Islands economy compared to the national average. Despite their non-base status, these sectors remain important for economic diversity and stability, but they are not the main strength of the province. The government administration sector (O) and the education sector (P) are also in the non-base category with LQs of 0.67 and 0.41 respectively, indicating that their contribution to the provincial economic structure is relatively smaller. Overall, this table indicates that base sectors such as mining, processing industry, and construction have competitive advantages that can significantly support the Riau Islands economy, while non-base sectors play a role in diversifying the economy, although their contribution is not as large as the base sector.

### **3.1.2. Wajo Regency, South Sulawesi**

Wajo Regency is one of the districts located in South Sulawesi Province, Indonesia. In Wajo Regency, each sub-district has different economic advantages, as illustrated in their contribution to the region's GDP (figure 3.1). Tempe District stands out in the service and trade sectors thanks to its large population and public facilities that support economic activities. Belawa District is dominated by the agricultural sector, although the service sector and the processing industry also make a significant contribution. To increase economic excellence in each sub-district in Wajo Regency, a development strategy that is in accordance with the characteristics of each sector can be implemented. In Tempe District, which is prominent in the service and trade sectors, strengthening infrastructure and empowering the local economy can increase the competitiveness of the region. The development of SMEs and digital-based services, such as those implemented in Bandung, can significantly drive the growth of this sector (Ratnasari et al., 2022). Meanwhile, in Belawa District, which focuses more on the agricultural sector, the adoption of modern agricultural technology and the construction of agricultural product processing facilities can strengthen the resilience and productivity of an agriculture-based economy. Studies in various regions of Indonesia show that modernization of the agricultural sector through mechanization and the provision of local processing facilities can increase crop yields and added value of agricultural products (Otsuka, 2021). In its implementation, local governments can form partnerships with the private sector and communities to build local innovation centers or business incubators to encourage technological adaptation and job skills improvement in each sector. The establishment of village-owned enterprises (BUMDes) that focus on leading sectors such as agriculture in Belawa or services and trade in Tempe, can be a strategic step to strengthen the local economy by mobilizing village funds and supporting local

businesses ((Paulus et al., 2020). With proper implementation and synergy between the government, the private sector, and the community, Wajo Regency can increase its contribution to regional GDP and build a stronger and more sustainable regional economy.



Figure 3.1. Contribution of the GDP Sector per District in Wajo Regency in 2022

Meanwhile, Tanasitolo is a leading player in the processing and construction industry sector, which plays an important role in driving local economic growth. In Maniangpajo sub-district, the agriculture, trade, and construction sectors are the main sectors, while Sabbangparu has the largest contribution to the agriculture and trade sectors. Pammana stands out in the agriculture and service sectors, with the additional contribution from the mining sector being quite high. On the other hand, Bola has a different dominance, namely in the mining and construction sectors. Takkalalla District shows a big role in the trade and service sectors, while Penrang is known for its contributions in the agricultural and processing industry sectors. Keera District has a high contribution in the mining sector, supported by the agricultural sector. Finally, Pitumpanua plays an important role in the trade sector and the manufacturing industry. The distribution of economic potential in Wajo Regency shows how each sub-district utilizes the resources it has to support its key sectors, which ultimately contributes to the overall economic growth of the district. Wajo Regency has economic potential that varies between sub-districts, and to increase the contribution of key sectors, each sub-district can implement strategies tailored to their sectoral characteristics. In Tanasitolo, which excels in the processing and construction industry sectors, it is important to develop industrial estates with adequate infrastructure to strengthen the role of the processing sector, similar to the



development of the industrial sector in Bandung which has succeeded in increasing the competitiveness of its region (Ratnasari et al., 2022). In Maniangpajo, the improvement of the agricultural and trade sectors can be achieved through the implementation of product diversification strategies and optimization of the marketing of agricultural products, as is done in several regions of Indonesia which shows a significant improvement in the welfare of farmers through focused marketing strategies (Luckyardi et al., 2022). In Sabbangparu and Pammana, both of which depend on the agricultural sector, technology-based approaches and value-added product development can increase productivity. Studies in Indonesia show that mechanization and diversification of agricultural products can increase selling value and increase regional income (Otsuka, 2021). In Bola and Keera, which have a large contribution from the mining sector, sustainable resource management policies are needed to preserve the environment while improving the efficiency of mining production, as implemented in several regions that depend on extractive industries in Indonesia (Basuki, 2023). The implementation of this strategy requires coordination between local governments, economic institutions, and local business actors. The government can play a role in facilitating skills training for local workers, providing infrastructure, as well as subsidy policies for sectors that require further development. Cooperation-based approaches and technology adaptation have proven effective in increasing regional competitiveness, as shown in research that supports the integration of government policies with the development of local resources in several Indonesian districts (Dahliah et al., 2020). Thus, strengthening the main economic sectors in each sub-district will strengthen the economic structure of Wajo Regency as a whole.

In the context of Wajo Regency's GDP, the oil and gas sector is included in the mining and quarrying category. In this district, the mining sector includes the exploration and production of natural resources such as oil and gas. Although the contribution of this sector as a whole to the GDP of Wajo Regency may not be as large as the agricultural or service sector, the oil and gas sector still provides added value, especially in sub-districts that have these resource reserves. Districts such as Bola and Keera were identified as having a higher contribution in the mining sector compared to other sub-districts in Wajo. This is most likely due to the presence of natural resources such as oil and gas explored in the area. Therefore, the oil and gas potential of Wajo Regency is mainly located in sub-districts with more prominent mining activities, such as Bola and Keera, which can support regional income and create local jobs. To increase the contribution of the oil and gas sector in Wajo Regency, especially in sub-districts such as Bola and Keera, several strategies can be implemented for the optimization and sustainable utilization of these natural resources. One of the key approaches is increased investment in the oil and gas sector to support more effective exploration and exploitation, including the use of advanced technologies such as EOR

that can significantly increase production in mature oil fields (Achmad et al., 2022). The implementation of solar energy-based EOR, for example, not only increases production but also reduces carbon footprint, thus supporting national energy sustainability goals (Shafa Alifia Salsabila et al., 2023). In addition, the development of Regional-Owned Enterprises (BUMD) that focus on the oil and gas sector can be a solution to increase PAD. This has been implemented in Bojonegoro Regency, where BUMDs operating in the oil and gas sector make a significant contribution to regional revenue, although good management is needed to optimize local benefits from this sector (Qurbani et al., 2020). To implement this strategy, close collaboration between local governments, the private sector, and academia is needed in creating policies that support investment and new technologies. For example, collaborating with universities for innovative research in the energy sector can support the application of sustainable technologies and help create job opportunities in the local area. With a combination of technological improvements, local management, and the right policies, the oil and gas sector in Wajo Regency can have a greater and more sustainable economic impact.

The establishment of Regionally Owned Enterprises (BUMD) in the oil and gas sector can provide several strategic benefits for Wajo Regency, especially in increasing the contribution of the mining sector to the region's GDP. Given that the mining sector, including oil and gas, still has a relatively small contribution compared to other major sectors such as agriculture, the existence of BUMDs in this field has the potential to optimize regional income and empower local resources. The Potential Benefits of the Establishment of Oil and Gas BUMD for Wajo Regency have several important things, including:

1. Increasing regional revenue, BUMDs in the oil and gas sector can become a new source of PAD through share ownership or the distribution of production proceeds. This increase in income can be allocated for regional development and improve the welfare of the local community. To increase PAD through Regionally Owned Enterprises (BUMD) in the oil and gas sector, several strategies can be applied to optimize share ownership or share of production results. A study on the management of regional participation in the Cepu Block, for example, shows that collaboration between BUMDs and private companies with the Public-Private Partnership financing scheme can help the region in utilizing the PI in the oil and gas block, while significantly increasing regional income (Priadi, 2021). With this PI system, BUMD earns income through production revenue, which can then be allocated for local development and improving community welfare. In addition, regulations that support the role of BUMD in the exploration and management of energy resources, such as those implemented in Bojonegoro, can provide a legal framework and certainty in management and improve the efficiency of profit distribution to local governments (Qurbani et al., 2020). The implementation of

this PI scheme requires the active role of local governments in forming strategic cooperation with investors, as well as transparent management supported by periodic monitoring and evaluation to ensure optimal improvement of PAD. With this approach, BUMDs not only play a role as passive income recipients, but can also become a driving force for the local economy through reinvestment in profit sharing for infrastructure and social welfare programs. This strategy emphasizes the importance of synergy between local government policies and BUMD to support sustainable development and improve the welfare of people in oil and gas producing areas.

2. Optimization of Natural Resources Management, with the existence of BUMD, Wajo Regency has greater control over natural resource management. This allows for more integrated exploration and production with regional interests, reducing reliance on external companies that may not be aligned with local priorities. BUMDs that manage natural resources in Wajo Regency have great potential to increase regional control in the management of oil, gas, and other minerals, while maximizing local profits. To achieve this optimization, the implementation of strategies based on collaborative governance and technology integration is highly recommended. Studies show that the involvement of local governments, the private sector, and communities in the form of strategic cooperation can strengthen natural resource management through a pattern of direct and transparent involvement in the exploration and exploitation process, as successfully implemented in several regions with similar conditions in Indonesia (Gunawan, 2023). In addition, an approach that focuses on the use of technology to improve the efficiency of resource exploration has been shown to reduce dependence on external companies, making it more in line with local and sustainability priorities. In Indonesia, optimizing the role of BUMDs in resource management through information technology and process transparency can also minimize the risk of corruption and increase the efficiency of PAD (Pramugar & Sinaga, 2021). The implementation of this technology includes the implementation of an e-government system that records and monitors in real-time activities and production results, which can be directly accessed by local governments. With this strategy, Wajo Regency will be able to manage its natural resources more independently and sustainably, support local infrastructure development, and improve community welfare through more efficient PAD allocation.
3. Absorption of local labor, BUMD engaged in the oil and gas sector can open up job opportunities for local residents, especially in sub-districts that have the potential for these resources, such as Bola and Keera Districts. This can have a positive impact on reducing the unemployment rate and improving the skills of the workforce in the energy sector. To increase the absorption of local labor in the oil

and gas sector in Wajo Regency, especially in Bola and Keera sub-districts, strategic measures can be implemented to maximize the economic impact on local communities. BUMD can implement training and upskilling programs for local workers to support needs in the energy sector. For example, in Bojonegoro, BUMD in collaboration with the local government has succeeded in opening up job opportunities for local residents through training programs tailored to the needs of the oil and gas industry (Qurbani et al., 2020). By implementing this training and collaboration program, Wajo Regency can strengthen local labor participation in the oil and gas sector, reduce the unemployment rate, and improve relevant technical skills in the region.

4. Increasing the Contribution of the Mining Sector to GDP, with better management through BUMD, the mining sector, especially oil and gas, can increase its contribution to the GDP of Wajo Regency. This helps create a more balanced economic structure and enriches the economic base of the region, not only relying on the agricultural sector. To increase the contribution of the mining sector, especially oil and gas, to the Gross Regional Domestic Product (GDP) of Wajo Regency, a comprehensive approach is needed, including better management through Regionally-Owned Enterprises (BUMD). Based on several related studies that examine the mining sector and its contribution to GDP, there are several strategic steps that can be implemented. First, optimizing natural resource management through BUMD can be done by designating the mining sector as a priority sector in regional development, as shown by research in West Kutai and East Kalimantan Regencies. The research shows that the mining sector, especially oil and gas, is a leading sector that has great potential in driving economic growth if managed properly through the right policy priorities (Karmini et al., 2022). Second, the development of infrastructure and supporting facilities for the mining sector is very important to increase the contribution of GDP. In other studies, improving infrastructure such as transportation access and technical facilities has been proven to improve operational efficiency and competitiveness of the mining sector. This implementation requires collaboration between local governments and BUMDs to ensure adequate facilities are available to support the production and distribution of mining products. Third, the application of appropriate technology in mining activities can also increase the productivity of this sector. An evaluation of industrial technology capabilities conducted in other sectors shows that the right use of technology can increase the competitiveness and economic contribution of the sector. The use of technometric assessment methods can help in evaluating the technological readiness of BUMDs and ensuring that the technology used is in accordance with the needs of the mining industry (Malyana & Khoiriyah, 2021). Fourth, increasing the capacity of human resources through training and development of local workers in the mining sector is important to

ensure that the workforce has skills that are appropriate to the needs of the industry. Investments in technical skills training can be made by BUMDs in collaboration with local education and training institutions. Research shows that local labor empowerment can improve the economic welfare of the community and reduce dependence on labor from outside the region (Timronah et al., 2023). Overall, the implementation of these strategies will not only increase the contribution of the mining sector to the GDP of Wajo Regency, but also help create a more balanced economic structure with diversification of the regional economic base that does not only depend on the agricultural sector.

5. Source of funds for infrastructure development, the profits from BUMD can be used for infrastructure investment, which will support other sectors such as trade and services, as well as facilitate the distribution of oil and gas exploration results. To improve infrastructure development in the oil and gas mining sector, the profits obtained from BUMD can be optimized for infrastructure investment. This approach has been discussed in various studies, which provide guidance on strategic measures that can be implemented. First, research shows that effective fund management from BUMDs can increase investment capacity for relevant infrastructure projects. Studies on infrastructure improvements in different regions show the importance of coordination between local governments and related companies to ensure the sustainability of these projects. For example, research in the tourism and educational infrastructure sector in Malang emphasizes the importance of involving local communities and stakeholders in infrastructure planning and development to ensure the sustainability of the local economy (Prihanta et al., 2022). Second, research related to joint ventures in electricity infrastructure development shows that strategic partnerships between local governments and private entities can accelerate infrastructure development. Through this partnership model, BUMD can act as a facilitator of investment and local capacity development. This experience is relevant in the context of the development of oil and gas distribution infrastructure, where collaboration between the government and the private sector is needed to overcome logistical and operational challenges (Paulin, 2021). Third, the development of local resources and technical infrastructure is an important element in supporting the distribution of oil and gas exploration results. Studies on the utilization of local natural resources to support infrastructure projects suggest intensive efforts to improve local technical skills and supporting infrastructure, which includes technical training and the development of efficient distribution facilities (Andani, 2022). Overall, the profits from BUMDs should be directed to fund strategic infrastructure projects, involving public-private partnerships, effective management, and local capacity building to improve distribution efficiency and support the trade and related services sectors. The implementation of these

measures will strengthen the resilience of the region's economy and ensure long-term benefits for local communities.

6. The establishment of a BUMD that focuses on oil and gas can be a strategic step for Wajo Regency to utilize the potential of natural resources more optimally, strengthen the local economy, and increase regional financial independence. The establishment of BUMD focusing on the oil and gas sector can be a strategic step to utilize the potential of natural resources more optimally, strengthen the local economy, and increase regional financial independence such as in Wajo Regency. Based on some literature, this strategy can be implemented through several main steps. First, strengthening the management capacity of BUMD is very important in ensuring efficient management of natural resources. The development of technical skills and knowledge at the local level, as revealed in research related to the empowerment of local workers in agriculture and natural resource-based industries, can help increase the productivity and operational efficiency of local companies (Nurhidayati et al., 2020). Second, investment in infrastructure that supports oil and gas exploration and distribution needs to be prioritized. This includes the construction of supporting facilities such as roads, ports, and distribution networks that can facilitate easier access to the results of exploration. Research shows that the development of supporting infrastructure can increase the competitiveness of the local economic sector, as well as support more sustainable economic growth (Soesilowati et al., 2020). Third, the application of environmentally friendly technology in the exploration and production process can be one way to increase efficiency and reduce environmental impact. Studies related to the green economy in several countries show that the adoption of green technology can encourage sustainable economic growth while preserving the environment (Thahirah & Adam, 2022). Overall, the establishment of BUMDs that focus on the oil and gas sector with strategic measures such as management capacity building, infrastructure investment, and the adoption of green technology can have a positive impact on the local economy and regional financial independence.

The establishment of Regionally Owned Enterprises (BUMD) in Wajo Regency as mentioned in the (Bappelitbangda Kabupaten Wajo, 2021), especially related to the oil and gas sector, has considerable potential. Wajo Regency is included in the oil and gas employment contract area, which gives the local government the right to a PI of 10% for oil and gas production activities in its area. This PI will be submitted to the producing regions at the exploitation (production) stage. The establishment of BUMD in the oil and gas sector is expected to increase PAD and community welfare. With the existence of BUMD, local governments can extract revenue from the oil and gas sector and provide services to the community, which is a demand that must be

met. In addition, BUMD is expected to play a role in producing the goods and/or services needed to realize the prosperity of the local community. Overall, the establishment of BUMD in the oil and gas sector in Wajo Regency not only aims to increase PAD but also to provide benefits for improving community welfare through the management of existing oil and gas resources.

### **3.2. Relevance of the establishment of BUMD**

#### **3.2.1. Riau Islands Province**

The technical aspects that support the establishment of Energy BUMDs in Riau Islands Province include several strategic capabilities or capacities. One of the main capabilities is the availability of infrastructure and technical facilities in the Mako Field, Duyung Block, which is ready to be used for natural gas production. This field already has facilities owned by Medco E&P Natuna, and the joint utilization of this infrastructure has been regulated through a FSA between Conrad Petroleum and Medco, so that BUMD can optimize the existing infrastructure without the need for large initial investments. Other technical capacities include high-quality, high-quality gas resources, with 2C reserves (contingent resources) reaching 495 BCF which is almost 100% methane, making it efficient and ready for distribution. In addition, the management of PI of 10% allows BUMD to play a role in oil and gas exploration and production activities, which will be supported by subsea processing technology and gas transportation systems through the West Natuna Transportation System (WNTS). These aspects demonstrate the readiness of infrastructure and the quality of resources that allow BUMDs to achieve the expected level of efficiency and profitability. The technical approach that supports the establishment of Energy BUMD in Riau Islands Province, especially related to the use of infrastructure and technical facilities in the Mako Field, Duyung Block, can be optimized with several strategic steps supported by the latest literature and research. First, the joint use of infrastructure through a FSA is a strategic step to reduce the initial cost of investment. Studies on collaboration in the utilization of existing facilities show that this approach can improve operational efficiency and reduce the financial risks typically associated with large projects in the energy sector (Paulin, 2021). Second, the availability of high-quality gas reserves in the Mermaid Block, with a content of almost 100% methane, indicates the potential for high efficiency in exploration and distribution. The management of these resources can be optimized by applying subsea processing technology that has been proven effective in reducing production costs and improving operational safety, as explained in a study on the use of subsea technology in the oil and gas sector (Thahirah & Adam, 2022). Third, the management of PI of 10% provides opportunities for BUMDs to play an active role in oil and gas exploration and production. This participation not only increases local energy independence, but also strengthens the capacity of local management in managing energy projects. This

implementation can be improved with intensive training for local workers in the field of oil and gas technology and resource management, as recommended in several studies on strengthening human resource capacity in the energy sector ((Malyana & Khoiriyah, 2021). Fourth, integration with the WNTS gas transportation system can be used to facilitate the distribution of exploration results. This transportation infrastructure, if used effectively, can increase the competitiveness of BUMDs and minimize logistical constraints that are often an obstacle in natural gas distribution. By utilizing existing facilities, applying the right technology, and strengthening local capacity, the establishment of an Energy BUMD in Riau Islands Province can make a significant contribution to the local and national economy.

Table 3.5. Supporting factors for the relevance of the establishment of Energy BUMD in Riau Islands Province

| Supporting Factors                      | Description                                                                                                                                                                                                           | Related Values/Results                                                                                                                                                                                           |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Resource Availability                   | The Mako Field, Mermaid Block has significant gas potential and is ready to be developed.                                                                                                                             | The potential production reaches 40-45 MMSCFD (peak production) with gas reserves reaching 495 BCF.                                                                                                              |
| Government Policy                       | Special Task Force for Upstream Oil and Gas business Activities (SKK Migas offers a 10% PI to be managed by BUMD as a form of compliance with the Minister of Energy and Mineral Resources Regulation No. 37 of 2016. | SKK Migas' letter No. SRT-0413/SKKMA000/2022/S9 dated October 4, 2022 requests the appointment of a BUMD to manage 10% PI.                                                                                       |
| Potential for Increased PAD             | By participating in the management of PI 10%, BUMDs can obtain profits that increase PAD.                                                                                                                             | Increase in PAD through proportional profits from oil and gas exploration and production activities.                                                                                                             |
| Infrastructure and Technology Support   | The infrastructure at the Mako Field is managed jointly with the Medco E&P Natuna facility through an FSA agreement.                                                                                                  | FSA between Conrad Petroleum and Medco E&P Natuna for the use of the facility.                                                                                                                                   |
| Regional Economic development           | BUMD provides opportunities for local economic growth through the provision of jobs and social programs.                                                                                                              | Job opportunities, especially for skilled workers in the oil and gas sector as well as the Corporate Social Responsibility and Community development Partnership Program programs for the surrounding community. |
| BUMD Special Regulations                | Regulations mandate the formation of BUMD with a focus on oil and gas exploration and production.                                                                                                                     | BUMD is in the form of a Regional Limited-Liability Company that specifically handles PI and is regulated through Regional Regulations.                                                                          |
| Quality and Potential of Gas Production | The Mako Field produces high-quality gas, nearly 100% methane, with verified significant reserves.                                                                                                                    | Category 2C gas resources reached 495 BCF, and category 3C reached 108% higher than the initial estimate.                                                                                                        |

*Source: processed data, 2023*

The establishment of the Energy Regionally Owned Enterprise (BUMD) in Riau Islands Province aims to manage the right to participate PI 10% in the Mako Field, Mermaid Work Area. The existence of BUMD Energi aims to enable local governments to play an active role in oil and gas exploration and production activities, which brings several benefits as follows:



1. Regional Economic Growth Boosters: BUMDs allow regional participation in oil and gas production, which will drive local and national economic growth. This participation also helps in meeting national energy needs. The establishment of BUMD that allows regional participation in oil and gas production can be a significant driver for local and national economic growth. This step is in line with various studies that highlight the importance of regional investment in the energy sector. First, local participation in oil and gas production allows regions to directly utilize their natural resources, thereby increasing regional revenues and reducing dependence on the central government. A related study shows that regional investment in strategic sectors such as oil and gas can increase GDP and create multiple economic effects, such as increasing employment opportunities and strengthening the purchasing power of local communities (Ayuningtyas et al., 2023). Second, to support sustainable economic growth, BUMD needs to play an active role in the management of oil and gas resources, including in terms of exploration and production. In a study on the National Economic Recovery Program, a policy approach that encourages local investment in strategic sectors has been proven to be able to accelerate economic recovery after the COVID-19 pandemic, which also applies to the energy sector at the regional level (Indiarti et al., 2022). Third, the implementation of local participation in the oil and gas sector needs to be supported by an adequate regulatory framework. Research on investment law in Indonesia shows that legal protection for local investors and policy certainty are essential to create a conducive and attractive investment environment for regional investment (Ayuningtyas et al., 2023). Overall, BUMD's participation in oil and gas production is a strategic step that requires appropriate policy support, professional management, and collaboration between local governments and the private sector to maximize local economic potential and support national energy security.
2. Increase in PAD: Profits from oil and gas production activities are not only in the form of profit-sharing Funds but also from the proportion of profits as a contractor shareholder. This will increase fiscal capacity and PAD. Profits from oil and gas production activities through BUMD are not only obtained through the Revenue Sharing Fund, but also from the proportion of profits as a contractor shareholder. This has the potential to increase PAD and regional fiscal capacity. Several studies support this approach as a PAD improvement strategy. First, a study on the contribution of PAD to regional economic growth shows that increasing PAD can strengthen the budget structure of local governments and increase fiscal autonomy. In some regions, the potential of PAD from the oil and gas sector has become one of the main contributors to the regional budget, which allows for more effective allocation of funds for infrastructure development and public services (Christanti, 2020). Second, regional resource management strategies

need to be focused on efficiency and optimal utilization of oil and gas profits. This can be realized through the development of policies that support local investment in the energy sector and encourage the involvement of BUMDs in oil and gas resource management. Clear regulations regarding the sharing of profits between local governments and private companies, as well as a legal framework that supports fiscal autonomy, are important aspects to ensure the sustainability of regional revenues (Juliarini, 2020). Third, research shows that the participation of BUMDs in the oil and gas sector can reduce dependence on the central government by strengthening regional revenues directly. BUMDs that have successfully managed local assets and resources show a significant contribution to PAD through active participation in oil and gas exploration and production (Widiprana, 2022). Thus, optimizing profits from oil and gas production activities through BUMD participation not only increases PAD, but also strengthens sustainable regional fiscal capacity. This implementation requires collaboration between local governments and the private sector as well as strengthening regulations to support greater local participation in the energy sector.

3. **Community Welfare:** The existence of BUMDs has the potential to create jobs, improve welfare through CSR programs, as well as partnership and environmental development programs. This can help reduce unemployment and poverty rates in the region. The existence of BUMD has great potential in improving community welfare through job opening, CSR programs, as well as partnership and environmental development programs. This has proven to be effective in reducing unemployment and poverty in certain regions. Based on several studies, there are several steps that can be implemented to maximize the positive impact of BUMD on community welfare. First, empowering local communities through skills training and technological innovation can increase community income and welfare. A study on empowerment programs in rural areas shows that technology-based training and periodic mentoring can provide optimal results in improving community welfare, especially in creating local business opportunities (Mashur et al., 2021). Second, the implementation of the CSR program by BUMD can also be an important catalyst for poverty alleviation. Several studies emphasize that well-structured social responsibility programs, such as health education and environmental programs, not only improve people's quality of life but also create better relationships between companies and local communities (Nurhidayati et al., 2020). The establishment of BUMD that focuses on socio-economic programs can improve the welfare of the community by creating jobs, improving the quality of life, and empowering local communities through various structured and sustainable programs.

Thus, the establishment of this Energy BUMD is expected to support regional economic progress while contributing to the welfare of the people in Riau Islands Province.

### 3.2.2. Wajo Regency Province

The establishment of BUMD is an effort by local governments in regional revenue by utilizing various resources owned. The establishment of BUMD to explore revenue for the region and provide services to the community is a demand that must be met. The two targets for the establishment of BUMD require a feasibility study that looks at the capacity of local governments' ability to finance and meet the needs of the community through the services provided. BUMD is divided into two groups, the first is Regional Companies to serve the public interest and two, regional companies for the purpose of increasing regional revenue in PAD. The study of the needs of the establishment of BUMD was carried out to determine the type of services and business needs that will be carried out later. The needs study was carried out in reviewing the 10% PI business and the integrated agriculture, market, and parking business fields (table 3.5). Both business fields have the opportunity to be managed professionally through the establishment of BUMD independently considering the needs of the community and business opportunities with the availability of markets in the Wajo Regency area. The results of the use of Nominal Group Technique (NTG) carried out throughout the Wajo Regency area in determining the business field to be established and subsequently included in the business feasibility study are described in the following table:

Table 3.6. Results of Nominal Group Technique (NTG) Data Processing

| No. | BUMD business field                                                                                                                    | Total Score | NGT Consensus Priorities |
|-----|----------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------|
| 1.  | PI business field in Oil and Gas Working Area in Wajo Regency                                                                          | 1,103       | 2                        |
| 2.  | Integrated Agricultural business, Market, and parking                                                                                  | 1,119       | 1                        |
| 3.  | Other business Fields according to the Survey (Most-1; Digital-Based Modern Agricultural, Plantation, Livestock, & Fisheries business) | 1,026       | 3                        |
| 4.  | Other business Fields according to the Survey (Most-2; Creative Economy-business Strengthening of 16 Creative Industry Sub-Sectors)    | 760         | 4                        |
| 5.  | Other business Fields according to the Survey (Most-3; Manufacturing Industry According to the Potential of Wajo Regency)              | 592         | 7                        |
| 6.  | Other business Fields according to the Survey (Most-4; Community Internet Services-Cheap & Quality)                                    | 623         | 6                        |
| 7.  | Other business Fields according to the Survey (Most-5; Management of Basic Commodities)                                                | 726         | 5                        |

*Source: processed data, 2020*

The establishment of Regional-Owned Enterprises (BUMD) can play an important role in exploring the potential of regional revenue and providing services to the community. Based on existing literature studies, several implementation steps that can be taken to maximize the establishment of BUMD and its impact on regional income and community services have been documented. First, research on the optimization of the agricultural sector and other sectors shows that investment in business sectors that have local potential, such as integrated agriculture, can provide significant results. Initiatives such as the Agroschooling program have proven that the introduction of the agricultural sector to the younger generation is able to increase interest and engagement in the sector. This creates opportunities to develop integrated agricultural businesses that can be professionally managed by BUMDs (Saputro & Saputro, 2020). Second, the management of energy resources through the PI business field in the Oil and Gas Working Area shows significant profit potential to increase PAD. Regional participation in oil and gas production can not only provide additional revenue through a proportion of profits, but also strengthen local management capacity and expertise in the energy sector (Tokan et al., 2023). Third, the development of infrastructure and supporting facilities, such as markets and parking, is also an interesting field for BUMDs to manage independently. This infrastructure development can help meet the needs of local communities while creating a business environment that is conducive to regional economic growth (Wisudawati et al., 2023). By utilizing existing resources and focusing on sectors with high economic potential, the establishment of BUMD can be carried out more effectively. The implementation of these measures requires careful planning through comprehensive feasibility studies, as well as ongoing evaluation to tailor business strategies to community needs and market opportunities.

BUMD is an effort by the local government to meet the needs of services to the community. Likewise, the establishment of BUMD in Wajo Regency is expected to meet the needs of services in general to the Wajo community. The need for public services through the management of BUMD at this time, through the analysis of needs, there are three types of businesses identified, namely: 1) Integrated Agricultural business, Market, and parking; 2) PI business field in the Oil and Gas Working Area and 3) Digital-Based Modern Agricultural, Plantation, Livestock, & Fisheries business. The three business fields, two of which have similar business fields with the difference in adding digital resources in their management. For the most chosen business fields, namely the integrated agricultural business field, markets, and parking can be managed jointly in a business management. This is of course to anticipate the various potentials and types of businesses that exist in the existing local government to be used as one in a business forum called a holding company. In addition, the participating interest business field (PI 10%) has a policy that must stand alone without the inclusion of other businesses.

The establishment of BUMD in Wajo Regency, which involves three main types of businesses, namely integrated agriculture, markets, and parking; PI in Oil and Gas Working Areas; and digital-based modern agricultural business, is a strategic step to meet the needs of community services while exploring the economic potential of the region. Based on several literature, there are several implementations that can increase the effectiveness of the establishment of BUMD in this region. First, an integrated agricultural sector that includes markets and parking can be managed effectively through integration in a single management system, such as in the holding company approach. This will allow for more efficient and professional management, as well as facilitate coordination between business units. A study in the agricultural sector shows that agricultural integration and modernization, including the use of technology such as E-paddy applications, have succeeded in increasing the involvement of young people in the agricultural sector, which in turn increases local agricultural productivity (Mambang et al., 2022). Second, the separation of the 10% PI business as a stand-alone entity is very important to optimize performance in the energy sector. Independent management of PI in the oil and gas sector allows a focus on exploration and production, as well as providing opportunities for regions to develop technical and managerial capabilities. Research related to oil and gas management shows that regional participation in this sector not only increases PAD, but also strengthens local capacity in managing strategic resources (Tokan et al., 2023). Third, the use of digital technology in modern agriculture, plantation, livestock, and fisheries businesses can increase efficiency and expand market access. The use of appropriate technology, such as Android-based applications for agriculture, can help farmers manage their businesses more effectively, accelerate access to information, and increase the competitiveness of regional agricultural products in a wider market (Nuraeni, 2020). With the implementation of the above steps, the establishment of BUMD in Wajo Regency is expected not only to meet the needs of public services to the community, but also to act as a driving force for regional economic growth through the optimization of local resources and the use of modern technology.

The integrated agriculture business, Market, and parking business sector has received considerable attention by the Wajo community. This condition is considering the priority conditions objectively related to the need for food availability, market management as a place of community business and parking management. The need for an integrated agricultural business is one of the strategies of the Wajo Regency government to take advantage of food availability and have an impact on improving the standard of living of patani. Likewise with the market business field, currently, Wajo district has a market that is traditionally managed so that it cannot provide income for the region. The market is currently managed by technical implementation units under the Department of Industry, Trade, Cooperatives and Micro, Small

Medium Enterprise (MSMEs). The available markets are spread across several sub-districts, this is an opportunity for the local government to strive for more modern market management. Not far different, the same thing also happens in parking management. Parking management is the authority of the Transportation Office. For this reason, in order to increase the value of results, parking management is better distributed with professional management in a business entity.

Furthermore, the study of service aspects for PI services shows that the community needs service management in energy management from gas and petroleum. Public expression of the need for interest participation services for businesses related to oil and gas produced in the Wajo Regency area. The BUMD in question will later manage support for the implementation of drilling contracts. When the contractor submits the first development plan (Plant of development), the conditions are determined for the contractor to involve the producing areas to participate in production activities, by offering the producing areas to participate in production activities (Article 11 of the Regulation of the Minister of Energy and Mineral Resources Number 6 of 2010). Various community expectations with the existence of BUMD PI are poured out to improve welfare in Wajo Regency has challenges in its management that must have Proof of Delivery (P.O.D.) as a condition for the formation of the BUMD. Later, the BUMD will manage derivative products from oil and gas management in the Wajo Block.

The study of regional needs for the establishment of the BUMD business field outlines the types of services prepared and the conditions of service availability. The business field that will be determined must explain that there is a gap between the conditions that occur or in fact with the desired conditions, both in the availability of integrated agriculture, Market, and parking management services and the utilization of PI opportunities. The effort to establish a BUMD is expected to have a positive impact on the establishment of BUMD in Wajo Regency is urgently needed considering that the BUMD can: Create Jobs (Reduce Unemployment), Can Increase PAD and Community, Can Reduce Illegal Levies. The third general argument for the establishment of BUMD comes from the explanation of the cloud community in Wajo Regency. The community has high hopes for the establishment of BUMD in Wajo to improve the economy in general and avoid the leakage of local revenue. Parking management has so far required reliable management to increase profits in doing good at the lower level of the implementing officers.

Efforts to extract local original revenue from the oil and gas sector are an effort by the Wajo Regency government regardless of the inherent authority. The government regulates the establishment of oil and gas BUMD which is the authority of the province regulated in the Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016 concerning the Provisions of PI Bidding (10%) in oil and gas working areas which allows producing regions to be involved in oil and gas

development while being able to improve community welfare. One of the regional involvement mechanisms is regulated regarding the PI mechanism which aims to provide a portion of the management of producing local governments based on certain parts that have been agreed upon with the business to business (BoB) mechanism through Regionally Owned Enterprises (BUMD) after obtaining the approval of the Minister of Energy and Mineral Resources (ESDM). Oil and gas management business opportunities continue to be pursued by the local government to seek profits with the existence of oil and gas fields in the Wajo Regency area.

With the establishment of BUMD, the government is concerned about the community in various fields, in addition, the goal is clear in developing the economic level of the community and providing benefits of facilities for the region. PI which is the right of the region must be ensured to be utilized by the regions through BUMD which is fully owned by the region. The local government through the establishment of BUMD seeks to find opportunities by partnering with the provincial government to take advantage of opportunities to explore profits in improving PAD and the regional economy. The involvement of provinces that have the authority to manage PI is contained in the Regulation of the Minister of Energy and Mineral Resources No. 37 of 2016 concerning the Provisions of PI Offerings, namely in article 4 and article 9 paragraph (1). BUMD PI must be managed properly in order to provide benefits and benefits for local governments which can ultimately improve the welfare of the community

The involvement of South Sulawesi Province with its authority to become a coordinator for the establishment of regional business entities. In article 4 for fields located on land within 1 (one) province or offshore waters farthest up to 4 (four) nautical miles, the offer of 10% PI is given to 1 (one) Regionally Owned Enterprise whose establishment is coordinated by the governor by involving the regent/mayor whose administrative area has a field approved for the development plan. The Regulation of the Minister of Energy and Mineral Resources emphasizes the authority of the province in coordinating the establishment of BUMD for PI for regions whose areas become oil and gas well fields with an oil and gas field development plan (plan of development).

This BUMD has not become/can be understood well by the community at large where the benefits that can be obtained by the community by PI. The existence of regional companies must be aimed at supporting development and community services by not harming regional finances, and must even provide benefits for regional finances. The Wajo Regency government needs to understand more deeply the potential and management of the 10% PI which is an important part of the equalization of capital and services that will be produced by BUMD later. The governor's power in the management of BUMD PI is the highest authority at the local government level, so the Wajo Regency government needs to have various strategies

in achieving the establishment of BUMD PI. The authority to establish BUMD PI is fully the province's right to coordinate and appoint its BUMD. The authority is regulated in article 9 (1) The Contractor is obliged to submit a written offer of 10% PI to the Regionally Owned Enterprise that has been appointed by the governor as referred to in article 8 paragraph (3) with a copy to the Director General, Head of SKK Migas, and the governor (Bappelitbangda Kabupaten Wajo, 2021).

The importance of the establishment of this 10% PI BUMD can increase the income of the Regional Origin. The ownership of BUMD is purely financed by the local government, so the benefits from the PI will be maximized by the regions or several regions. The establishment of BUMD in the field of oil and gas business in Wajo Regency is needed because it can have a positive impact on the regional economy in this area to get profits/profits as well as encourage community involvement in oil and gas work areas to improve the community's economy and become regional income. Another hope is that the establishment of BUMD will increase the Regional Revenue of Wajo Regency is urgently needed to create jobs and increase regional revenue BUMD have always faced two opposite sides. The purpose of forming BUMD as a source of regional finance to improve the ability and strength of the region in organizing regional affairs on the other hand, BUMD is expected to be a tool of the Regional Government in carrying out public facility services for the community. What services are needed by the Wajo community, how much is the distribution of household gas. Another hope conveyed by the community, with the establishment of BUMD PI 10% is a good opportunity to be able to develop PAD in the district government. Wajo also increased regional participation in oil and gas management.

### **3.3. The influence of regional policies in the management of BUMD.**

Regional policies play an important role in optimizing the management of BUMDs and supporting local economic growth. Recent research shows that inter-regional investment policies, such as the provision of infrastructure and the reduction of administrative burdens, significantly improve BUMD investment decisions, spurring more targeted regional economic growth. Local government support through specific industry policies, such as fiscal allocations, can also improve the efficiency of BUMD investment, reduce the risk of overinvestment, and boost regional productivity (Sang et al., 2023; Dai et al., 2021).

To prepare an effective cross-regional investment policy to support the growth of BUMD, several important aspects need to be considered, including the stages of the mechanism, the parties involved, and the time frame for its implementation. Recent studies show that improving infrastructure, especially communications and transportation, is crucial as it has been shown to attract higher investment to certain regions. Administrative efficiency is also a key factor, where the government needs to reduce the administrative burden for local and foreign investors to speed up the



investment process and increase regional attractiveness (Sang et al., 2023; Sedova & Filatov, 2020). In this preparation, an integrated policy framework and investment strategy are an important basis, especially since it includes a specific plan for each sector of the economy in order to achieve the region's long-term goals (Stepanets & Shafiieva, 2021). This policy preparation mechanism includes multi-stakeholder coordination, where local governments must work closely with the private sector, planning agencies, and local communities to ensure investment policies reflect the needs of all stakeholders. This approach allows for more effective monitoring of policy success and adjusting strategies according to the monitoring results. In addition, continuous monitoring is essential in ensuring that each investment project runs effectively through pre-compiled success indicators (Živojinović, 2020; Nevyantseva, 2022). Responsible parties include local governments as the main stakeholders in setting these policies, supported by the legislature and the executive to pass the necessary regulations. Economic planning institutions, regional companies, and the private sector also need to be involved in providing input on the specific needs of each region (Li et al., 2023).

In addition, local government green policies encourage disruptive innovation in BUMDs in the energy and industrial sectors, facilitating the adoption of environmentally friendly technologies that support the operational sustainability of BUMDs (Xu et al., 2022). Regional autonomy policies in Indonesia, especially in finance, show a significant increase in the fiscal management of BUMD which contributes to local original income and economic independence, supporting regional fiscal sustainability (Pakpahan, 2023). Local macroeconomic policies have a big role to play in improving the efficiency of BUMDs, especially through local government interventions that can reduce excess risks and improve fiscal allocations in strategic sectors. Important preparations in this regard include strengthening fiscal infrastructure and regional administration, as well as the development of regulations that ensure transparency and budget discipline (Duan et al., 2022; Zhang et al., 2021). In addition, to encourage efficiency in investment, it is necessary to closely monitor expenditures and levels of regional debt which can have a direct impact on the efficiency of BUMDs (Dai et al., 2021; Ai et al., 2020). The mechanism for preparing this policy involves several stages: first, an analysis of the needs of the local industrial sector to identify funding priorities; second, the preparation of regulations that support investment in the sector; and third, the establishment of a comprehensive BUMD performance monitoring system to evaluate the efficiency of the use of the regional budget (Zheng & Wang, 2023). Local governments, along with legislative institutions, and BUMDs themselves need to cooperate in this process, with the government acting as policy setters and BUMDs as implementers who must comply with predetermined efficiency standards (Oliinyk & Kucheriava, 2023). Thus, this strategy is expected to maximize the efficiency of BUMDs and support sustainable

economic development at the regional level. Furthermore, regional policies that focus on increasing local original income through BUMD management have proven to be effective in encouraging socio-economic development at the local level, reducing dependence on the central budget, and creating more equitable economic development (Fauzi & Widarjo, 2021). Thus, this study emphasizes that regional policies that are tailored to local needs play a crucial role in optimizing the contribution of BUMD to economic growth and community welfare.

### **3.4. Conclusion**

This document highlights the importance of the role of BUMD in the energy and oil and gas (oil and gas) sectors to support regional economic growth, especially in the Riau Islands Province and Wajo Regency. The establishment of BUMD that focuses on oil and gas is considered to be able to optimize the potential of natural resources, increase Regional Original Revenue (PAD), and create jobs for local communities. In the Riau Islands Province, the potential for gas reserves in the Duyung Block is very large and can be utilized through shared infrastructure regulated in the FSA, so that the initial investment becomes more efficient and accelerates gas production. Meanwhile, in Wajo Regency, the 10% PI scheme provides opportunities for producing regions to participate in oil and gas production, the impact of which can be directly felt by the local community through economic improvement and social welfare.

A number of recommendations are proposed to maximize the benefits of the oil and gas sector in producing areas. First, it is important for local governments to support the role of BUMDs with appropriate regulations and training programs in the energy sector so that BUMDs can manage resources optimally. In addition, cooperation between BUMDs, the private sector, and universities is very important in research and adoption of environmentally friendly technologies to improve the efficiency and sustainability of oil and gas management. Skills training programs for local workers are also recommended so that the community can participate directly in the growing oil and gas industry. Finally, some of the profits of BUMDs should be directed to fund the development of public infrastructure, which will support other sectors such as trade and services, and overall strengthen the regional economy. With these strategic steps, the oil and gas sector have the potential to become the main pillar for sustainable economic growth in oil and gas producing areas.

## Reference

- Achmad, Y., Syahnur, S., & Seftarita, C. (2022). The Effect of the Exploration and Exploitation of Oil and Gas on Indonesian Economic Growth. *International Journal of Quantitative Research and Modeling*, 3(3). <https://doi.org/10.46336/ijqrm.v3i3.342>
- Alaloul, W. S., Musarat, M. A., Rabbani, M. B. A., Iqbal, Q., Maqsoom, A., & Farooq, W. (2021). Construction sector contribution to economic stability: Malaysian gdp distribution. *Sustainability (Switzerland)*, 13(9). <https://doi.org/10.3390/su13095012>
- Andani, D. (2022). Kinerja Dinas Pekerjaan Umum Dan Penataan Ruang Dalam Pengelolaan Sumber Daya Air Di Kabupaten Subang. *The World of Public Administration Journal*. <https://doi.org/10.37950/wpaj.v4i2.1494>
- Ayuningtyas, V. P., Puspita, N. A., & Prakoso, B. (2023). Peran Hukum Investasi Terhadap Pertumbuhan Ekonomi Nasional Dalam Prespektif Neo-Classical Economy Theory. *Journal of Economic and Business Law Review*, 3(2). <https://doi.org/10.19184/jebclr.v3i2.43956>
- Bappelitbangda Kabupaten Wajo. (2021). *Studi Kebutuhan Daerah dalam Pendirian Badan Usaha Milik Daerah (BUMD) Di Kabupaten Wajo*.
- Basuki, A. T. (2023). Do Macroeconomic Variables and Effective Fiscal Policies Affect Indonesian Economic Development? *European Journal of Development Studies*, 3(2). <https://doi.org/10.24018/ejdevelop.2023.3.2.240>
- Christanti, P. L. (2020). ANALISIS POTENSI PERTUMBUHAN PENDAPATAN ASLI DAERAH (PAD) UNTUK OPTIMALISASI PENDAPATAN PEMERINTAH PROVINSI JAWA TENGAH. *Stability: Journal of Management and Business*, 3(1). <https://doi.org/10.26877/sta.v3i1.6424>
- Dahliah, D., Kurniawan, A., & Putra, A. H. P. K. (2020). Analysis and strategy of economic development policy for SMEs in Indonesia. *Journal of Asian Finance, Economics and Business*, 7(5). <https://doi.org/10.13106/JAFEB.2020.VOL7.NO5.103>
- Gunawan, B. T. (2023). Do Natural Resources Affect Unemployment? Evidence from Indonesian Province Panel Data. *Signifikan: Jurnal Ilmu Ekonomi*, 12(2). <https://doi.org/10.15408/sjie.v12i2.31824>
- Indiarti, M., Liong, Y., Riskasari, R., & Gunawan, Y. I. (2022). ANALISIS PELAKSANAAN PROGRAM PEMULIHAN EKONOMI NASIONAL (PEN) SEBAGAI FAKTOR PENDORONG PERTUMBUHAN EKONOMI INDONESIA UNTUK MENGATASI DAMPAK EKONOMI PANDEMI COVID-19. *Jurnal Manajemen Kewirausahaan*, 19(2). <https://doi.org/10.33370/jmk.v19i2.899>
- Jamolv, J. (2021). IMPROVING METHODOLOGICAL APPROACHES IN THE IMPLEMENTATION OF GROSS REGIONAL PRODUCT. *INNOVATIONS IN ECONOMY*, 4(4), 26–32. <https://doi.org/10.26739/2181-9491-2021-4-4>

- Juliarini, A. (2020). KOMPARASI PENERIMAAN PAJAK DAERAH KOTA DAN KABUPATEN DI INDONESIA SETELAH BERLAKUNYA UNDANG-UNDANG PAJAK DAERAH DAN RETRIBUSI DAERAH. *Jurnal BPPK: Badan Pendidikan Dan Pelatihan Keuangan*, 13(2). <https://doi.org/10.48108/jurnalbppk.v13i2.227>
- Karmini, K., Saroyo, S., Karyati, K., Widiati, K. Y., Widuri, N., & Sulichantini, E. D. (2022). SEKTOR UNGGULAN DI KABUPATEN KUTAI BARAT DAN KONTRIBUSINYA DALAM PENYERAPAN TENAGA KERJA DI PROVINSI KALIMANTAN TIMUR. *JURNAL RISET PEMBANGUNAN*, 5(1). <https://doi.org/10.36087/jrp.v5i1.114>
- Kuzmin, P. I., & Zinoviev, A. G. (2020). ANALYSIS AND ASSESSMENT OF REGIONAL ECONOMIC DEVELOPMENT USING THE ANALOG MODEL OF L. R. KLEIN. *Economics Profession Business*, 2. <https://doi.org/10.14258/epb201972>
- Lin, B., & Zhu, R. (2021). Energy efficiency of the mining sector in China, what are the main influence factors? *Resources, Conservation and Recycling*, 167. <https://doi.org/10.1016/j.resconrec.2020.105321>
- Luckyardi, S., Soegoto, E. S., Supatmi, S., Warlina, L., & Hassan, F. H. (2022). MARKETING STRATEGY FOR LOCAL SUPERIOR COMMODITIES AND REGIONAL ECONOMIC CONTRIBUTIONS OF INDONESIA. *Journal of Eastern European and Central Asian Research*, 9(1). <https://doi.org/10.15549/jeecar.v9i1.866>
- Malyana, N., & Khoiriyah, N. (2021). Evaluasi Kontribusi Teknologi Dalam Upaya Peningkatan Daya Saing IKM Agroindustri Hasil Laut di Kabupaten Demak Menggunakan Metode THIO+ (THIOCMP). *JURNAL TEKNIK INDUSTRI*, 11(2). <https://doi.org/10.25105/jti.v11i2.9701>
- Mambang, M., Cipta, S. P., Marleny, F. D., Ansari, N. H., Baddrudin, A., Yenitia, A., Dixky, D., Melda, M., Azizah, N., Mutmainah, M., Fikri, R. M., & Salsabila, T. (2022). E-Padi Berbasis Android Untuk Meningkatkan Minat Generasi Muda Pada Sektor Pertanian. *Jurnal Nasional Komputasi Dan Teknologi Informasi (JNKTI)*, 5(1). <https://doi.org/10.32672/jnkti.v5i1.3968>
- Mashur, M., Subagio, S., Hamid, G., & Oktaviana, D. (2021). Pemberdayaan Masyarakat Desa Taman Ayu Melalui Inovasi Teknologi Sistem Integrasi Jagung Dan Sapi (Sijasa). *Sasambo: Jurnal Abdimas (Journal of Community Service)*, 3(2). <https://doi.org/10.36312/sasambo.v3i2.422>
- Meglin, R., Kytzia, S., & Habert, G. (2022). Regional circular economy of building materials: Environmental and economic assessment combining Material Flow Analysis, Input-Output Analyses, and Life Cycle Assessment. *Journal of Industrial Ecology*, 26(2). <https://doi.org/10.1111/jiec.13205>
- Meyer, D. F., & Niyimbanira, F. (2021). Formulation and application of a multi-variable location quotient index in the Mpumalanga Province, South Africa. *Local Economy*, 36(4). <https://doi.org/10.1177/02690942211049505>
- Nuraeni, Y. (2020). Kinerja Seksi Usaha Ekonomi Masyarakat Dalam Pemberdayaan Pengelola Badan Usaha Milik Desa (BUMDES) Di Kabupaten Subang. *The World of Business Administration Journal*. <https://doi.org/10.37950/wbaj.vi.748>

- Nurhidayati, S., Khaeruman, K., & Lukitasari, D. (2020). Pemberdayaan Kelompok Masyarakat Desa Ketapang Raya Melalui Usaha Produktif Terasi Rebon Pasca Gempa Lombok. *Lumbung Inovasi: Jurnal Pengabdian Kepada Masyarakat*, 5(1). <https://doi.org/10.36312/linov.v5i1.458>
- Otsuka, K. (2021). Strategy for Transforming Indonesian Agriculture. *Bulletin of Indonesian Economic Studies*, 57(3). <https://doi.org/10.1080/00074918.2021.2002387>
- Paulin, S. T. (2021). PERKEMBANGAN JOINT VENTURE COMPANY DALAM PEMBANGUNAN INFRASTRUKTUR KETENAGALISTRIKAN. *Fiat Iustitia: Jurnal Hukum*. <https://doi.org/10.54367/fiat.v2i1.1287>
- Paulus, C. A., Azmanajaya, E., Pellokila, M. R., & Paranoan, N. (2020). Prospective strategies for sustainable local economic development in support of the SDGs' goals "inclusive and sustainable economic growth" in the border region of Indonesia-Timor Leste, Belu Regency, East Nusa Tenggara Province, Indonesia. *Journal of Physics: Conference Series*, 1464(1). <https://doi.org/10.1088/1742-6596/1464/1/012053>
- Pramugar, R. N., & Sinaga, R. Y. (2021). E-GOVERNMENT IN OPTIMIZING NON-TAX REVENUE OF THE MINING SECTOR IN INDONESIA. *JAF- Journal of Accounting and Finance*, 5(1). <https://doi.org/10.25124/jaf.v5i1.3743>
- Priadi, S. N. (2021). *The Success of Managing Participating Interest (PI) in Cepu Block in Increasing Regional Revenue InEast Java*. <https://doi.org/10.29118/ipa21-bc-99>
- Prihanta, W., Purwanti, E., & Zainuri, Ach. M. (2022). Konservasi Sumber Air dan Wisata Edukasi di Desa Ngenep, Kecamatan Karangploso, Kabupaten Malang. *Lumbung Inovasi: Jurnal Pengabdian Kepada Masyarakat*, 7(4). <https://doi.org/10.36312/linov.v7i4.629>
- Qurbani, I., Sumarno, T., & Cassy, R. (2020). Regional Economic Development Strategy: Increasing Local Generated Domestic Revenue of the Regional-Owned Enterprises in the Oil and Gas Sector. *Brawijaya Law Journal*, 7(1), 70–81. <https://doi.org/10.21776/ub.blj.2020.007.01.05>
- Ratnasari, N. E., Ningrum, S., Susanti, E., & Ginting, N. M. (2022). Rethinking Strategies To Improve Economic Development In Bandung Regency. *Economics Development Analysis Journal*, 11(3). <https://doi.org/10.15294/edaj.v11i3.61199>
- Saputro, W. A., & Saputro, F. E. N. (2020). Program Agroschooling pada Siswa Sekolah Dasar SD 01 Manang untuk Meningkatkan Minat terhadap Bidang Pertanian. *Indonesian Journal of Community Services*, 2(1). <https://doi.org/10.30659/ijocs.2.1.68-79>
- Shafa Alifia Salsabila, Monika Putri Maharani, & Ariyanti Putri Joestiawan. (2023). Solar Enhanced Oil Recovery as the Solution to Enhance Oil and Gas

- Production for Mature Fields in Indonesia. *Indonesian Journal of Energy*, 6(2). <https://doi.org/10.33116/ije.v6i2.163>
- Soesilowati, E., Martuti, N. K. T., Sumastuti, E., & Setiawan, A. B. (2020). REVITALISASI KELEMBAGAAN PETANI SEBAGAI WAHANA ALIH TEKNOLOGI DAN INKUBATOR BISNIS PENDUKUNG AGRO TECHNO-PARK PORWOSARI, SEMARANG. *Jurnal Graha Pengabdian*, 2(4). <https://doi.org/10.17977/um078v2i42020p335-346>
- Thahirah, U., & Adam, M. (2022). MODEL PANEL GREEN ECONOMY DALAM RANGKA PENCAPAIAN PERTUMBUHAN EKONOMI BERKELANJUTAN PADA 21 NEGARA ANGGOTA OKI. *Jurnal Muara Ilmu Ekonomi Dan Bisnis*, 6(1). <https://doi.org/10.24912/jmie.v6i1.12709>
- Timronah, T., Setyowati, R., & Winarno, J. (2023). PERSEPSI PETANI KOPI TERHADAP PEMBERDAYAAN OLEH KOMUNITAS ASSALWA RESOURCE CENTER (KASUS DI DESA TOMBO KECAMATAN BANDAR KABUPATEN BATANG). *AGRORADIX: Jurnal Ilmu Pertanian*, 7(1). <https://doi.org/10.52166/agroteknologi.v7i1.4704>
- Tokan, F. B., Medho, Y. F., Lamawuran, Y. D., & Ethelbert, Y. K. (2023). Pelatihan tentang Proses Pendirian dan Penentuan Jenis Usaha Bumdes di Desa Watoone-Kecamatan Witihamu Kabupaten Flores Timur. *Jurnal Pengabdian Pada Masyarakat*, 8(4). <https://doi.org/10.30653/jppm.v8i4.530>
- Widiprana, R. B. (2022). Analisis Pengaruh Dana Otonomi Khusus dan Pendapatan Asli Daerah terhadap Produk Domestik Regional Bruto pada Kabupaten dan Kota di Provinsi Papua Barat. *Lensa Ekonomi*, 16(02). <https://doi.org/10.30862/lensa.v16i02.246>
- Wisudawati, N., Irfani, M. G., Hastarina, M., & Santoso, B. (2023). Penggunaan Metode Importance-Performance Analysis (IPA) Untuk Menganalisis Kepuasan Masyarakat Terhadap Pelayanan Administrasi Kependudukan. *Integrasi: Jurnal Ilmiah Teknik Industri*, 8(1). <https://doi.org/10.32502/js.v8i1.5969>
- Yakhshilikov, J. J. (2020). Factors Determining the Regional Industrial Development and Industrial Production Potential: The Case of Samarkand Region. *Indonesian Journal of Law and Economics Review*, 7. <https://doi.org/10.21070/ijler.2020.v7.478>
- Yu, W. (2020). Analysis of Location quotient of major industries in Qinghai Province. *E3S Web of Conferences*, 189. <https://doi.org/10.1051/e3sconf/202018901009>
- Zhang, Q., Abdullah, A. R., Chong, C. W., & Ali, M. H. (2022). A Study on Regional GDP Forecasting Analysis Based on Radial Basis Function Neural Network with Genetic Algorithm (RBFNN-GA) for Shandong Economy. *Computational Intelligence and Neuroscience*, 2022. <https://doi.org/10.1155/2022/8235308>



# Policy Impact on Natural Resources Management

## Chapter

## 4

Aliffisya Ummu Raihan, Tedy Kardana

The policy framework for oil and gas natural resources management at the national and regional levels includes the role of the government in regulating and coordinating effective management, the implementation of environmental policies such as emission control and waste management, socio-economic impact analysis and sustainability challenges for natural resources and local communities, with policy recommendations that support a balance between economic benefits and environmental protection.

### **4.1. Policy Framework for oil and gas Natural Resources Management**

In the context of oil and gas natural resource management, the implementation of policy framework parameters requires an integrated approach that includes clear regulations, community involvement, and alignment with the sustainable development goals (SDGs). Effective regulation must be accompanied by strong enforcement and transparency in the decision-making process to prevent environmental degradation and maintain socio-economic stability. Studies by (Dhali et al., 2023) show that the implementation of environmentally friendly energy policies require regulatory revisions in line with the SDGs, especially in addressing sustainable energy shortages through more responsive policies. On a national scale in Indonesia, regulations that have been promulgated in the context of sustainable development such as the Oil and Gas Law (Law No. 22 of 2001) are prepared to improve the oil and gas governance system through the regulation of rights, obligations, and revenue sharing between the government and business entities, with the aim of creating a competitive investment climate and increasing the efficiency of the oil and gas sector. Its implementation is carried out through cooperation contracts, the granting of business licenses, and supervision that pays attention to the company's compliance with regulations. On the other hand, the law on Regional Government (Law No. 23 of 2014) functions to clarify the authority of the central and regional governments in the management of natural resources after the implementation of regional autonomy. Through this law, the role of regions is increased in the aspects of environmental supervision and the use of local natural resources, although challenges in harmonizing central-regional policies still often

arise. Furthermore, Government Regulation (PP) No. 79 of 2014 concerning the national energy policy is here to answer the increasing national energy needs by encouraging the sustainable use of oil and gas natural resources and reducing dependence on fossil energy. Its implementation includes energy diversification and incentives for the development of renewable energy. Presidential Regulation No. 22 of 2017 concerning the National Energy General Plan strengthens national energy policy with specific targets and guidelines for achieving sustainable energy until 2050, instructing the central and regional governments to prepare plans to reduce dependence on oil and gas through the development of renewable energy adapted to local conditions.

Indonesia's high dependence on petroleum shows that the need to fulfill this energy is something very vital, so that improving petroleum governance is an urgent thing to do, to create energy sovereignty in Indonesia. The oil and gas (oil and gas) industry is a strategic industry for all countries in the world because it will greatly affect many sectors of economic life. Oil found in various sources, both on land and in marine areas is obtained through the drilling process. The first oil drilling in Indonesia was carried out by Reerink, in 1871 independently in the area of Cibodas Tangat, Maja, Majalengka, West Java. Commercially successful drilling was only carried out in 1885 by Aeliko Jans Zeilker in the Telaga Said Field, North Sumatra. History then records that this is the forerunner of the Royal Dutch oil and gas company, The Royal Dutch Shell.

Our Constitution, the 1945 Constitution, officially regulates how energy should be managed (in the constitution we know as natural wealth). It is clearly stated that in article 33 paragraph (2) the branches of production that are important to the state and that control the lives of the people are controlled by the state (3) The earth and water and the natural resources contained in it are controlled by the state and used for the greatest possible prosperity of the people. During the Soekarno administration, the Indonesian government issued regulations related to oil and gas, namely Law Number 44 PRP/1960 concerning Oil and Gas Mining. Regulations in the oil and gas sector continued to develop in line with the improvement in world oil prices at that time. One of them is the issuance of Law Number 8 of 1971 concerning the State Oil and Gas Mining Company.

In Indonesia, the regulation that regulates petroleum management is Law No. 22 of 2001 concerning oil and gas and then amended through Government Regulations in Lieu of Laws No. 2 of 2022 concerning Job Creation. In addition to being a legal umbrella in petroleum management, the Oil and Gas Law also regulates natural gas management, the realization of state policies in oil and gas management is always developing, which then gave birth to several oil and gas policies in the upstream and downstream sectors. Law Number 22 of 2001 as amended by Government Regulations in Lieu of Laws Nomor 2 of 2022 concerning Job Creation



defines that petroleum is the result of natural processes in the form of hydrocarbons that are under atmospheric pressure and temperature conditions in the form of liquid or solid phases, including asphalt, mineral wax or ozokerite, and bitumen obtained from the mining process, but does not include coal or other hydrocarbon deposits in solid form obtained from activities that are not related to oil and gas business activities, while natural gas is the result of a natural process in the form of hydrocarbons that are under pressure and atmosphere temperature conditions in the form of gas phases obtained from the Oil and Gas mining process. Furthermore, in article 4 paragraph 2, it is explained that oil and gas contained in Indonesia's mining jurisdiction includes national wealth controlled by the state. This article emphasizes that the management of oil and gas is fully controlled by the state and its purpose is clearly to meet the needs of many people. If we look again at article 5 (Oil and Gas Law) it is explained that, oil and gas business activities can be carried out with business licensing from the central government, this emphasizes that the management of oil and gas must indeed go through the approval of the central government, because oil and gas affairs are vital and must be used for the welfare of citizens and the country itself. This is a strengthening foundation for every derivative policy that regulates the management of the oil and gas sector, as stated in Government Regulation No. 35 of 2004 article 78 paragraph 1: All goods and equipment that are directly used in upstream business activities purchased by contractors become state property/property whose guidance is carried out by the government and managed by work units

In addition, PMK No. 89/PMK 06/2019 article 1 point 5 also explains that: Goods that are property/neara wealth derived from contractors here in after referred to as BMN Hulu Migas are all goods purchased or obtained by contractors in the context of the implementation of upstream oil and gas business activities as well as the remaining operations and remaining production as the implementation of cooperation contracts between contractors and the government. Policies in the upstream sector are broadly regulated in the Oil and Gas Law number 22 of 2001 as amended by Law No. 6 of 2023 concerning the Determination of Government Regulations in Lieu of Laws Number 2 of 2022 concerning Job Creation into law, where in article 5 which clearly regulates upstream and downstream business activities, downstream businesses include exploration and exploitation while downstream businesses include; processing, transportation, storage, and trading, specifically upstream activities in the oil and gas sector are regulated in PP 35 of 2004, with PP 34 of 2005, with PP No. 93 of 2021 concerning Upstream Oil and Gas.

Talking about oil and gas, we must also know the oil and gas institutions in Indonesia. Oil and gas affairs are specifically managed by the oil and gas Special Task Force (SKK), this institution was officially established through Presidential Decree No. 9 of 2013, SKK Migas carries out the implementation of the management of

upstream oil and gas business activities under the guidance, coordination, and supervision of the Minister. SKK Migas is fully responsible to the President of the Republic of Indonesia, SKK Migas is fully supervised by the supervisory commission consisting of (Minister of Energy and Mineral Resources, Deputy Minister of Finance for state financial affairs, Head of the Capital Management Agency and Deputy Minister of Energy and Mineral Resources), one of the tasks of the supervisory commission is to give approval to the proposed strategic policies and work plans of SKK Migas in the context of the implementation of the management of upstream oil and gas business activities. SKK Migas in its duties is responsible for upstream oil and gas activities, as mandated in article 6 of the Oil and Gas Law that: Upstream business activities are carried out and controlled through cooperation contracts. Cooperation contracts are carried out by cooperative contractors (KKS) who carry out the exploitation-production process, there are two types of KKS that collaborate with SKK Migas, namely Conventional and Unconventional, according to SKK Migas itself currently there are 151 Conventional KKS and nineteen Unconventional KKS that manage the oil and gas sector in Indonesia. The complete regulations governing oil and gas can be seen as follows:

1. Law: Law No. 22 of 2001 concerning oil and gas; Law No. 6 of 2023 concerning the Implementation of Government Regulations in Lieu of Law No. 2 of 2022 concerning Job Creation into Law.
2. Government regulations, consisting of: Government Regulation No. 35 of 2004 concerning Upstream Oil and Gas Activities; Government Regulation No. 34 of 2005 concerning Amendments to Government Regulation No. 35 of 2004 concerning Upstream Oil and Gas Activities; Government Regulation No. 55 of 2009 concerning the Second Amendment of Government Regulation No. 35 of 2004, Upstream Oil and Gas Activities; Government Regulation No. 79 of 2010 concerning Cost Recovery; Government Regulation No. 23 of 2015 concerning the Management of Oil and Gas Natural Resources in Aceh.
3. Presidential Instruction and Presidential Regulation, consisting of: Presidential Instruction No. 2 of 2012 concerning Increasing oil and gas Production; Presidential Decree No. 95 of 2012 concerning the Transfer of Authority of BP Migas; Presidential Decree No. 9 of 2013 concerning the Establishment of SKK Migas
4. Regulation of the Minister of Energy and Mineral Resources: Minister of Energy and Mineral Resources Regulation No. 48 of 2017 concerning Supervision of Business Operations in the Energy and Natural Resources Sector Regulation of the Minister of Energy and Mineral Resources No. 28 of 2006 concerning General Survey Guidelines; Ministerial Regulation of RSDM No. 37 of 2006 concerning Import Procedures; Minister of Energy and Mineral Resources Regulation No. 40 of 2006 concerning Procedures for Determining Work Areas; Minister of Energy and

Mineral Resources Regulation 02 of 2008 concerning DMO Contractors/KKS; Minister of Energy and Mineral Resources Regulation 03 of 2008 concerning Guidelines for the Return of Work Areas; Minister of Energy and Mineral Resources Regulation No. 22 of 2008 concerning Types of Non-Refundable Fees to KKS; Minister of Energy and Mineral Resources Regulation No. 35 of 2008 concerning Procedures for Determining Oil and Gas Working Areas; Minister of Energy and Mineral Resources Regulation 5 of 2012 concerning Procedures for Determining and Bidding Non-Conventional oil and gas Wks; Minister of Energy and Mineral Resources Regulation 15 of 2015 concerning the Management of Oil and Gas WK Terminated Contracts; Minister of Energy and Mineral Resources Regulation 8 of 2017 concerning Gross Split Profit Sharing Contracts; Minister of Energy and Mineral Resources Regulation 52 of 2017 concerning Amendments to Minister of Energy and Mineral Resources Regulation 8 of 2017 Gross Split Profit Sharing Contract; Minister of Energy and Mineral Resources Regulation 20 of 2019 concerning the Second Amendment to the Minister of Energy and Mineral Resources 8 of 2017 Gross Split Profit Sharing Contract; Minister of Energy and Mineral Resources Regulation 12 of 2020 concerning the Third Amendment of Minister of Energy and Mineral Resources Regulation 8 of 2017 Gross Split Profit Sharing Contract

Participating Interest (PI) in the oil and gas sector was born from a desire for oil and gas producing regions to get access to justice in the management of their natural resources. PI 10% (Ten Percent), hereinafter abbreviated as PI 10%, is the maximum amount of ten percent participating interest in the Cooperation Contract that must be offered by the Contractor to Regional-Owned Enterprises or State-Owned Enterprises. PI is not equated with share ownership because the regions that control 10% (ten percent) and contractors amounting to 90% (ninety percent) are only workers who manage the state area according to the Production Sharing Contract scheme. The 10% PI is the maximum amount that must be offered by the contractor to BUMD since the approval of the first field development plan, with the existence of the PI will be able to provide benefits for a region, so that oil and gas producing areas can enjoy their oil and gas wealth sources and to realize the welfare of people living in oil and gas areas. The rules on PI are contained in:

1. Government Regulation No. 35 of 2004 concerning upstream oil and gas business activities, where the rules on PI are listed in article 34 which reads, since the approval of the field development plan that will be produced for the first time from a work area, the contractor is obliged to offer a participating interest of 10% (ten percent) to the Regionally Owned Enterprise). Furthermore, article 35 regulates, the period of the statement of interest and the ability to take the PI within a period of 60 (sixty) days from the date of the offer from the contractor.

2. Regulation of the Minister of Energy and Mineral Resources (Permen ESDM) Number 37 of 2016 concerning the provisions for offering a PI of 10% in the Oil and Gas Working Area. In article 1, it is explained that: PI of 10% (ten percent) is the maximum amount of ten percent PI in the Cooperation Contract that must be offered by the contractor to Regional-Owned Enterprises or State-Owned Enterprises.
3. Article 2 of the Minister of Energy and Mineral Resources Regulation Number 37 of 2016 concerning PI Offering Provisions states, since the approval of the first field development plan to be produced which is located on land and/or offshore waters up to twelve nautical miles in a working area, contractors (KKKS) are required to offer 10% PI to Regionally Owned Enterprises (BUMD). The BUMD must have the following requirements: BUMD can be in the form of, a regional company whose entire share ownership is owned by the local government or, a limited-liability company whose shares are at least 99% owned by the local government and the rest of its share ownership is wholly affiliated with the local government; Its status is ratified through a Regional Regulation; not conducting business activities other than PI management

The implementation of the 10% PI offer is carried out by fulfilling the following conditions, for fields located on land within a province or offshore waters up to four nautical miles farthest away, the 10% PI offer is given to one BUMD whose formation is coordinated by the governor by involving the regent/mayor whose administrative area has a field approved for the development plan. For fields located in offshore waters with a distance of more than four nautical miles to twelve nautical miles measured from the coastline to the open sea, a 10% PI offer is given to BUMDs whose implementation is coordinated by the governor. For fields located on land and/or offshore waters in the administrative area of more than one province, the implementation of the 10% PI offer is carried out on the condition that it is based on an agreement between the governor concerned coordinated by the governor whose area covers most of the developed field, or in the event that the agreement between the governors as referred to in number 1 cannot be reached within a maximum of three months from the date of Request for the appointment of Regionally Owned Enterprises, the Minister determines the amount of PI that will be offered to each province. In the event that the management of the 10% PI is not managed by the new BUMD, the BUMD that receives the 10% PI offer can appoint a regional company. In the event that a 10% PI offer is given to SOEs, it is carried out in a business manner by taking into account proportionally of the operating costs incurred during the exploration and exploitation period based on the work plan and budget and the provisions of the cooperation scheme do not apply.

4. Furthermore, the Regulation of the Minister of Energy and Mineral Resources Number 48 of 2017 concerning Supervision of Business in the Energy and Mineral Resources Sector, in article three explains, contractors in transferring part or all of their interest participation to other parties must first obtain ministerial approval by taking into account the consideration of the head of SKK Migas. The contractor cannot transfer the majority of the PI to other parties who are not its affiliates within the first 3 years of the exploration period. To obtain the approval in letter a above, the contractor must submit a written application to the Minister through the head of Special Task Force for Upstream Oil and Gas Business Activities (namely SKK Migas) by attaching, a copy of the agreement of the parties on the transfer of interest (deed of assignment); a copy of the deed of establishment of the beneficiary company; a copy of the register of shareholders of the beneficiary company; the company profile of the beneficiary and the identity of the parent company (company profile) of the beneficiary in the event that there is a parent company of the beneficiary; the financial statements of the beneficiary company for the last three years that have been audited by a public accountant or the financial statements of the parent company for the beneficiary company Interest whose establishment has not reached three years; quantitative equivalent value report of the percentage of interests transferred and signed by both parties; Sales And Purchase Agreement (SPA) or similar documents underlying the transaction of interest transfer; data utilization permit; data confidentiality agreement; organizational structure of the interest recipient company and the taxpayer identification number of the interest recipient company and the management of the interest recipient company. Meanwhile, in article four, it is explained that the head of SKK Migas evaluates the application as referred to in article three; based on the results of the evaluation as referred to in paragraph one, the head of SKK Migas shall submit his consideration to the Minister within a maximum period of fourteen working days from the date the application is received completely and correctly; and the Minister shall give approval or rejection of the application for the transfer of PI within a maximum period of fourteen working days from the receipt of the consideration letter of the head of SKK Migas as referred to in paragraph two.
5. Decree of the Minister of Energy and Mineral Resources Number 223.K/MG.01/MEM. M/2002 concerning the Implementation of the Provisions for Offering 10% PI to BUMDs in Oil and Gas Working Areas. This Ministerial Decree technically explains several things, namely: Explanation of Regional Companies implementing 10% Participating Interest; Additional Time for the Preparation and Appointment of BUMDs in the 10% PI Offering; The provisions of the 10% PI Offer Policy relate to fields where some areas are above twelve nautical miles; Provisions for the implementation of the 10% PI Offer related to the Cooperation

Contract that regulates the 10% PI Offer to BUMDs that existed before the Minister of Energy and Mineral Resources Regulation No. 37/2016 and has not yet been implemented the 10% PI Offer. Cooperation Contracts That Are Not Required to Offer 10% PI. Incomplete Data Access Process and Deadline for Submitting 10% PI Transfer Application for Unsubmitted Applications. Supervision and Control of Bidding or Implementation of PI 10%.

#### **4.2. Community Involvement in the Management of the Oil and Gas Industry**

Community involvement in the management of the oil and gas industry in the affected areas is very important to create a sustainable and balanced environment. One of the recommended approaches to increase this engagement is through the implementation of Corporate Social Responsibility (CSR) that is more responsive to local social and environmental needs, as outlined in a study by (Krawchenko & Gordon, 2022) on the role of extractive industries in Siberia. Stronger CSR implementation can be done through direct collaboration with local communities, for example by building environmental education programs or job skills training to increase economic opportunities for local residents. To support a just transition, a collaborative approach between stakeholders involving companies, governments, and communities needs to be facilitated with structured discussion forums and training. This approach is supported by a study by (Krawchenko & Gordon, 2022), which found that community integration in oil and gas natural resource management decision-making improves socio-economic stability and reduces environment-related conflicts. In addition, technological innovation and sustainable supply chain management can optimize more environmentally friendly oil and gas operations, such as in a study that shows the effectiveness of artificial intelligence (AI) in environmental management of energy companies. This not only reduces environmental impact but also increases the financial stability of the company with higher efficiency (Chutcheva et al., 2022). By implementing a collaboration model supported by technology and increasing CSR, community involvement in oil and gas natural resource management can be increased, creating a long-term positive impact on local communities and the environment.

The implementation of community involvement (table 4.1.) in the management of the oil and gas industry, good practices that have been implemented are able to have an impact on the community. Best practices in the oil and gas industry show how an integrated approach can drive better sustainability and community engagement. One example is the integrated environmental management guidance developed by IOGP and UNEP, which includes best practices for managing environmental risks throughout the life cycle of oil and gas projects. These guidelines assist companies in adopting effective measures to protect local ecosystems as well as involve communities in environmental monitoring, thereby increasing corporate

transparency and responsibility to the surrounding community (Brown et al., 2020). In addition, a sustainable CSR program is also important in improving relationships with local communities. A study from the National Oil Corporation of Kenya shows that CSR programs that focus on social and environmental projects can create a positive impact on the surrounding community. These programs include job training and infrastructure development tailored to the needs of the community, supporting harmonious long-term relationships between companies and local communities and supporting sustainability in various social and economic aspects (Maundu (MBA), 2020).

Table 4.1. community involvement in oil and gas natural resource management

| Stages of the Mechanism                           | Description.                                                                                                              | Implementation Examples                                                                                                                                                                                            |
|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Identify Community Needs                       | Understand the social, economic, and environmental needs of communities affected by oil and gas activities.               | Surveys and interviews with residents around oil and gas exploration areas to identify community priorities. (Krasnoshtanova, 2023)                                                                                |
|                                                   |                                                                                                                           | In Indonesia, oil and gas companies such as Pertamina hold surveys and dialogues with communities in their operating areas to understand their socio-economic needs. (Cahyandito, 2017)                            |
| 2. Collaboration in Planning and Decision-Making  | Build an engagement forum between companies, governments, and communities to make decisions together.                     | Establish a joint supervisory committee with representatives from companies, local governments, and communities to monitor activities and compliance with environmental policies (Krawchenko & Gordon, 2022)       |
|                                                   |                                                                                                                           | In Malaysia, Petronas works with local communities to create CSR programs that are tailored to the needs of the surrounding community, such as education and infrastructure (Nordin et al., 2023)                  |
| 3. Implementation of Sustainable CSR Programs     | Implementation of CSR programs that are in line with local needs, such as job skills training or environmental education. | Skills training programs for local residents to work in the oil and gas sector or in other businesses that support the local economy (Cahyandito, 2017)                                                            |
|                                                   |                                                                                                                           | Petronas in Malaysia runs education and skills training programs for the local community, especially for the younger generation, to have the relevant skills to work in the energy industry (Mojarad et al., 2018) |
| 4. Use of Technology for Environmental Management | Implementing environmentally friendly technology in oil and gas operations to reduce environmental impact.                | Leveraging AI to monitor operational impacts on the environment, identify potential risks, and optimize production processes (Chutcheva et al., 2022)                                                              |
| 5. Impact Evaluation and Continuous Improvement   | Conduct periodic evaluations of programs and operational impacts, and adjust plans based on community feedback.           | An annual forum to assess the results of CSR programs and environmental initiatives with direct input from local communities (Gardas et al., 2019)                                                                 |
|                                                   |                                                                                                                           | Petronas conducts annual evaluations with local communities to measure the social and environmental impacts of their programs and adjust the programs based on community input (Wan Ahmad et al., 2016)            |

Sources: Author's search, 2024

In terms of energy efficiency and emission reduction, SPE through the Gaia Program introduces innovative technologies in the field of Health, Safety and Environment (HSE) to reduce the environmental impact of oil and gas operations. The

program includes the use of technologies such as real-time monitoring of carbon emissions and the application of AI in operational management, which not only improves efficiency but also helps reduce negative impacts on the environment (Knode, 2020). Furthermore, the World Bank recommends Community Development Agreements (CDAs) as an effective tool to ensure long-term benefits for local communities around natural resource projects. CDAs encourage companies to work with governments and communities in designing relevant development programs, such as economic development and skills training, that can sustainably improve local welfare (Otto, 2010). The last relevant practice is the integration of sustainability in supply chain management or sustainable supply chain management (SSCM). Research shows that the integration of environmentally friendly practices in the supply chain can increase the competitiveness of oil and gas companies by involving suppliers who have high environmental standards, as well as enabling companies to manage operational risks in a more environmentally responsible manner (Sadaghiani et al., 2015).

The oil and gas industry implements sustainability practices and community engagement through several important stages with clear responsibilities and outcomes. The first stage is the development of integrated environmental management guidelines prepared by industry organizations such as IOGP with the support of UNEP. These guidelines set out best practices for managing environmental risks throughout the project lifecycle, from exploration to production. These guidelines are updated regularly, and help companies maintain environmental compliance and strengthen relationships with local communities by ensuring transparency in their operations (Brown et al., 2020). The next stage is the implementation of the CSR program which focuses on empowering local communities. The program includes job training, infrastructure development, and other social initiatives tailored to the needs of the community. The main responsibility lies in the company's CSR department with collaboration from local governments and educational institutions. This program is carried out continuously throughout the project and has a positive impact on improving economic well-being and the relationship between the company and the surrounding community (Maundu (MBA), 2020). At the operational stage, the company uses technology to improve energy efficiency and monitor emissions in real-time. Technologies such as AI are being applied to detect and reduce the potential for excessive emissions. The company's Operations and Technology Department is responsible for this implementation, which continues throughout the production period. The impact is a reduction in carbon footprint and improved energy efficiency that contribute to the company's positive reputation in terms of sustainability (Knode, 2020). The CDA is another important stage that involves a formal agreement between the company and the community to ensure the company's contribution to local welfare. CDA enables collaboration in the provision



of relevant job training, health programs, and economic development, carried out by the company's CSR team with the government and community leaders. This agreement was drafted at the initial stage of the project and helped to create harmonious relations with the community and ensure the equitable economic benefits of the project (Otto, 2010). The final stage is the integration of sustainability in supply chain management, or SSCM, where companies work with suppliers who have sustainability commitments. The Procurement and Logistics Department ensures the supply chain meets sustainability standards throughout the project. The positive impact is the reduction of the environmental impact of the entire supply chain as well as the improvement of the company's reputation supported by high sustainability standards (Sadaghiani et al., 2015). With the implementation of these measures, oil and gas companies are not only strengthening sustainability in their operations but also strengthening relationships with communities, providing tangible economic benefits, and protecting the environment around the operational areas. These practices demonstrate that the oil and gas industry can run more sustainable and responsible operations with the integration of strong environmental and social approaches, creating long-term benefits for local communities and the surrounding environment.

#### **4.3. Adoption of the United Nations Framework Classification**

Adaptation to the SDGs can be achieved through the adoption of the United Nations Framework Classification (UNFC) framework, which provides integrative guidance for natural resource management by balancing social, economic, and environmental aspects. (Al-Ghnemi et al., 2020) show that the UNFC can be an effective instrument for managing natural resources within the framework of the SDGs, especially by incorporating social and environmental aspects into sustainability-focused resource management. The UNFC is a system designed by the United Nations to classify and manage resources such as energy, minerals, and other natural resources in a structured and transparent manner. First adopted in 2004 and updated in 2009, the UNFC is now the global standard for helping countries and companies assess the availability and economic, technical, social and environmental value of their resources. With a three-dimensional evaluation mechanism (economics, technical feasibility, and geological knowledge), the UNFC plays an important role in mapping resources based on their level of readiness to be developed. This system can also be adjusted and used by various types of resources, ranging from fossil energy, minerals, to renewable energy such as geothermal (MacDonald et al., 2018).

The UNFC was developed in line with the SDGs to ensure that the management of natural resources also consider the balance between economic, social and environmental sustainability. For example, the UNFC facilitates resource classification by paying attention to social and environmental impacts that can assist

stakeholders—both governments and companies—in decision-making in support of the SDGs, such as minimizing the environmental impact of resource extraction and increasing social benefits for local communities (Al-Ghnemi et al., 2020). UNFC is important because it provides a structured approach to sustainable resource management. It provides a framework for governments and companies to make decisions related to natural resources that are consistent, transparent, and of international standards. This is crucial in the midst of climate change issues and the need to maintain a reliable supply of energy and resources while maintaining ecological sustainability (Pribyl et al., 2021).

Table 4.2. UNFC implementation in the framework of achieving the SDGs

| Country      | UNFC implementation                                                                                                                        | Key Indicators                                       | Linkage to SDGs                                                                                                  |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| South Africa | Applying the UNFC in the classification of mineral and fossil resources, with a focus on economic growth and energy security.              | - Technical feasibility                              | SDG 9 (Industrial Infrastructure and Innovation), SDG 13 (Climate Change) (Ali et al., 2018)                     |
|              |                                                                                                                                            | - Economic availability and environmental impact     |                                                                                                                  |
| Brazil       | The use of the UNFC for the classification of natural resources, including renewable energy and environmental conservation.                | - Social impact of resource projects                 | SDG 15 (Terrestrial Ecosystems), SDG 2 (Food Security and Sustainable Agriculture) (Gil et al., 2019)            |
|              |                                                                                                                                            | - Economic linkages and environmental sustainability |                                                                                                                  |
| Jordan       | Develop a UNFC-based framework for sustainability assessments of non-residential buildings, supporting energy efficiency and conservation. | - Energy management                                  | SDG 11 (Sustainable Cities and Communities), SDG 9 (Industry, Innovation, Infrastructure) (Alawneh et al., 2019) |
|              |                                                                                                                                            | - Quality and sustainability of construction         |                                                                                                                  |
| Indonesia    | Implementing UNFC in sustainable development, especially to improve social justice and inclusion in society.                               | - Social inclusion                                   | SDG 16 (Peace, Justice and Strong Institutions) (Barmandi & Ellya Dameria Enesca, 2023)                          |
|              |                                                                                                                                            | - Human rights                                       |                                                                                                                  |
| Malaysia     | Using the UNFC to address environmental sustainability issues, especially related to pollution reduction and energy efficiency.            | -Tolerance                                           | SDG 16 (Peace, Justice and Strong Institutions) (Barmandi & Ellya Dameria Enesca, 2023)                          |
|              |                                                                                                                                            | - Pollution management                               |                                                                                                                  |
| Thailand     | Develop UNFC-based policies to improve energy security through the development of renewable energy technologies and energy efficiency.     | - Use of renewable energy                            | SDG 7 (Clean and Affordable Energy), SDG 12 (Responsible Consumption and Production) (Zulkifli et al., 2020)     |
|              |                                                                                                                                            | - Energy reserves                                    |                                                                                                                  |
| Philippines  | Involving youth in the implementation of the SDGs which includes education, empowerment, and involvement in development planning.          | - Energy access                                      | SDG 7 (Clean and Affordable Energy) (Tongsopit et al., 2016)                                                     |
|              |                                                                                                                                            | - Eco-friendly technology                            |                                                                                                                  |
|              |                                                                                                                                            | - Youth involvement                                  | SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth) (Mohd Yusof & Ariffin, 2021)                  |
|              |                                                                                                                                            | - Educational empowerment                            |                                                                                                                  |

Source : Author's search, 2024

The UNFC uses a three-axis framework that evaluates the economic, technical, and socio-environmental aspects of a resource project. The economic aspect assesses the financial benefits, the technical aspect assesses the feasibility of the project, and the socio-environmental aspect assesses its impact on society and ecosystems. The

system maps resources in categories that allow policymakers to make more informed decisions and focus on sustainable development (Purewal et al., 2019). Several countries have implemented the UNFC within the framework of achieving the SDGs, with relevant indicators used to measure the progress of their implementation (table 4.2).

With the implementation of the UNFC, countries can strategize for more effective and sustainable use of natural resources, help reduce negative environmental impacts, and promote CSR. This ultimately contributes to the achievement of SDGs targets, such as preserving the environment and improving community welfare (Rudko et al., 2019). Manager and Implementer: The development and management of the UNFC is carried out by the United Nations Economic Commission for Europe (UNECE), while its implementation on the ground is carried out by governments, companies, and resource experts who collaborate in the classification and evaluation process, ensuring that resources are managed with a sustainable approach and in accordance with international standards (Feder, 2019). Overall, the UNFC is an essential framework to support the SDGs by enabling more responsible and sustainable management of natural resources in various sectors.

#### **4.4. Implementation of Environmental Policies in the oil and gas Sector**

The implementation of environmental policies in the oil and gas sector includes a series of strategies and procedures to reduce the adverse impact of oil and gas activities on the environment. This policy includes efforts such as the implementation of standards-based Environmental Management Systems (EMS) such as ISO 14001, strict supervision of exploration activities, and regular monitoring to control industrial emissions and waste. For example, oil and gas companies in Indonesia have implemented EMS as part of a larger environmental mitigation strategy, as well as conducting environmental impact assessments (EIAs) to ensure that each of their activities meets applicable environmental standards (Muzanni et al., 2022). The importance of implementing this policy lies in protecting the ecosystem and meeting the demands of environmental regulations, especially considering that the oil and gas sector has great potential to pollute soil, water, and air. Without strict regulations, long-term impacts such as land degradation, water pollution, and increased greenhouse gas emissions can occur and threaten the sustainability of natural resources and public health (Cordes et al., 2016). The implementation of Environmental Policy has also been a scientific concern highlighted by various indicators (table 4.3.). The positive impact of environmental policies in the oil and gas sector includes increasing the company's competitiveness through reducing the risk of high-cost environmental damage and improving the company's reputation in the eyes of the public and investors. Studies show that the implementation of EMS and continuous efforts to meet ESG (Environmental, Social, and Governance) standards

can improve a company's financial performance, attract investors, and create opportunities for innovation in more environmentally friendly technologies (Nazarova & Tikhomirov, 2022).

Table 4.3. Environmental Policy Implementation, Indicators and impacts

| Implementation                                            | Description                                                                                                                                                                                             | Key Indicators                                             | Expected Impact                                                                                                        |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| EMS                                                       | The application of ISO 14001 to environmental management standards, includes emission monitoring, waste management, and pollution reduction in every oil and gas activity.                              | - Compliance with ISO 14001 standards                      | Improving operational efficiency and reducing environmental risks (Muzanni et al., 2022)                               |
|                                                           |                                                                                                                                                                                                         | - Amount of waste reduction                                |                                                                                                                        |
|                                                           |                                                                                                                                                                                                         | - Greenhouse gas emission levels                           |                                                                                                                        |
| EIA                                                       | A comprehensive analysis of the potential impact of oil and gas activities on the environment before the project is implemented.                                                                        | - AMDAL Results                                            | Identify and mitigate negative impacts on local ecosystems (Sheydai et al., 2021)                                      |
|                                                           |                                                                                                                                                                                                         | - Number of recommendations and mitigation actions taken   |                                                                                                                        |
| Emission Monitoring & Pollution Control                   | Regular monitoring to measure and control air, water, and soil pollution emissions during the oil and gas exploration and production process.                                                           | - The amount and type of emissions produced                | Reducing the impact of pollution and meeting local environmental regulations (Cordes et al., 2016)                     |
|                                                           |                                                                                                                                                                                                         | - Compliance with government-regulated emission limits     |                                                                                                                        |
| Use of Renewable Energy                                   | Utilizing renewable energy sources in oil and gas company operations, such as solar and wind power, to reduce dependence on fossil fuels.                                                               | - Percentage of renewable energy in operations             | Reducing carbon emissions and improving long-term sustainability (Ferdiana & Ginting, 2023)                            |
|                                                           |                                                                                                                                                                                                         | - Amount of reduction in fossil fuel consumption           |                                                                                                                        |
| Application of AI Technology for Environmental Management | Using AI to monitor, analyze, and optimize environmental management in every phase of oil and gas operations.                                                                                           | - Energy efficiency                                        | Improving responses to environmental risks and process efficiency (Chutcheva et al., 2022)                             |
|                                                           |                                                                                                                                                                                                         | - The level of accuracy of environmental impact prediction |                                                                                                                        |
| Implementation of Post-Mine Reclamation System            | The program is designed to restore affected land and ecosystems after oil and gas activities are completed.                                                                                             | - Percentage of reclaimed area successfully                | Restoring affected ecosystems and maintaining habitat sustainability (Valishvili, 2020)                                |
|                                                           |                                                                                                                                                                                                         | - Vegetation density after reclamation                     |                                                                                                                        |
| Social Life Cycle Assessment                              | The social impact assessment of oil and gas technology uses the Social Life Cycle Assessment (S-LCA) approach to identify social areas that need to be improved for sustainable technology development. | - Local community involvement                              | Reducing social resistance and supporting the adoption of environmentally friendly technologies (Hannouf et al., 2020) |
|                                                           |                                                                                                                                                                                                         | - Compliance with human rights                             |                                                                                                                        |
| Integrated Ecological Policy (HSE MS)                     | Implementation of the health, safety, and EMS (HSE MS) in oil and gas companies with the target of achieving international environmental standards.                                                     | - HSE MS compliance level                                  | Improve operational safety and regulatory compliance (Kochetkova et al., 2016)                                         |
|                                                           |                                                                                                                                                                                                         | - Number of accidents and incidents                        |                                                                                                                        |
| Technology Enhancements for Energy Efficiency             | The use of AI to improve energy efficiency and environmental monitoring in oil and gas operations, with the aim of reducing the impact of emissions and pollution.                                      | - Percentage of renewable energy used                      | Accelerating response to incidents and reducing carbon footprint (Chutcheva et al., 2022)                              |
|                                                           |                                                                                                                                                                                                         | - Total carbon emissions                                   |                                                                                                                        |
|                                                           | Development of indicators based on the pressure-state-response                                                                                                                                          | - Total oil emissions                                      | Ensuring that offshore activities minimize                                                                             |
|                                                           |                                                                                                                                                                                                         | - Inspection frequency                                     |                                                                                                                        |

| Implementation                                    | Description                                                                                                                                                                      | Key Indicators                            | Expected Impact                                                                                    |
|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------|
| Environmental Licensing Indicators                | (PSR) model to monitor offshore production activities in Brazil, with indicators of emissions, water toxicity, and inspection frequency.                                         | - Water toxicity level                    | environmental impact (de Oliveira Bredariol, 2020)                                                 |
| Sustainability Reporting with the IPIECA Approach | The use of IPIECA guidelines for sustainability reporting of oil and gas companies in GCC countries, includes indicators such as emissions, worker safety, and water management. | - Total annual emissions                  | Increasing transparency and accountability in sustainability reporting (Aljanadi & Alazzani, 2023) |
|                                                   |                                                                                                                                                                                  | - Worker accidents per 1,000 hours worked |                                                                                                    |

*Sources: Author's search, 2024*

The management and implementation of this policy involves various stakeholders, including the government that sets regulations, as well as oil and gas companies that implement environmental management policies and programs. Policy implementation is often overseen by government agencies and involves international agencies that promote consistent environmental standards around the world (Valishvili, 2020). By consistently implementing environmental policies, the oil and gas sector can reduce its negative impact on the ecosystem and build more sustainable business practices, in line with the global agenda to maintain environmental sustainability for future generations.

#### **4.5. Challenges, Obstacles and Recommendations for Natural Resources Sustainability**

Environmental policies in the oil and gas (oil and gas) sector, such as gas flaring management, waste recovery, and the implementation of an EMS, can contribute positively to environmentally friendly management by reducing carbon emissions, water pollution, and other environmental risks. For example, flaring gas recovery policies and the implementation of EMS have been proven to reduce greenhouse gas emissions and improve energy efficiency, thereby supporting the operational sustainability of oil and gas companies (Sinha et al., 2020). However, these policies can hinder optimal environmental management if companies experience financial or technical resource constraints, which can reduce their motivation to implement costly measures, such as emission reduction technologies.

This policy has been widely implemented since the 1990s, especially when awareness of the environmental impact of the oil and gas industry is increasing. This policy is constantly evolving and improved with technological innovations such as AI for environmental monitoring. The implementation of AI allows companies to monitor and respond to potential environmental risks more quickly and accurately, thereby providing efficiency in compliance with regulations and reducing negative impacts on ecosystems (Chutcheva et al., 2022). The impact of this policy not only provides environmental benefits, but also encourages a positive image of the company and increases the attractiveness of investors, especially those who care about ESG standards. In the long-term, the integration of these sustainability policies supports

companies in meeting energy needs in a safe and sustainable way, as well as meeting regulatory and societal expectations, which in turn can improve the financial and operational stability of companies (Nazarova & Tikhomirov, 2022). The implementation of environmental policies in the oil and gas sector plays an important role in supporting more environmentally friendly and sustainable management, although it requires significant investment which may be a challenge for some companies.

Sustainability policies in the oil and gas sector face a number of significant challenges, ranging from economic uncertainty, regulatory pressures, to the need for investment in environmentally friendly technologies. One of the main challenges is the high costs and risks associated with implementing low-emission technologies and other sustainability strategies, such as the use of renewable energy and waste recovery systems. On the other hand, less stringent and inconsistent regulations in some countries hinder progress in the implementation of these sustainability policies (Mojarad et al., 2018).

The implementation of sustainable environmental policies in the oil and gas sector faces various challenges. One of the main obstacles is the high cost of low-emission technologies, such as the reduction of flare gases or the utilization of renewable energy, which often require large initial investments. The following is an illustration of reducing gas flares with gas reuse technology. An oil and gas company wants to reduce emissions from flare gas with gas reuse technology. This technology allows gas that would normally be burned in flares to be collected, compressed, and sold as liquefied natural gas (LNG). This not only reduces emissions, but can also provide additional revenue.

Parameters and Assumptions:

- flare gas capacity to be reduced: 10 million cubic meters per year;
- initial investment cost of gas reuse technology: USD 5 million;
- annual operating and maintenance (O&M) costs: USD 200,000 per year;
- LNG selling price: USD 0.50 per cubic meter;
- estimated project lifespan: 10 years;
- discount rate for present value analysis (NPV): 8% per annum.

Calculation Steps:

- initial Investment: USD 5 million;
- annual Revenue from LNG Sales:
  - total gas sold per year = 10 million cubic meters;
  - annual revenue = 10 million m<sup>3</sup> \* USD 0.50/m<sup>3</sup> = USD 5 million per year
- Annual Operating Fee = USD 200,000;
- Annual Net Income:

$$\begin{aligned} \text{Annual Net Revenue} &= \text{Annual Revenue} - \text{O\&M Expenses} \\ &= 5,000,000 - 200,000 = 4,800,000 \text{ USD per year} \end{aligned}$$

Calculation of present value using the NPV formula:

$$NPV = \sum_{t=1}^n \frac{\text{Annual Net Income}}{(1-r)^t} - \text{Initial Investment} \dots \dots \dots (1)$$

Where:

r = discount rate (8%)

t = tth year

n = project lifespan (10 years)

NPV calculation (rough example without precision calculation):

$$NPV \approx \frac{4,800,000}{(1 + 0.08)^1} + \frac{4,800,000}{(1 + 0.08)^2} + \dots + \frac{4,800,000}{(1 + 0.08)^{10}} - 5,000,000$$

Analysis of the results if the  $NPV > 0$ , then the project is considered profitable in the long run. On the other hand, if the  $NPV < 0$ , then the investment may not be financially feasible. Flare gas reduction projects with gas reuse technology can generate significant annual revenue and provide emission reductions. However, an initial investment of USD 5 million is a significant cost that requires an in-depth evaluation using NPV to ascertain whether the savings and net income from LNG sales are able to cover the initial investment and operating costs over the life of the project.

This simulation makes it difficult for small companies or countries with limited resources, as they are less able to bear the additional costs for better environmental management (Mojarad et al., 2018). Another obstacle stems from the complexity of regulations and inconsistent legal infrastructure, especially in developing countries that have weaknesses in environmental law enforcement. Overlapping and frequently changing regulations make it difficult for companies to meet expected environmental standards. This is seen in some countries, where regulatory inconsistencies hinder efforts to mitigate the environmental impact of oil and gas exploration and production (Doric & Dimovski, 2018). In addition, the oil and gas sector also face technological challenges in integrating EMSs based on AI and digitalization. While this technology promises to be more accurate and efficient monitoring, many companies have not been able to adopt it due to the lack of adequate supporting infrastructure and technical expertise. In Russia and Kazakhstan, for example, the integration of digital technology is still constrained by the lack of competent human resources in these technologies (Evseeva et al., 2023). Obstacles in the implementation of environmental policies in the oil and gas sector show the need for improvements in regulations, increased investment in green technology, and the development of competent human resources in advanced technology. This can accelerate the transition to more sustainable and environmentally friendly oil and gas management practices in the future.

Table 4.4. Digital transformation trends in the oil and gas industry

| Country                                      | Past Trends (before 2020).                                                                                                                                  | Present Trends (2020-2023).                                                                                                                                  | Future Trends (after 2023).                                                                                                                              |
|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Russia (Tretyakov & Cherepovitsyn, 2022)     | The initial implementation of digitalization focuses on improving operational efficiency. However, the technology is still in the early stages of adoption. | Focus on comprehensive digitalization, especially in the Arctic region. The technologies used include IoT and AI to increase productivity.                   | It will accelerate digitalization with a focus on clean energy technologies, especially in the Arctic, and improving efficiency through big data and AI. |
| Norwegia (Haoael & Nemeslaki, 2023)          | Early use of digital technologies, including the application of IoT in several areas to improve the efficiency of offshore oil operations.                  | Norway is currently leading the way in the implementation of digitalization with a focus on collaborative data platforms and partnerships between companies. | Future focus on improving digital strategies to support the clean energy transition and improve energy security and efficiency management.               |
| United States (Wanasinghe et al., 2020)      | The implementation of digital technology is limited to applications in the field of exploration and production.                                             | Increasing the adoption of technologies such as Digital Twins and IoT to monitor assets and improve operational safety.                                      | The focus will shift to reducing the carbon footprint through digitalization to support sustainability and improve energy efficiency in production.      |
| Kazakhstan (Omarov & Taikulakova, 2023)      | Digital transformation is carried out in stages with the use of project management applications for process optimization and data management.               | Focus on implementing digital applications to improve project management efficiency, especially in the field of oil and gas turnarounds.                     | It is expected to expand the use of digital platforms in supply chain management to improve operational efficiency and reduce costs.                     |
| Vietnam (Nguyen Linh & Sarah Gilleski, 2022) | Early adoption of digital technology in oil and gas exploration, focusing on cost efficiency.                                                               | Increasing the use of cloud computing and big data to optimize costs and competitiveness in the energy sector.                                               | The use of AI and IoT will be enhanced for real-time operational monitoring and more accurate management of environmental risks.                         |
| Singapura (Do et al., 2020)                  | The application of digital technology for oil and gas operational optimization, but limited to a small scale.                                               | Focus on leveraging AI, IoT, and cloud solutions for supply chain management and improving operational efficiency.                                           | It will continue to be a regional leader in digital technology adoption and operational innovation, with a focus on energy sustainability.               |
| Thailand (Do et al., 2020)                   | Digitalization adoption is limited to certain areas of the oil and gas sector, with a focus on process automation.                                          | Improve risk management and operational efficiency through the application of basic digital technologies.                                                    | Will develop a more robust digital platform to optimize operational safety and efficiency of oil and gas supply chains.                                  |
| Filipina (Do et al., 2020)                   | Limited to operational improvements and manual data management.                                                                                             | Start adopting digital technologies to improve sustainability and risk management in the oil and gas sector.                                                 | It is expected to apply more digital technologies in the oil and gas supply chain to reduce environmental costs and risks.                               |

Source : Author's search, 2024

Key recommendations to address these challenges include increased cooperation between governments and the private sector in the development of consistent standards and regulations around the world. Additionally, investments in digital technology and AI are highly recommended as they can help monitor environmental impacts and improve operational efficiency. This technology also allows companies to identify and respond to environmental risks more quickly and accurately (Chutcheva et al., 2022). Increased cooperation between the government



and the private sector in the development of standards and regulations in the oil and gas sector, as well as investments in digital technology and AI are essential to improve operational efficiency and environmental impact monitoring. This is important because the oil and gas sector faces major challenges in reducing environmental risks and ensuring safe and sustainable operations. Digital technologies, including the Internet of Things (IoT) and Digital Twins, enable real-time monitoring, rapid data analysis, and better risk management, which supports the sustainability goals of the oil and gas sector (Wanasinghe et al., 2020).

This implementation needs to start immediately because the trend of digital transformation in the oil and gas industry is already underway (table 4.4), and the adoption of new technologies such as AI continues to grow. However, the overall adoption across sectors is still in its infancy, especially in the global adoption of digital technology in this sector (Wanasinghe et al., 2020).

The impact of this cooperation and investment includes an increase in operational efficiency of up to 100% in some cases, a decrease in costs, a reduction in the time required in critical processes, and an increase in the ability to manage environmental risks more accurately (Amer et al., 2022). In addition, the management of greenhouse gas and energy emissions has also become more efficient, in line with the goal of reducing the carbon footprint of the oil and gas sector (Rossi et al., 2022). The management of this program usually involves governments and regulatory bodies that collaborate with global oil and gas companies and technology developers. The government is in charge of regulating and setting international standards, while oil and gas companies together with technology providers carry out implementation in the field (Keys & Taylor, 2021). To achieve sustainability and efficiency in the oil and gas sector, public-private collaboration and the adoption of digital technologies such as AI must be carried out urgently to significantly reduce environmental and operational risks.

#### **4.6. Conclusion**

The main findings related to the impact of policies on natural resource management in the oil and gas sector highlight that government policies, both at the national and regional levels, have a significant influence in determining environmentally friendly management practices. Here are some relevant findings:

1. **National Policies Encourage Sustainable Natural Resources Management:** National policies, such as the Oil and Gas Law No. 22 of 2001 and related environmental regulations, are designed to ensure that oil and gas natural resources are managed sustainably. This policy sets standards for the effective use of natural resources, while prioritizing environmental impact control through EIA assessments and the implementation of an EMS based on the ISO 14001 standard. The implementation of this policy can support more environmentally

friendly natural resource management, for example through carbon emission reduction programs and the utilization of oil and gas waste.

2. Disharmony of Central and Regional Policies: One of the main obstacles to the implementation of environmental policies in the oil and gas sector is the disharmony between central and regional government policies. Regional autonomy, which gives greater authority to local governments in natural resource management, often leads to disagreements with central policies. This can hinder the implementation of comprehensive policies, especially related to environmental regulations aimed at reducing pollution and maintaining the sustainability of natural resources. For example, central regulations governing waste and gas flaring management do not always run smoothly at the local level due to lack of coordination and limited local resources.
3. Environmental Policy implementation Still Varies: In some regions, Environmental Policy implementation still faces challenges, especially related to technical and financial limitations. Although environmental regulations such as AMDAL assessments are mandatory, their oversight and enforcement are uneven across regions, leading to often suboptimal natural resource management. On the other hand, countries with stricter and more consistent environmental policies, such as Singapore and Malaysia, are able to better integrate digital technologies and renewable energy sources, which significantly supports sustainability efforts in the oil and gas sector.
4. The Role of Technology in Supporting Policy: Policies that encourage the use of digital technologies such as AI and the IoT have proven to support more environmentally friendly natural resource management. This technology allows companies to monitor environmental impacts in real-time, improve operational efficiency, and mitigate environmental risks faster. This shows that policies that facilitate the application of technology can directly support the sustainability of oil and gas operations.

The impact of policies on natural resource management in the oil and gas sector shows that national and regional policies have a crucial role in determining how these natural resources are managed. Good policies can support environmentally friendly management, while policies that are poorly coordinated or inconsistent between the central and local governments can hinder sustainability efforts. For example, in Indonesia, the implementation of environmental policies such as gas flaring recovery, the implementation of an EMS, and EIA has helped reduce carbon emissions and improve energy efficiency in the oil and gas sector. National policies, such as the Oil and Gas Law and its derivative regulations, provide a legal framework for oil and gas management, including the sustainable use of natural resources. However, this policy still often faces obstacles in harmonizing with regional policies, especially since

regional autonomy was enforced. Increasing the role of regions in environmental supervision is very important, but the gap in the implementation of regulations between the central and regional governments can hinder the effectiveness of more environmentally friendly natural resource management. On the other hand, environmental policies such as the use of renewable energy and digital technologies, including AI, for environmental monitoring have proven effective in supporting more sustainable management. AI allows companies to more quickly identify environmental risks and respond more accurately, thereby improving compliance with environmental regulations and lowering negative impacts on ecosystems.

The government needs to strengthen harmonization between central and regional policies, especially in terms of environmental management, to avoid overlap or gaps in policy implementation. In addition, oil and gas companies need to be encouraged to adopt more advanced digital technologies, such as AI and renewable energy, to improve the efficiency and sustainability of their operations. The government should also provide incentives for companies that are committed to environmental sustainability, including in terms of emission reduction and waste management. Successful sustainable oil and gas natural resource management requires coherent policies, technological support, and collaboration between various stakeholders, including the central government, local governments, and the private sector.

## Reference

- Alawneh, R., Ghazali, F., Ali, H., & Sadullah, A. F. (2019). A Novel framework for integrating United Nations Sustainable Development Goals into sustainable non-residential building assessment and management in Jordan. *Sustainable Cities and Society*, 49. <https://doi.org/10.1016/j.scs.2019.101612>
- Al-Ghnemi, M., Al-Sane, A., Dhote, P., Bora, A., Al-Bahar, M., Purewal, S., Walker, J., Dharanidharan, B., & Hornbrook, J. (2020). Application of united nations framework classification for hydrocarbon reserves and resources volumes for a mature oil reservoir in Kuwait. *Proceedings - SPE Annual Technical Conference and Exhibition, 2020-October*. <https://doi.org/10.2118/201606-ms>
- Ali, S., Hussain, T., Zhang, G., Nurunnabi, M., & Li, B. (2018). The implementation of sustainable development goals in “BRICS” countries. *Sustainability (Switzerland)*, 10(7). <https://doi.org/10.3390/su10072513>
- Aljanadi, Y., & Alazzani, A. (2023). Sustainability reporting indicators used by oil and gas companies in GCC countries: IPIECA guidance approach. *Frontiers in Environmental Science*, 11. <https://doi.org/10.3389/fenvs.2023.1069152>
- Amer, M., Radwhi, A., Ali, A., & Ali, A. (2022). An Integrated Digital Collaborative Work Environment for Drilling. *International Petroleum Technology Conference, IPTC 2022*. <https://doi.org/10.2523/IPTC-22546-EA>
- Barmandi, I. F., & Ellya Dameria Enesca. (2023). SDG 16 IN ASEAN: CASE STUDY ON BUILDING JUST AND INCLUSIVE SOCIETIES IN INDONESIA. *Sociae Polites*, 24(1). <https://doi.org/10.33541/sp.v24i1.4691>
- Brown, W., Kostareli, A., & Sealy, I. (2020). Environmental management in the oil & gas industry, a guide to environmental management good practices in the upstream oil & gas industry - Second edition. *Society of Petroleum Engineers - SPE International Conference and Exhibition on Health, Safety, Environment, and Sustainability 2020, HSE and Sustainability 2020*. <https://doi.org/10.2118/199456-ms>
- Cahyandito, M. F. (2017). The Effectiveness of Community Development and Environmental Protection Program in Oil and Gas Industry in Indonesia: Policy, Institutional, and Implementation Review. *Journal of Management and Sustainability*, 7(1). <https://doi.org/10.5539/jms.v7n1p115>
- Chutcheva, Y. V., Kuprianova, L. M., Seregina, A. A., & Kukushkin, S. N. (2022). Environmental management of companies in the oil and gas markets based on AI for sustainable development: An international review. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.952102>

- Cordes, E. E., Jones, D. O. B., Schlacher, T. A., Amon, D. J., Bernardino, A. F., Brooke, S., Carney, R., DeLeo, D. M., Dunlop, K. M., Escobar-Briones, E. G., Gates, A. R., Génio, L., Gobin, J., Henry, L. A., Herrera, S., Hoyt, S., Joye, M., Kark, S., Mestre, N. C., ... Witte, U. (2016). Environmental impacts of the deep-water oil and gas industry: A review to guide management strategies. In *Frontiers in Environmental Science* (Vol. 4, Issue SEP). <https://doi.org/10.3389/fenvs.2016.00058>
- de Oliveira Bredariol, T. (2020). Developing indicators for environmental licensing the case of the Brazilian offshore oil and gas sector. *Impact Assessment and Project Appraisal*, 38(5). <https://doi.org/10.1080/14615517.2020.1804305>
- Dhali, M., Hassan, S., & Subramaniam, U. (2023). Comparative Analysis of Oil and Gas Legal Frameworks in Bangladesh and Nigeria: A Pathway towards Achieving Sustainable Energy through Policy. *Sustainability (Switzerland)*, 15(21). <https://doi.org/10.3390/su152115228>
- Do, H. Q., Bhatti, M. I., & Shahbaz, M. (2020). Is 'oil and gas' industry of ASEAN5 countries integrated with the US counterpart? *Applied Economics*, 52(37). <https://doi.org/10.1080/00036846.2020.1731408>
- Doric, B., & Dimovski, V. (2018). Managing petroleum sector performance - A sustainable administrative design. *Economic Research-Ekonomska Istrazivanja*, 31(1). <https://doi.org/10.1080/1331677X.2017.1421995>
- Evseeva, O., Shymchenko, A., Miller, A., & Davidenko, L. (2023). Technological challenges in the economy of the oil and gas sector. *E3S Web of Conferences*, 419. <https://doi.org/10.1051/e3sconf/202341901020>
- Feder, J. (2019). Transforming natural resource management for a sustainable planet. *JPT, Journal of Petroleum Technology*, 71(8). <https://doi.org/10.2118/0819-0076-JPT>
- Ferdiana, W., & Ginting, H. (2023). A Bibliometric Analysis of Management Policies to Support Renewable Energy Implementation in Oil and Gas Company Using VOSviewer. *European Journal of Studies in Management and Business*, 27. <https://doi.org/10.32038/mbrq.2023.27.02>
- Gardas, B. B., Mangla, S. K., Raut, R. D., Narkhede, B., & Luthra, S. (2019). Green talent management to unlock sustainability in the oil and gas sector. *Journal of Cleaner Production*, 229. <https://doi.org/10.1016/j.jclepro.2019.05.018>
- Gil, J. D. B., Reidsma, P., Giller, K., Todman, L., Whitmore, A., & van Ittersum, M. (2019). Sustainable development goal 2: Improved targets and indicators for agriculture and food security. *Ambio*, 48(7). <https://doi.org/10.1007/s13280-018-1101-4>

- Hannouf, M., Assefa, G., & Gates, I. (2020). From social hotspots to policies for successful implementation of environmentally better technologies? The example of social life cycle assessment of oil and gas technologies in Alberta, Canada. *Environmental Science and Policy*, 110. <https://doi.org/10.1016/j.envsci.2020.05.002>
- Haouel, C., & Nemeslaki, A. (2023). Digital Transformation in Oil and Gas Industry. *Periodica Polytechnica Social and Management Sciences*, 32(1). <https://doi.org/10.3311/ppso.20830>
- Keys, M., & Taylor, M. (2021). International standardisation driving global competitiveness and sustainability of the oil and gas and future energy industries. *The APPEA Journal*, 61(2). <https://doi.org/10.1071/aj20156>
- Knodel, T. (2020). Technology Focus: Health, Safety, and Environment (August 2020). *Journal of Petroleum Technology*, 72(08). <https://doi.org/10.2118/0820-0064-jpt>
- Kochetkova, O. P., Glyzina, T. S., Vazim, A. A., & Tugutova, S. S. (2016). Ecological policy in oil-gas complexes, HSE MS implementation in oil and gas company. *IOP Conference Series: Earth and Environmental Science*, 43(1). <https://doi.org/10.1088/1755-1315/43/1/012043>
- Krasnoshtanova, N. (2023). Sustainability of Local Communities in a New Oil and Gas Region: The Case of Eastern Siberia. *Sustainability (Switzerland)*, 15(12). <https://doi.org/10.3390/su15129293>
- Krawchenko, T. A., & Gordon, M. (2022). Just Transitions for Oil and Gas Regions and the Role of Regional Development Policies. *Energies*, 15(13). <https://doi.org/10.3390/en15134834>
- MacDonald, D., Hilton, J., Elliott, D., Heiberg, S., Tulsidas, H., & Griffiths, C. (2018). Transforming natural resource management for a sustainable planet. *Proceedings - SPE Annual Technical Conference and Exhibition, 2018-September*. <https://doi.org/10.2118/191537-ms>
- Maundu (MBA), J. (2020). IMPACT OF SUSTAINABLE BUSINESS PRACTICES IN PETROLEUM INDUSTRY: A CASE STUDY OF NATIONAL OIL CORPORATION OF KENYA. *Strategic Journal of Business & Change Management*, 7(3). <https://doi.org/10.61426/sjbcm.v7i3.1680>
- Mohd Yusof, M. I., & Ariffin, M. M. (2021). Youth Engagement in the Implementation of The Sustainable Development Goals (SDGs) in Asean Countries. *International Journal of Academic Research in Progressive Education and Development*, 10(3). <https://doi.org/10.6007/ijarped/v10-i3/10359>
- Mojarad, A. A. S., Atashbari, V., & Tantau, A. (2018). Challenges for sustainable development strategies in oil and gas industries. *Proceedings of the*

*International Conference on Business Excellence*, 12(1).  
<https://doi.org/10.2478/picbe-2018-0056>

- Muzanni, A., Soesilo, T. E. B., Martono, D. N., Hamzah, U. S., Berkademi, W., & Febraldo, D. (2022). Review of Environmental Management System Implementation in the Oil and Gas Company in Indonesia. *IOP Conference Series: Earth and Environmental Science*, 1111(1). <https://doi.org/10.1088/1755-1315/1111/1/012018>
- Nazarova, V. V., & Tikhomirov, E. D. (2022). The impact of environmental performance of oil and gas companies on their financial performance. *Moscow University Economics Bulletin*, 5. <https://doi.org/10.38050/01300105202258>
- Nguyen Linh, & Sarah Gilleski. (2022). Vietnam Issues the National Strategy on Climate Change by 2050 and the Action Plan on Methane Emissions Reduction by 2030. In *U.S. DEPARTMENT OF AGRICULTURE*.
- Nordin, S. M., Mokhtar, N. I., Priyadi, U., Tarjo, T., Wan Ahmad, W. F., & Ahmad Rizal, A. R. (2023). Communicating Sustainable Brand Equity in a High Carbon Footprint and High-Risk Sector: Comparing Malaysia and Indonesia Oil and Gas Industry. *Sustainability (Switzerland)*, 15(10). <https://doi.org/10.3390/su15107738>
- Omarov, T., & Taikulakova, G. (2023). USING OF DIGITAL APPLICATIONS TO TRANSFORM PROJECT MANAGEMENT PROCESSES AND MANAGE DATA IN THE OIL AND GAS INDUSTRY. *European Project Management Journal*, 13(2). <https://doi.org/10.56889/bhgn3378>
- Otto, J. M. (2010). Community Development Agreement. In *Community Development Agreement*. <https://doi.org/10.1596/27729>
- Pribyl, B., Purewal, S., & Tulsidas, H. (2021). Development of the petroleum resource specifications and guidelines PRSG - A petroleum classification system for the energy transition. *Proceedings - SPE Annual Technical Conference and Exhibition, 2021-September*. <https://doi.org/10.2118/205847-MS>
- Purewal, S., Toquero, F. J., Burgos, E. S., Meneses-Scherrer, E. J., & Arellano Sánchez, E. A. (2019). Mexico pilot project to classify oil and gas projects using united nations framework classification UNFC. *Proceedings - SPE Annual Technical Conference and Exhibition, 2019-September*. <https://doi.org/10.2118/196566-ms>
- Rossi, G., Cadei, L., Bitetti, M., Gerardi, R., Vaccari, D., Ghetti, M., Forte, M., Collura, L., & Ricci, A. (2022). Energy and Ghg Management of a Giant Oilfield: A New Digital Way to Face Challenge and Certify the Results. *Society of Petroleum Engineers - ADIPEC 2022*. <https://doi.org/10.2118/210962-MS>

- Rudko, H. I., Lovyniukov, V. I., Lytvyniuk, S. F., & Netskyi, O. V. (2019). Mineral Resources Management on the basis of the United Nations Framework Classification (National Classification of Mineral Reserves and Resources of Ukraine). *Prospecting and Development of Oil and Gas Fields*, 4(73). [https://doi.org/10.31471/1993-9973-2019-4\(73\)-7-15](https://doi.org/10.31471/1993-9973-2019-4(73)-7-15)
- Sadaghiani, S., Ahmad, K. W., Rezaei, J., & Tavasszy, L. (2015). Evaluation of external forces affecting supply chain sustainability in oil and gas industry using Best Worst Method. *Mediterranean Gas and Oil International Conference, MedGO 2015 - Conference Proceedings*. <https://doi.org/10.1109/MedGO.2015.7330322>
- Sheydai, T., Nykyforuk, O., Berezhnytska, U., Melnychuk, I., & Mandryk, I. (2021). Environmental management in small and medium-sized enterprises of oil and gas industry. *IOP Conference Series: Earth and Environmental Science*, 628(1). <https://doi.org/10.1088/1755-1315/628/1/012021>
- Sinha, B., Roy, S., & Bhagat, M. (2020). Sustainable Green Policy by Managing Flare Gas Recovery: A Case with Middle East Oil and Gas Industry. *Vision*, 24(1). <https://doi.org/10.1177/0972262919862410>
- Tongsopit, S., Kittner, N., Chang, Y., Aksornkij, A., & Wangjiraniran, W. (2016). Energy security in ASEAN: A quantitative approach for sustainable energy policy. *Energy Policy*, 90. <https://doi.org/10.1016/j.enpol.2015.11.019>
- Tretyakov, N. A., & Cherepovitsyn, A. E. (2022). DIGITAL TRANSFORMATION OF THE ARCTIC OIL AND GAS INDUSTRIAL COMPLEX: NEW CHALLENGES AND OPPORTUNITIES. *Sever i Rynok: Formirovanie Ekonomicheskogo Poradka*, 25(1). <https://doi.org/10.37614/2220-802X.1.2022.75.002>
- Valishvili, M. A. (2020). D&R OBLIGATIONS OF OIL PRODUCING COMPANIES: ECONOMIC AND LEGAL MECHANISMS FOR IMPLEMENTATION. *Vestnik Universiteta*, 7. <https://doi.org/10.26425/1816-4277-2020-7-59-67>
- Wan Ahmad, W. N. K., Rezaei, J., Tavasszy, L. A., & de Brito, M. P. (2016). Commitment to and preparedness for sustainable supply chain management in the oil and gas industry. *Journal of Environmental Management*, 180. <https://doi.org/10.1016/j.jenvman.2016.04.056>
- Wanasinghe, T. R., Gosine, R. G., James, L. A., Mann, G. K. I., De Silva, O., & Warrian, P. J. (2020). The Internet of Things in the Oil and Gas Industry: A Systematic Review. *IEEE Internet of Things Journal*, 7(9). <https://doi.org/10.1109/JIOT.2020.2995617>
- Zulkifli, N., Najid, N. A., Mohd Noor, R., Abdul Rahim, A. F., & Yaacob, N. A. (2020). Achieving Environmental Sustainability through Good Regulatory Practice



(GRP). In *Charting a Sustainable Future of ASEAN in Business and Social Sciences*. [https://doi.org/10.1007/978-981-15-3859-9\\_42](https://doi.org/10.1007/978-981-15-3859-9_42)



# Community Participation and Environmental Protection

Chapter

5

Risa Adelina Tarigan, Amalia Ida Gunawati

The importance of community involvement in oil and gas resource management through BUMD to achieve economic prosperity and environmental sustainability. A collaborative and participatory approach reduces conflict and strengthens accountability and transparency at every stage of management. Training, strong regulations, and adaptive management are recommended to increase the capacity of the community to play an active role.

## 5.1. Community involvement in oil and gas management

Community involvement in oil and gas management through BUMDs is based on a number of important reasons from social, economic, and environmental aspects. In Bojonegoro, Indonesia, the oil and gas sector contributes greatly to regional economic growth but provides few local jobs. By involving the community in BUMD, it is hoped that Regional Original Revenue (PAD) can increase, as well as strengthen the economic participation of local residents for more equitable development (Qurbani et al., 2020). Furthermore, in Lokichar, Kenya, community engagement allows local communities to prioritize projects according to their real needs, not just perceptions from the outside. It increases a sense of ownership over resources and strengthens people's sovereignty over their own land, reducing dependency and promoting sustainable local empowerment (FR. AremanL. Paull, 2023). Collaboration between communities and policymakers, such as the one implemented in Uganda, has also proven effective in reducing power inequality and improving the outcomes of collaboration between stakeholders. By involving the community, the benefits of the oil and gas sector can be more sustainable and balanced for the community and the surrounding environment (Coleman et al., 2023). In addition, community participation in the Environmental Impact Assessment (EIA) process, as in Tanzania, plays an important role in minimizing the negative impact of oil and gas activities. The active involvement of the community in EIA allows for more effective and transparent monitoring and management of environmental impacts, thus maintaining the ecological balance of the region (Mwanyoka et al., 2019). Community involvement in oil and gas management through BUMDs is very important to improve economic

welfare, empower local communities, preserve the environment, and strengthen collaboration between various stakeholders.

The scheme of community involvement in oil and gas management through Regionally Owned Enterprises (namely BUMD) and the preparations needed for the implementation of the program include several stages. Community Involvement Scheme in Oil and Gas Management through BUMD, Participation through Participating Interest (PI) Ownership: In some cases, BUMDs own up to 10% of PI ownership, such as in the Cepu block in East Java, where this participation helps direct some of the profits from the oil and gas sector to the local area. This scheme allows BUMDs to oversee the allocation of results and encourage community involvement in the management of regional assets (Priadi, 2021). Community involvement in the decision-making process, in Uganda, Collaborative Governance mechanisms show that community participation in oil and gas sector decision-making through BUMDs helps balance power between local communities and decision-makers. Interventions that take into account the needs of the community can improve collaboration outcomes and reduce power inequality (Coleman et al., 2023). Sustainable Economic Development Scheme Through BUMD, in Bojonegoro Regency, Indonesia, the regional economic development strategy through BUMDs in the oil and gas sector focuses on increasing Regional Original Revenue (namely PAD). The scheme also supports local economic resilience and sustainability, although the contribution of local employment is still relatively low (Qurbani et al., 2020).

Meanwhile, for the necessary preparations for community involvement in oil and gas management through BUMD, the formation of regulations and regional regulations, regulations that support community involvement must be developed to provide a legal basis for BUMDs in managing PI and involving the community in decision-making and supervision. This adjustment can help BUMDs in building more transparent and locally-oriented collaborations (Muryanto et al., 2020). Capacity Development and Community Training, to manage oil and gas properly through BUMD, the community and BUMDs need training in the fields of resource management, finance, and environmental governance. The experience in Sidokepong shows that community participation will increase if they are equipped with sufficient knowledge and feel that the long-term benefits are clear (Zhafira & Choiriyah, 2022). The Socialization and Participatory Involvement Approach by holding community meetings and in-person socialization is a crucial step to increase public understanding and build their support for BUMD activities. Programs that involve socialization, such as in Lokichar, Kenya, can ensure that oil and gas projects are introduced with the approval and priorities of local communities (FR. AremanL. Paull, 2023). Increased Accountability through monitoring systems, environmental and economic monitoring systems supervised by the community can help identify problems early and ensure that oil and gas management by BUMDs truly provides long-term economic and

social benefits without damaging the local environment. The scheme of community involvement in oil and gas management through BUMD requires a regulatory approach, capacity building, socialization, and a solid monitoring system. With the right preparation, BUMD can be an effective means to empower local communities and ensure sustainable oil and gas management.

Theoretical approaches that can be used to encourage community involvement in oil and gas management through Regional-Owned Enterprises (BUMD) include several concepts and models that emphasize community participation, adaptation, and collaboration. In theories that support community involvement in oil and gas management through BUMD, there are several key elements that are easy to understand and their indicators. These approaches not only support effective community engagement but also ensure that oil and gas projects managed by BUMDs run with full support from the community, through a sustainable and adaptive process. These indicators can help BUMDs and other stakeholders monitor the effectiveness of community engagement and ensure that oil and gas projects run transparently, collaboratively, and sustainably.

### **5.3.1. Adaptive Management**

This approach focuses on management that is responsive to regional conditions and allows for continuous adjustment to internal and external impacts, such as those applied in the oil and gas industry to balance the needs of companies with the socio-economic well-being of surrounding communities (Agaurov et al., 2023). Adaptive management is a dynamic management approach that focuses on responding to changing environmental and social conditions that are constantly evolving. This is important because it allows organizations or companies to continuously adjust their strategies to fit internal and external changes, such as climate change, social dynamics, and the local economy (Agaurov et al., 2023). Adaptive management is able to reduce risks and improve operational sustainability by ensuring that the policies implemented are relevant to the current context, both in terms of community needs and environmental conditions. The mechanism for implementing adaptive management involves periodic impact evaluations to monitor changes that occur in the social and environmental scope. The results of this evaluation then become the basis for making policy adjustments, which involve reviewing and modifying operational policies to remain relevant and effective. Community engagement is also an important part of this mechanism, ensuring that their voices and interests are accommodated in every decision-making and policy adjustment. This approach integrates feedback from various stakeholders to create responsive and inclusive solutions (Agaurov et al., 2023). Adaptive management involves a wide range of stakeholders, including governments, companies, local communities, non-governmental organizations (NGOs), as well as academics and scientists who

contribute to the impact evaluation process and policy adjustments. This collaboration is important to ensure that all perspectives and needs are represented, allowing a balance to be struck between economic benefits and social and environmental well-being. The government plays a role in providing a flexible regulatory framework, while companies are responsible for the implementation of adaptive and transparent policies. The implementation of adaptive management has a positive impact on creating more sustainable and harmonious operations with the surrounding environment. This can reduce the potential for conflict between the company and the local community, increase public trust, and strengthen the company's reputation as a responsible entity. In addition, data-driven policy adjustments and periodic impact evaluations can improve operational efficiency and minimize risks to the environment. While adaptive management offers many benefits, there are a number of challenges that can hinder its implementation. One of the main challenges is the scientific uncertainty that arises from rapid environmental changes, which can make it difficult to predict long-term impacts. Additionally, the cost and resources required to conduct periodic impact monitoring and evaluation can be a burden, especially for organizations with limited capacity. Another obstacle is resistance to change, both from internal parties of the organization who may be reluctant to make policy adjustments, as well as from external stakeholders who have diverse interests. An adaptive management approach requires long-term commitment and multi-stakeholder engagement to ensure a sustainable and inclusive policy adjustment process, so that these challenges can be addressed gradually through collaboration and institutional capacity building.

The application of adaptive management in ASEAN countries based on research, the application of Adaptive Ecosystem Management in Southeast Asia: Studies show that the application of adaptive management is often focused on biological conservation and ecosystem management. However, researchers learn more about governance and learning processes compared to ecosystems or biological conservation itself. This suggests that adaptive management in the region is still in its infancy with a focus on learning about governance rather than on full implementation in a particular ecosystem (Fabricius & Cundill, 2014). Adaptation in Policy Response to COVID-19 in ASEAN, during the COVID-19 pandemic, several countries in ASEAN adopted adaptive policy strategies that varied in their responses. Thailand was identified as the country with the best preparation in terms of global health security, while other countries such as Laos, Cambodia, and Malaysia were considered less prepared. This policy response reflects the level of adaptation and policy experimentation carried out by ASEAN countries in dealing with the pandemic crisis (Purnomo et al., 2022). Evaluation of Environmental Carrying Capacity in Southeast Asia: Research on environmental carrying capacity in Southeast Asia revealed that most countries experienced an increase in resource carrying capacity

until 2020, but then decreased. This decline is attributed to the need to control population size and adopt a green economic growth model to support sustainable development. This study also emphasizes the importance of an adaptive approach in balancing development with environmental sustainability (Zeng et al., 2023).

### **5.1.2. Collaborative Governance**

The implementation of Collaborative Governance in Uganda's oil and gas sector is an important effort to overcome the power imbalance between local communities and policymakers. This approach allows for more equal community participation in decision-making related to oil and gas projects, so that the policies taken better reflect the needs of local communities. A number of studies show that balanced participation can improve the relationship between the community and companies and the government, as well as reduce tensions related to natural resource management (Coleman et al., 2023). The Collaborative Governance mechanism in the oil and gas sector in Uganda involves the establishment of a dialogue forum between local communities, the government, and oil and gas companies. In this process, the community participates through joint meetings, surveys, and consultation sessions that prioritize information transparency. For example, this approach was used in 107 villages in Uganda, where communities and decision-makers worked together to determine steps related to oil and gas exploration, as well as obtain accurate information regarding the project's impact on their livelihoods (Coleman et al., 2023).

Community involvement in the decision-making process can increase satisfaction with the project being carried out, as well as create a sense of belonging among the local community. In addition, with better information transparency, the public becomes more aware of the policies taken and their impacts, thus preventing potential conflicts. A study of this practice shows that interventions that pay attention to the needs of the community can improve collaborative relationships between actors involved in oil and gas projects (Arai et al., 2021). However, the implementation of Collaborative Governance in Uganda faces various challenges. Power inequality remains a major issue, where governments or corporations often have greater influence than society. In addition, the lack of community capacity to understand the technical aspects of oil and gas projects and the limited resources to actively participate often hinder the effectiveness of this collaboration. Therefore, more intensive training and facilitation are needed to increase community capacity in this process (Mwanyoka et al., 2019).

Collaborative Governance is an important approach to ensure that oil and gas projects in Uganda not only benefit companies and the government, but also provide balanced benefits to local communities. Despite challenges such as power inequality, this approach remains a potential solution to increase community participation and

satisfaction in natural resource management. Some of the practices of this approach have been carried out referring to some of the studies summarized in table 5.1.

Table 5.1. Collaborative Governance Implications and Indicators

| Aspects                                    | Implementation                                                                                                                                                                                                                               | Indicator.                                                                           |
|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Community and Corporate Collaboration      | Involve local communities in decision-making related to oil and gas projects. The dialogue was held to discuss the impact of the project on the environment and community welfare (Coleman et al., 2023).                                    | - Number of consultative meetings between companies, governments, and the community. |
|                                            |                                                                                                                                                                                                                                              | - The proportion of decisions taken based on input from the community.               |
| Information Transparency                   | Provide open access to project information, such as development plans and environmental impacts, so that the public can make more informed decisions (Mwanyoka et al., 2019)                                                                 | - Availability of environmental impact reports.                                      |
|                                            |                                                                                                                                                                                                                                              | - The level of public understanding of project information.                          |
| Strengthening Community Capacity           | Train the community to participate more effectively in dialogue and decision-making, such as training to understand the technical aspects of oil and gas projects (Arai et al., 2021).                                                       | - The number of people who participated in the training.                             |
|                                            |                                                                                                                                                                                                                                              | - Quality of participation in discussions (measured through surveys).                |
| Community Satisfaction                     | Measure the level of satisfaction of the community with the results of the collaboration, including whether their needs are met by the ongoing project (Mawa et al., 2022).                                                                  | - The level of community satisfaction measured through surveys.                      |
|                                            |                                                                                                                                                                                                                                              | - Changes in public perception of the company.                                       |
| Joint Supervision                          | Involve the community in regular monitoring of the project to ensure that the project is running according to the agreements that have been reached (Sitieni et al., 2021).                                                                  | - The number of joint supervision activities.                                        |
|                                            |                                                                                                                                                                                                                                              | - Reporting of project violations or non-conformities.                               |
| Government-Private Collaboration           | In Indonesia, PT Gas Negara collaborates with the Yogyakarta City government to support <i>the smart city program</i> through the provision of infrastructure and gas energy as an alternative (Kurniasari et al., 2020)                     | - The number of cooperation agreements signed.                                       |
|                                            |                                                                                                                                                                                                                                              | - Realization of gas infrastructure development.                                     |
| Transparency in Projects                   | The implementation of <i>the Trans-ASEAN Gas Pipeline (TAGP)</i> in Indonesia is an effort to ensure energy stability with information disclosure regarding gas distribution and availability (Rivai & Luneto, 2022)                         | - Availability of public reports related to gas distribution.                        |
|                                            |                                                                                                                                                                                                                                              | - The level of stakeholder satisfaction with access to information.                  |
| Joint Oversight and Accountability         | In the oil and gas sector, supervision and evaluation of projects are carried out jointly between the government, the community, and companies, such as in the residential rehabilitation program in Surabaya (Basyar & Puspaningtyas, 2022) | - Number of joint audits and evaluations.                                            |
|                                            |                                                                                                                                                                                                                                              | - The level of transparency in reporting audit results.                              |
| Active Involvement in Economic Development | The government in Buton Regency, Indonesia, implements <i>Collaborative Governance</i> for sustainable economic development through the empowerment of MSMEs and local communities (Sadat, 2020)                                             | - The number of MSMEs involved in the development program.                           |
|                                            |                                                                                                                                                                                                                                              | - Regional economic growth.                                                          |

Source: author search, 2024

This implementation illustrates how collaboration between the government, companies, and communities can create energy stability, improve the local economy, and transparency in resource management in the ASEAN region. This approach also strengthens community participation and transparency in programs that involve multiple stakeholders.

### **5.1.3. Stakeholder Theory dan Social Capital**

The application of the Stakeholder Theory approach and the development of Social Capital is very important in the oil and gas sector because it allows for the creation of better relationships between companies, BUMDs, and local communities. By building mutual trust and influence, companies can ensure community involvement in strategic projects, which helps in mitigating potential conflicts and increasing acceptance of oil and gas activities in the region. This approach also encourages companies to be more socially responsible, improving operational sustainability in the future (Ring, 2021). This approach is usually implemented through a mechanism of dialogue and cooperation between BUMDs, local governments, and the community. This process involves regular meetings, satisfaction surveys, and community empowerment programs. For example, stakeholder identification and mapping conducted using social network analysis helps identify key actors and build stronger networks of collaboration between companies and communities (Cottafava & Corazza, 2021).

Parties involved in this approach include oil and gas companies, BUMDs, local communities, and local and central governments. In addition, academics and civil society organizations often play a role in facilitating dialogue and providing technical input to improve the effectiveness of collaboration. The participation of these various stakeholders ensures that every decision taken reflects the needs and interests of the community, thus creating a sense of belonging among the local community (Bouguerra et al., 2023). The implementation of Stakeholder Theory and the development of Social Capital in the oil and gas sector have had several positive impacts, such as increasing public trust in the company and increasing community involvement in the decision-making process. This can also increase public satisfaction with the programs carried out, thereby reducing the risk of social conflicts and extending the life of oil and gas projects. Studies show that companies that develop sustainable community engagement frameworks can create higher shared value for the community and the company itself (Doni et al., 2022). However, there are various challenges that must be faced, such as the capacity gap between companies and the community, as well as differences in perception of project benefits. Inequality in access to information often hinders the full participation of the community. In addition, the unbalanced power dynamics between the government and local communities can be an obstacle to achieving an inclusive consensus (Gregory et al., 2020). Efforts to address these challenges require increased information transparency and training for communities to strengthen their capacity to participate effectively. The application of Stakeholder Theory and the development of Social Capital can create better collaboration between companies, BUMDs, and the community, which can ultimately improve the sustainability of oil and gas projects in



the future. The implementation of the *Stakeholder Theory* and *Social Capital approach* in the oil and gas sector is fully described in table 5.2.

Table 5.2. Implementation of the *Stakeholder Theory* and *Social Capital approach*

| Aspects                                                        | Implementation                                                                                                                                                                                                    | Indicator.                                                                                                         |
|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Collaboration with Stakeholders                                | In the case of oil and gas projects in Iran, mapping and stakeholder engagement strategies are carried out through hybrid SWOT analysis and Delphi methods to address social conflicts (Khalilzadeh et al., 2023) | - The number of engagement strategies implemented.                                                                 |
|                                                                |                                                                                                                                                                                                                   | - The effectiveness of strategies in reducing conflict, measured through satisfaction surveys.                     |
| Transparency and Accountability                                | Oil and gas companies in Europe are increasing sustainability reporting that focuses on social issues, by adopting a sustainability-oriented governance model (Doni et al., 2022)                                 | - The company's social score in the sustainability index.                                                          |
|                                                                |                                                                                                                                                                                                                   | - The number of disclosure reports published to the public.                                                        |
| Increasing Social Capital through Community Involvement        | In Spain, community involvement in health projects that uses social network analysis to understand the linkages between various stakeholders (Franco-Trigo et al., 2020)                                          | - The number of collaborative relationships between stakeholders.                                                  |
|                                                                |                                                                                                                                                                                                                   | - The level of community participation in project planning.                                                        |
| Development of a Sustainable Engagement Framework              | In the oil and gas sector, the company implements a <i>Sustainable Community Engagement</i> framework that combines CSR and Triple Bottom Line (TBL) (Ring, 2021)                                                 | - The number of CSR programs carried out.                                                                          |
|                                                                |                                                                                                                                                                                                                   | - Improvement of the company's relationship with the community as measured through community satisfaction surveys. |
| The Use of Social Network Analytics for Stakeholder Engagement | In Italy, the company uses participatory mapping methods and social network analysis to understand the role of stakeholders in sustainable development projects (Cottafava & Corazza, 2021)                       | - The level of stakeholder connectedness in the network.                                                           |
|                                                                |                                                                                                                                                                                                                   | - <i>Betweenness centrality</i> indicator to measure key roles in the network.                                     |
| Collaboration with Stakeholders                                | In Indonesia, palm oil companies implement <i>Social Life Cycle Assessment</i> (SLCA) to increase the involvement of local communities in the decision-making process to reduce social conflicts (Budiani, 2020)  | - The number of SLCA initiatives implemented.                                                                      |
|                                                                |                                                                                                                                                                                                                   | - The level of community participation in the SLCA process.                                                        |
| Transparency and Accountability                                | Companies in ASEAN, particularly in the energy sector, are increasing sustainability reporting involving governments and communities to ensure responsible business practices (Karyani & Maulina, 2021)           | - Number of sustainability reports published.                                                                      |
|                                                                |                                                                                                                                                                                                                   | - Disclosure of information related to the project's impact on the community.                                      |
| Increasing Social Capital through Community Involvement        | In Thailand, the community-based tourism community works closely with local governments to develop sustainable tourism through multi-stakeholder engagement (Thananusak & Suriyankietkaew, 2023)                  | - The level of local participation in tourism projects.                                                            |
|                                                                |                                                                                                                                                                                                                   | - Increased community satisfaction with tourism initiatives.                                                       |
| Strengthening Relationships through Business Cooperation       | Oil and gas companies in ASEAN are implementing stakeholder engagement strategies to ensure business continuity amid global market uncertainty (Nkiinebari Patrick PhD & Kate Chukwunonso, 2022)                  | - The amount of cooperation with local stakeholders.                                                               |
|                                                                |                                                                                                                                                                                                                   | - An index of positive relationships with local communities based on satisfaction surveys.                         |
| Government and Private Involvement                             | In several ASEAN countries, energy companies are working with governments to improve market competitiveness and maintain the stability of energy supply in the region (Setiawan et al., 2020)                     | - The number of cooperation initiatives between the company and the government.                                    |
|                                                                |                                                                                                                                                                                                                   | - Economic impact as measured by energy sector growth.                                                             |

Source: author search, 2024

This table explains how the Stakeholder Theory approach and Social Capital development are applied in the oil and gas sector in the ASEAN region. This implementation focuses on increasing community engagement, transparency, and collaboration between various stakeholders to achieve long-term sustainability and stability. Each indicator helps measure the impact of the initiative in creating better relationships between companies, communities, and governments.

#### **5.1.4. Consensus Participation Model**

The implementation of the Consensus Participation Model is important in oil and gas projects because it allows for mutual agreement to be reached through a negotiation process involving the government, companies, and the community. This approach helps to reduce frequent conflicts between various parties related to the project, such as environmental issues and social impacts on local communities. By creating an inclusive decision-making process, all affected parties can express their views, resulting in more equitable and sustainable solutions (Wu et al., 2020). The Consensus Participation Model mechanism is carried out through a series of formal meetings and dialogues between stakeholders. These meetings involve the development of a common agenda, mapping out key issues facing the community, and data-driven negotiations on possible solutions. In the case of oil and gas projects in Uganda, for example, this model is applied through the collection of input from local communities to design more sustainable and inclusive policies (Coleman et al., 2022).

Parties involved in this model include central and regional governments, oil and gas companies, local communities, and civil society organizations. Each party has an important role to play in ensuring that their views and interests are represented in the decision-making process. In some cases, independent experts or mediators may be involved to help maintain a balance between the various parties and ensure that the dialogue runs constructively (Khalilzadeh et al., 2021). The implementation of this model is able to produce several positive impacts, such as increasing public satisfaction with project decisions and reducing the number of conflicts that occur. In addition, with open dialogue, the community can feel more involved and have a sense of ownership over the decisions taken. This also increases the sustainability of the project, as the resulting solution is more acceptable to all parties (Doni et al., 2021). However, the implementation of the Consensus Participation Model is faced with a number of challenges, such as the inequality of power between companies and the community, as well as differences in technical understanding of oil and gas projects. Limited resources to facilitate dialogue, as well as initial public distrust of the company, are also major obstacles that need to be overcome. Continuous efforts are needed to build trust and create a conducive dialogue environment (Zhang et al., 2021). The Consensus Participation Model offers a framework for reaching more

effective mutual agreements in oil and gas projects, which can help ensure sustainability and social acceptance of such projects.

Table 5.3. Implementation Consensus Participation Model

| Aspects                                              | Implementation                                                                                                                                                                                                                                                | Indicator.                                                                                   |
|------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Consensus-Based Conflict Resolution                  | In Iran, the application of the consensus model in conflict resolution in oil and gas construction projects use SWOT analysis and Delphi methods to identify optimal strategies (Khalilzadeh et al., 2023).                                                   | - Meeting frequency for consensus dialogue.                                                  |
|                                                      |                                                                                                                                                                                                                                                               | - The number of conflicts resolved through the consensus method.                             |
| Use of the Fuzzy Model in Conflict Resolution        | The <i>Graph Model for Conflict Resolution</i> (GMCR) with fuzzy preferences is applied to understand and manage the preferences of various stakeholders in sustainability-related conflicts in the oil and gas sector (Wu et al., 2020).                     | - The number of consensus solutions generated.                                               |
|                                                      |                                                                                                                                                                                                                                                               | - Conflict resolution index based on fuzzy model.                                            |
| Consensus in Resource Allocation                     | Development of an adaptive consensus model for the selection of sustainable raw materials in the energy sector, by prioritizing dialogue between related parties to optimize the distribution of renewable products (Gitinavard et al., 2020).                | - Number of consensus meetings related to resource allocation.                               |
|                                                      |                                                                                                                                                                                                                                                               | - The level of efficiency of the agreed resource allocation.                                 |
| Consensus-Based Policy Formulation                   | In the European region, oil and gas companies implement a sustainability governance model that involves stakeholders in the formulation of corporate policies to improve social performance (Doni et al., 2022).                                              | - The number of policies that are prepared based on consensus results.                       |
|                                                      |                                                                                                                                                                                                                                                               | - The level of public satisfaction with the resulting policies.                              |
| Consensus in Transboundary Haze Pollution Management | ASEAN uses a consensus approach in addressing transboundary haze pollution, which involves dialogue between member states and the establishment of the <i>ASEAN Agreement on Transboundary Haze Pollution</i> (Hurley & Lee, 2021).                           | - Frequency of consensus meetings related to cross-border smoke handling.                    |
|                                                      |                                                                                                                                                                                                                                                               | - The number of countries participating in the agreement and implementation of the solution. |
| Strengthening Sustainability through Clean Energy    | Through the <i>Belt and Road Initiative</i> (BRI), China and ASEAN collaborate on renewable energy projects, but face challenges in ensuring that green energy policies are implemented consistently (Liao, 2022).                                            | - The level of community satisfaction with green energy policies.                            |
|                                                      |                                                                                                                                                                                                                                                               | - Percentage of clean energy projects implemented compared to conventional energy projects.  |
| Consensus-Based Conflict Resolution in Energy Trade  | In Indonesia and several other ASEAN countries, there is a consensus effort in energy trade to reduce tensions and maximize economic benefits through the <i>Comprehensive Economic Partnership Agreement</i> (CEPA) with the European Union (Limenta, 2022). | - The number of energy trade deals reached.                                                  |
|                                                      |                                                                                                                                                                                                                                                               | - The number of conflicts resolved through energy trade consensus dialogue.                  |
| Consensus Model in Environmental Policy              | ASEAN adopts a consensus model in environmental policy arrangements, which includes multilateral dialogue to balance economic and environmental needs among member states (Suzuki, 2021).                                                                     | - The number of environmental policies agreed upon through consensus.                        |
|                                                      |                                                                                                                                                                                                                                                               | - The level of policy implementation in each ASEAN member country.                           |
| Consensus Approach to Energy Sustainability in ASEAN | ASEAN implements consensus in the transition to clean energy, focusing on reducing dependence on fossil fuels and increasing the use of clean energy technologies (Phoumin et al., 2021).                                                                     | - Frequency of consensus meetings regarding clean energy policies.                           |
|                                                      |                                                                                                                                                                                                                                                               | - The number of renewable energies projects supported through consensus policies.            |

Source: author search, 2024

How consensus-based participation models are applied in oil and gas projects to achieve conflict resolution, sustainability management, and resource allocation.

This implementation involves various parties such as companies, governments, and the community, with the aim of creating an agreement that is acceptable to all parties, resulting in fairer and more sustainable outcomes. The indicators used to help measure the effectiveness of this approach in various aspects are presented in table 5.3. Table 5.3 illustrates how the Consensus Participation Model approach is applied in ASEAN, especially in the management of environmental and energy issues. This model helps reach a more inclusive agreement on addressing cross-border issues such as smog pollution and renewable energy development. The indicators used help measure the effectiveness of this approach in various aspects, such as the frequency of dialogue, state participation, and community satisfaction levels.

#### **5.1.5. Community-Based Natural Resource Management (CBNRM)**

The CBNRM approach is very important in natural resource management because it places the community as the main actor in the planning, monitoring, and implementation of resource management. Through this approach, local communities have greater control over the resources in their environment, so that they can preserve nature and empower the local economy. CBNRM also allows for direct monitoring of conservation practices, which often results in improved environmental quality and economic sustainability for the communities involved (Tladi-Sekgwama & Ntseane, 2020). The CBNRM mechanism involves a number of stages, ranging from the identification and mapping of local resources, the formation of community groups responsible for management, to the implementation of routine monitoring. One example of implementation is community involvement in conservation and economic development activities in Ghana and Zambia, where local communities are involved in the preparation of joint management plans, as well as receiving training to improve their ability to maintain and manage natural resources in a sustainable manner (Adeyanju et al., 2021).

In the implementation of CBNRM, various parties are involved, including local communities, local governments, NGOs, and research institutions. The role of local communities is as the main manager who supervises and carries out daily activities, while the government and NGOs often provide support in the form of training and funding. Research institutions also play an important role in providing data and methods that can be used to monitor the results of the CBNRM program (Krasnoshtanova, 2023). The implementation of CBNRM can have a positive impact such as increasing environmental sustainability and increasing community income. For example, in several projects in Botswana, CBNRM has improved people's access to resources and provided economic opportunities through community-based tourism programs. This helps communities to be more involved in conservation efforts and improve their quality of life (Chitsove & Madebwe, 2023). Despite its many benefits, CBNRM also faces challenges such as inequality in the distribution of

economic benefits and a lack of technical skills among local communities. Lack of coordination between the actors involved can also be an obstacle, especially in ensuring the involvement of all parties in decision-making. In addition, CBNRM programs often depend on funding from outside donors, which can lead to unsustainability if the funds are discontinued (Shereni & Saarinen, 2020). CBNRM is an effective approach to manage natural resources sustainably by involving local communities as the main drivers.

Tabel 5.4. Implementation CBNRM

| Aspects                                              | Implementation.                                                                                                                                                                                                  | Indicator.                                                                              |
|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Community Involvement in Forest Management           | In Indonesia, the CBNRM approach is applied in community forest projects to increase local participation in state forest management with improved community welfare (Friedman et al., 2020).                     | - The number of local participants in the planning and implementation of the project.   |
|                                                      |                                                                                                                                                                                                                  | - Index of land ownership by the community.                                             |
| Landscape Sustainability through a Rating System     | The use of the Sustainable Landscapes Rating Tool (SLRT) in several countries to assess the condition of sustainable governance by involving stakeholders in the validation of indicators (Peteru et al., 2021). | - Validated landscape sustainability indicators.                                        |
|                                                      |                                                                                                                                                                                                                  | - Frequency of validation meetings by multi-stakeholders.                               |
| Economic Benefits of Community Forests               | In Uganda, community forest programs give community groups the right to legally manage forest products and obtain economic benefits, increasing access to Social Capital (Mawa et al., 2021).                    | - Average income from forest products.                                                  |
|                                                      |                                                                                                                                                                                                                  | - Poverty reduction in the management community.                                        |
| Indicators of Welfare from Community Tourism         | In Bangladesh, the communities of Lake Boga developed their own operating sustainability indicators to measure the impact of community tourism directly (Islam et al., 2023).                                    | - Community tourism economic indicators.                                                |
|                                                      |                                                                                                                                                                                                                  | - The level of community satisfaction with the economic benefits of tourism.            |
| Community-Based Resource Management                  | In West Kalimantan, Indonesia, participatory projects for peatland fire prevention are carried out through collaboration between the government and communities to reduce power inequality (Arai et al., 2021).  | - The number of community members involved in the facilitation team.                    |
|                                                      |                                                                                                                                                                                                                  | - Decrease in the number of peatland fire incidents.                                    |
| Ecosystem Sustainability through Forest Conservation | In communal forests in Yogyakarta, Indonesia, community involvement in forest management through community empowerment programs in Forest Areas with Special Purposes (KHDTK) (Haryono et al., 2022).            | - The number of community members involved in forest management.                        |
|                                                      |                                                                                                                                                                                                                  | - The level of forest sustainability measured through the biodiversity index.           |
| Economic Benefits of Community-Based Tourism         | In Lake Toba, Sumatra, Indonesia, community-based tourism projects are carried out by measuring community satisfaction with the economic benefits generated (Limenta, 2022).                                     | - The average income of the community from tourism activities.                          |
|                                                      |                                                                                                                                                                                                                  | - The level of public satisfaction with income from tourism.                            |
| Community Participation in Fisheries Management      | In the Philippines, communities are involved in the management of fishery areas, with indicators of involvement in monitoring and restoring local fish stocks (Nguyen et al., 2020).                             | - The number of monitoring activities carried out by the community.                     |
|                                                      |                                                                                                                                                                                                                  | - Local fish stock health index.                                                        |
| Improving Climate Resilience in Rural Areas          | In Thailand, CBNRM is applied to manage rural areas in the face of climate change by involving communities in planning and monitoring local ecosystems (Phoumin et al., 2021).                                   | - The number of climate adaptation planning activities that communities participate in. |
|                                                      |                                                                                                                                                                                                                  | - Environmental resilience index to climate change.                                     |

Source: author search, 2024

Table 5.4 shows how the implementation of CBNRM in the ASEAN region helps improve environmental sustainability and provide economic benefits to local communities. Each project is supported by indicators to measure success, such as the number of community participation, the level of ecosystem sustainability, and the economic impact on local communities.

#### **5.1.6. Interconnection Between Theoretical Approaches to Community Engagement**

Some of the key approaches in community engagement focus on natural resource management and sustainable development. These approaches are interrelated and complementary, creating synergies in achieving more holistic goals. Collaborative Governance is a management process that emphasizes transparency, participation in decision-making, and community satisfaction. This model connects directly to the Consensus Participation Model, where transparency and participation are key in ensuring decisions are taken collectively and are oriented toward mutual agreement. Adaptive Management facilitates flexibility in the management process by utilizing continuous feedback from the community and related parties. This allows for policy adjustments based on periodic impact evaluations and active community participation. CBNRM emphasizes local participation in natural resource management with a focus on long-term sustainability. Ultimately, the Stakeholder and Social Capital theories are the basis for building a strong network of cooperation between Adaptive Management and CBNRM, allowing active participation from various parties, both local and external, to achieve sustainable common goals. The relationship between these approaches creates an adaptive, participatory, and solution-oriented management system that is mutually agreed upon, which is necessary to achieve more effective sustainability. This approach proves that community involvement not only plays a role in decision-making, but also becomes a key element in the creation of trust, transparency, and long-term sustainability.

Approaches such as Collaborative Governance, Adaptive Management, Consensus Participation Model, Stakeholder Theory and Social Capital, and CBNRM have an important role in sustainable natural resource management (figure 1). The implementation of these approaches encourages community participation in decision-making, process transparency, and increased community satisfaction. The implementation mechanism involves a periodic cycle of policy evaluation and adjustment, which allows for rapid response to changes in environmental conditions and community needs.

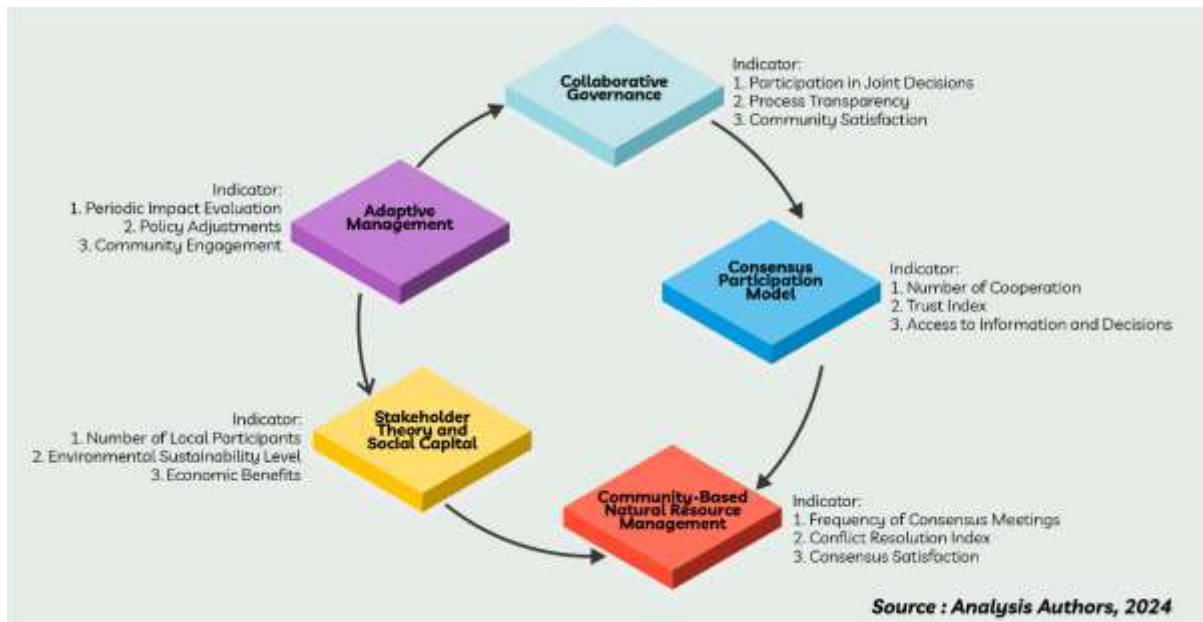


Figure 5.1. Interconnection between theoretical approaches for community involvement in oil and gas management through BUMD

The parties involved in this model include local community members, local governments, researchers, NGOs, and the private sector. The impact includes increasing environmental sustainability, strengthening the local economy, and improving the quality of life of the community around natural resources. However, the main challenge in implementing this model is the complexity of bringing together diverse interests and cultural differences between stakeholders. Other obstacles are the need for large funding, as well as resistance from some parties who do not understand the importance of cross-sectoral collaboration. This approach is very effective in natural resource management, but it requires commitment and adaptation from all parties so that the benefits can be felt optimally. In the ASEAN region, there are several interconnection initiatives implemented to improve the integration of energy, transportation, and telecommunications between countries (table 5.5.).

The implementation of interconnection in the ASEAN region (table 5.5.) has a variety of significant benefits that support regional integration and strengthen economic resilience, security, and social stability. One of the main benefits is the increased efficiency of trade and investment. Initiatives such as the ASW facilitate the cross-border trade process by reducing export-import time and costs, thereby increasing ASEAN's competitiveness as an integrated economic region. In addition, interconnection also strengthens financial inclusion through the ABIF, which facilitates cross-border access to financial services for ASEAN people.

Table 5.5. Interconnection initiatives in interstate integration

| Implementation Interconnection Field                        | Description                                                                                                                                                                                                                                                                                                                                                                                               | Key Indicators                                                    |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| Energy<br>ASEAN Power Grid (APG)                            | The APG project aims to connect the power grids of ASEAN countries so that there is a cross-border energy exchange, thereby increasing regional energy security and reducing energy costs. The project has connected the power grids of Thailand, Laos, Malaysia, and Singapore, as well as allowing countries with energy surpluses to sell it to countries in need (Nguyen Linh & Sarah Gilleski, 2022) | - Interconnection Capacity (MW)                                   |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Energy Trade Volume (GWh)                                       |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Reduced Energy Costs                                            |
| Gas Alam TAGP                                               | The Trans-ASEAN Gas Pipeline project aims to connect natural gas pipelines in ASEAN to distribute natural gas across countries. The project supports energy security by expanding gas supplies from producing countries, such as Indonesia and Malaysia, to consumer countries, such as Thailand and Singapore. (Abdul-Aziz Ahmad & Jais, 2024)                                                           | - Length of Connected Pipe (km)                                   |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Volume of Distributed Gas                                       |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Diversification of Energy Supply                                |
| ASEAN<br>Maritime Security Initiative (AMSI)                | The initiative enhances maritime security coordination between ASEAN member states in terms of water monitoring, joint patrols, and information exchange to combat transnational crimes such as piracy and smuggling (Nguyen Linh & Sarah Gilleski, 2022)                                                                                                                                                 | - Number of Joint Maritime Patrols                                |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Declining Rate of Maritime Crime Incidents                      |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Number of Maritime Security Training                            |
| Pertanian<br>ASEAN Food Security Information System (AFSIS) | AFSIS provides a platform for the exchange of information related to food security, such as data on production, consumption, and food stocks in ASEAN. This system helps ASEAN countries better respond to the threat of food crises (Jing Chen et al., 2023)                                                                                                                                             | - Amount of Data Updated Regularly                                |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Emergency Food Response (number of countries receiving support) |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Decline in Average Food Prices During Crisis                    |
| ASEAN<br>BioDiaspora Virtual Center (ABVC) Health           | ABVC assists ASEAN countries in sharing health data related to infectious diseases and outbreaks, facilitating the coordination of health responses, especially during the COVID-19 pandemic. This enhances ASEAN's response capacity and health resilience (Goh et al., 2024)                                                                                                                            | - Frequency of Health Data Exchange                               |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Outbreak Response Speed in the Region                           |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                                                           | - Decrease in the Spread of Infectious Diseases                   |

Source: author search, 2024

This provides more opportunities for individuals and businesses to obtain the necessary financial services. In the tourism sector, the ASEAN Mutual Recognition Arrangement on Tourism Professionals enables cross-border tourism workforce mobility, thereby improving the service standards and quality of the tourism industry in the region. In terms of security, the ASEAN Maritime Security Initiative plays an important role in maintaining maritime stability by improving security coordination between countries. Joint patrols and information exchange facilitated by this initiative help in preventing criminal activities in ASEAN waters. For food security, the ASEAN Food Security Information System supports the ability of ASEAN countries to manage food crises through the exchange of data on production, consumption, and food stocks. This system provides a quick response to the threat of a food crisis that may arise. In the health sector, the ABVC has proven effective, especially during the COVID-



19 pandemic, in facilitating rapid responses to infectious disease outbreaks through data exchange and intensive public health coordination between member states.

However, the implementation of this interconnection is faced with various challenges. One of them is the difference in policies and regulations between ASEAN countries that makes it difficult to implement integration effectively. The limitations of digital and physical infrastructure in several ASEAN countries are also a major obstacle in achieving optimal connectivity. In addition, the limitations of human resources, especially in terms of skilled labor in specialized areas such as cybersecurity and risk management, hinder the smooth implementation of these various initiatives. Geopolitical challenges, such as tensions in the South China Sea region, could also affect maritime cooperation efforts between ASEAN countries. The implementation of various interconnection initiatives demonstrates ASEAN's commitment to strengthening cross-border cooperation in various strategic fields, with the main goal of creating stability, supporting economic growth, and enhancing regional resilience to various global challenges.

## **5.2. Community involvement in environmental impact monitoring**

Participatory policies in environmental management often use Participatory Governance Theory and Systemic Approaches. Participatory governance allows for direct involvement of various stakeholders in decision-making, increasing transparency and accountability (Baldwin, 2020). The systemic approach includes a comprehensive understanding of socio-ecological interactions and considers long-term impacts, so that policies become adaptive and more responsive to environmental changes (De Smedt & Borch, 2022). The implementation of this policy involves regular meetings between oil and gas companies, local communities, governments, and scientists to assess the environmental impact of industrial activities. In this case, a participatory approach can be applied through a participatory modeling model that allows all stakeholders to provide input on the company's planning and operations (Halbe et al., 2020). This approach also often includes educational activities and community consultations to build a common understanding of the impacts and mitigation strategies taken by oil and gas companies.

The main reason for the implementation of participatory policies in environmental management in the oil and gas sector is to increase the legitimacy and sustainability of the policy. Through stakeholder engagement, policies become more acceptable to the community, and the risk of conflict can be minimized. In addition, direct involvement can also encourage more creative and sustainable solutions in managing the environmental impact of oil and gas industry activities (Jager et al., 2021). This policy involves a variety of actors, including oil and gas companies, governments, local communities, environmental scientists, and NGOs. Their roles

vary, from monitoring to implementation and education, with a focus on collaboration and mutual input in the formulation and implementation of sustainable environmental policies (Blomkamp, 2022). Participatory policies in the oil and gas sector are usually implemented in a sustainable manner, especially at the planning, evaluation, and policy adjustment stages. The iterative cycle of planning and evaluation allows companies and stakeholders to regularly review policies and make adjustments according to current conditions (Ramanadhan et al., 2024).

### **5.2.1. Participatory Governance**

Participatory Governance Theory is an approach that encourages the active involvement of various stakeholders in the decision-making process, particularly in resource management and environmental policy. With direct participation from the community, governments, and NGOs, the theory aims to create decisions that are more inclusive and responsive to the needs of all parties, while increasing transparency and accountability in public policy (Jager et al., 2021). The importance of participatory governance lies in its ability to increase policy legitimacy and community engagement with decision outcomes. When stakeholders feel heard and have a contribution to the process, they tend to be more supportive and execute policies with a higher commitment. In addition, this approach allows governments and related institutions to more quickly adjust policies based on actual input from the field, so that policies can become more relevant and sustainable in the long term (Larkin et al., 2020).

Participatory governance mechanisms typically involve various stages such as public discussion forums, stakeholder consultations, and participatory modeling. In the early stages, meetings are held to identify common needs and problems, followed by in-depth consultations to explore potential solutions and strategies. Participatory modeling, such as those used in water management, helps to visualize policy impacts through simulation, allowing all parties to understand and agree on the most suitable policy (Shahvi et al., 2021). Actors involved in participatory governance include governments, local communities, NGOs, and technical and scientific experts who act as consultants in policy impact evaluation. Each party has a unique role to play in conveying its perspective and providing input based on its area of expertise, so that decisions can take into account various viewpoints and existing needs (Salamanca-Cano & Durán-Díaz, 2023).

The impact of participatory governance is significant, especially in improving the quality of environmental policies, accelerating implementation, and building trust between stakeholders. Studies show that participatory governance can improve environmental standards from decision-making outcomes as well as strengthen more effective monitoring mechanisms (Baldwin, 2020). Key challenges in participatory governance include difficulties in reaching consensus, additional costs in the

consultation process, and power imbalances between stakeholders that can hinder the active participation of all parties. Another obstacle is the lack of resources and time to accommodate diverse views, so this process requires good planning and management to achieve optimal results (Partelow et al., 2020). The implementation of participatory governance policies in ASEAN countries is summarized in table 5.6.

Table 5.6. Implementation of participatory governance policies in ASEAN countries

| Implementation                                                            | Description.                                                                                                                                                                                                                                                           | Indicator                                                                                     |
|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Participation in Peat Fire Management in West Kalimantan, Indonesia       | Engage local communities through a facilitation team consisting of the government and villagers to prevent peat fires. This team provides training, knowledge sharing, and capacity building so that citizens can make more independent decisions (Arai et al., 2021). | 1. The amount of training provided to residents                                               |
|                                                                           |                                                                                                                                                                                                                                                                        | 2. The level of community participation in fire prevention activities                         |
|                                                                           |                                                                                                                                                                                                                                                                        | 3. Reduction in the frequency of peat fires                                                   |
| Marine Debris Management in ASEAN                                         | Following the Bangkok Declaration and the framework of action to reduce marine plastic waste through cross-border collaborations and local initiatives to improve waste management (Hermawan & Astuti, 2021).                                                          | 1. Number of plastic reduction policies adopted by ASEAN member states                        |
|                                                                           |                                                                                                                                                                                                                                                                        | 2. The volume of plastic waste that has been successfully reduced from the ocean              |
|                                                                           |                                                                                                                                                                                                                                                                        | 3. The level of compliance of the industrial sector with plastic waste management regulations |
| Participatory Budget for Sustainability at Thai Universities              | Through participatory budgeting, students and staff can choose environmental sustainability projects to implement on campus. This process encourages the involvement of the campus community in selecting and funding environmental projects (Watson Todd, 2022).      | 1. Number of projects funded through participatory budgeting                                  |
|                                                                           |                                                                                                                                                                                                                                                                        | 2. The level of student involvement in the project selection process                          |
|                                                                           |                                                                                                                                                                                                                                                                        | 3. Impact of the project on sustainability awareness on campus                                |
| ASEAN-China Energy and Environment Collaboration within the BRI Framework | ASEAN is working with China to implement sustainable energy projects within the framework of the BRI, including renewable energy projects to support sustainable development (Liao, 2022).                                                                             | 1. Number of renewable energy projects implemented                                            |
|                                                                           |                                                                                                                                                                                                                                                                        | 2. The rate of reduction in carbon emissions from the project                                 |
|                                                                           |                                                                                                                                                                                                                                                                        | 3. Increasing renewable energy capacity in ASEAN member countries                             |
| ASEAN Environmental Governance in Climate Change Mitigation               | The participation of non-state actors in the ASEAN transnational climate governance network involving various stakeholders in the development of climate management practices (Salazar, 2023).                                                                         | 1. Number of non-state organizations involved                                                 |
|                                                                           |                                                                                                                                                                                                                                                                        | 2. Frequency of regional meetings                                                             |
|                                                                           |                                                                                                                                                                                                                                                                        | 3. Number of policies proposed and adopted                                                    |
| UHC (Universal Health Coverage) Thailand                                  | Universal health policy in Thailand is set to support participatory governance, with legislation providing space for citizens to participate in health service evaluations (Marshall et al., 2021).                                                                    | 1. The level of public participation in service assessment                                    |
|                                                                           |                                                                                                                                                                                                                                                                        | 2. Number of health policies improved                                                         |
|                                                                           |                                                                                                                                                                                                                                                                        | 3. Public satisfaction with UHC services                                                      |
| ASEAN Security Governance                                                 | The ASEAN Political and Security Community (APSC) was established to encourage a participatory security community in addressing cross-border security challenges, involving state and non-state actors (Caballero-Anthony, 2020).                                      | 1. Number of cross-border consultations per year                                              |
|                                                                           |                                                                                                                                                                                                                                                                        | 2. Number of security recommendations received                                                |
|                                                                           |                                                                                                                                                                                                                                                                        | 3. Level of trust between ASEAN countries                                                     |

Source: author search, 2024

The results of the implementation of participatory governance in ASEAN (table 5.6) show significant progress in various sectors, especially related to climate change mitigation, health services, and regional security. In the climate context, the involvement of non-state actors such as civil society organizations and the private sector has increased, enabling cross-sectoral collaboration that enriches the policy-making process. Through this participation, ASEAN has succeeded in creating a more inclusive and relevant climate policy, with success measured by the number of organizations involved, the frequency of regional meetings, and policies adopted jointly (Salazar, 2023). In the health sector, Thailand applies the principle of participatory governance in the UHC program, which allows the public to participate in the evaluation and adjustment of health services. This public participation has proven to be effective in improving health policies, improving user satisfaction, and strengthening government transparency. Indicators of its success include the level of community participation, the number of policies adjusted, and the satisfaction of healthcare users. This program has succeeded in creating more responsive health services and supporting government accountability in meeting public health needs (Marshall et al., 2021).

In the field of security, ASEAN through the APSC builds an inclusive security community, by involving state and non-state actors in addressing cross-border security challenges. The increase in coordination between member countries can be seen from the frequency of annual consultations, the acceptance of security policy recommendations, and the increase in trust between countries. This approach reduces regional tensions and strengthens security cooperation with a more participatory and collaborative approach (Caballero-Anthony, 2020). The implementation of participatory governance in ASEAN results in wider engagement from non-state actors, improved public policies tailored to the needs of society, and stronger coordination on security issues. Success indicators such as participation rates, regular consultations, and increased public satisfaction underscore the effectiveness of this approach in strengthening transparency and governance responsiveness in key ASEAN sectors.

### **5.2.2. Systemic Approach**

Participatory policy in environmental management using a systemic approach is a method in which all stakeholders, including governments, communities, and the private sector, are involved in the decision-making process related to environmental issues. This approach is important because it allows diverse perspectives and needs to be accommodated in a single policy system, resulting in more comprehensive and adaptive solutions to environmental and social changes. This systemic approach to participatory policy integrates different levels of government with local communities

and environmentalists. Through forums and public consultations, stakeholders can share views and identify the potential impact of each decision taken.

Stakeholders include central and local governments, environmental NGOs, local communities, scientific communities, and the private sector. The role of the government is as a facilitator, providing a legal and policy framework that allows for public participation, while the community and NGOs provide critical input and a bottom-up view that is often more suited to the conditions on the ground. This approach has a significant positive impact, such as improving the quality of policy decisions, higher compliance with environmental regulations, and strengthening community capacity to manage natural resources. However, this approach faces challenges, such as differences of opinion among stakeholders, lack of resources, and sometimes resistance from certain parties who feel disadvantaged by stricter policies. This obstacle often arises from economic interests that collide with sustainability goals. In addition, limited funds and time to conduct a thorough consultation can also hinder this process. Despite its challenges, a systemic approach to participatory environmental management policies can create sustainable change through multi-actor collaboration and greater responsiveness to local environmental needs.

### **5.3. Conclusion**

Chapter 5 discusses community involvement in natural resource management, especially in the oil and gas sector through BUMD, with a focus on collaborative and participatory approaches to achieve social and environmental sustainability. The main problems identified were the inequality of power between the community and the company or government, the lack of community skills to actively participate, and the risk of conflicts of interest. The conclusion of this chapter emphasizes that community participation is essential in every stage of resource management. By engaging local communities, policies become more relevant, transparent, and accepted by the community. This approach has proven to reduce potential conflicts, increase accountability, and strengthen a sense of community ownership over local projects that directly impact them. The suggestions given are the need for community training and capacity building, strengthening regulations that support community involvement, and implementing adaptive and collaborative management models to ensure that policies remain responsive to local needs and changing environmental conditions. The novelty of chapter 5 is the integration of various theoretical approaches such as Collaborative Governance, Adaptive Management, and Consensus Participation Model that emphasizes active community participation, adaptability, and consensus-based approaches to optimize sustainable natural resource management.

## Reference

- Abdul-Aziz Ahmad, M., & Jais, J. (2024). The mediating effect of service quality on the relationship between logistics resources and sustainable competitive advantage in Iraqi Kurdistan hotels. *Cogent Business & Management*, 11(1). <https://doi.org/10.1080/23311975.2024.2360597>
- Agaurov, S. Yu., Zykova, N. V., & Smirnova, I. G. (2023). Adaptive management in oil and gas industry taking into account regional conditions. *Economics and Management*, 29(12). <https://doi.org/10.35854/1998-1627-2023-12-1523-1531>
- Arai, Y., Maswadi, Oktoriana, S., Suharyani, A., Didik, & Inoue, M. (2021). How can we mitigate power imbalances in collaborative environmental governance? Examining the role of the village facilitation team approach observed in west Kalimantan, Indonesia. *Sustainability (Switzerland)*, 13(7). <https://doi.org/10.3390/su13073972>
- Baldwin, E. (2020). Why and how does participatory governance affect policy outcomes? Theory and evidence from the electric sector. *Journal of Public Administration Research and Theory*, 30(3). <https://doi.org/10.1093/jopart/muz033>
- Basyar, M. R., & Puspaningtyas, A. (2022). Collaborative governance in CSR management program for slum area rehabilitation. *Publisia: Jurnal Ilmu Administrasi Publik*, 7(1). <https://doi.org/10.26905/pjiap.v7i1.7480>
- Blomkamp, E. (2022). Systemic design practice for participatory policymaking. *Policy Design and Practice*, 5(1). <https://doi.org/10.1080/25741292.2021.1887576>
- Bouguerra, A., Hughes, M., Cakir, M. S., & Tatoglu, E. (2023). Linking Entrepreneurial Orientation to Environmental Collaboration: A Stakeholder Theory and Evidence from Multinational Companies in an Emerging Market. *British Journal of Management*, 34(1). <https://doi.org/10.1111/1467-8551.12590>
- Budiani, I. (2020). Enhancing the community engagement of Indonesian Palm Oil Companies through the implementation of the Social Life Cycle Assessment (SLCA). *ASEAN Journal of Community Engagement*, 4(1). <https://doi.org/10.7454/ajcev4i1.1050>
- Caballero-Anthony, M. (2020). Security Governance and ASEAN's Political Security Community: Fragmented but Inclusive Security Communities? *Fudan Journal of the Humanities and Social Sciences*, 13(1). <https://doi.org/10.1007/s40647-019-00269-z>
- Coleman, E. A., Schultz, B., Rani Parker, A., Manyindo, J., & Mukuru, E. M. (2023). How Communities Benefit from Collaborative Governance: Experimental Evidence

- in Ugandan Oil and Gas. *Journal of Public Administration Research and Theory*, 33(4). <https://doi.org/10.1093/jopart/muac050>
- Cottafava, D., & Corazza, L. (2021). Co-design of a stakeholders' ecosystem: an assessment methodology by linking social network analysis, stakeholder theory and participatory mapping. *Kybernetes*, 50(3). <https://doi.org/10.1108/K-12-2019-0861>
- De Smedt, P., & Borch, K. (2022). Participatory policy design in system innovation. *Policy Design and Practice*, 5(1). <https://doi.org/10.1080/25741292.2021.1887592>
- Doni, F., Corvino, A., & Bianchi Martini, S. (2022). Corporate governance model, stakeholder engagement and social issues evidence from European oil and gas industry. *Social Responsibility Journal*, 18(3). <https://doi.org/10.1108/SRJ-08-2020-0336>
- Fabricius, C., & Cundill, G. (2014). Learning in adaptive management: Insights from published practice. *Ecology and Society*, 19(1). <https://doi.org/10.5751/ES-06263-190129>
- FR. AremanL. PaulL. (2023). The role of local community in oil exploration in Lokichar basin, Turkana County, Kenya. *Open Access Research Journal of Multidisciplinary Studies*, 6(2). <https://doi.org/10.53022/oarjms.2023.6.2.0054>
- Franco-Trigo, L., Marqués-Sánchez, P., Tudball, J., Benrimoj, S. I., Martínez-Martínez, F., & Sabater-Hernández, D. (2020). Collaborative health service planning: A stakeholder analysis with social network analysis to develop a community pharmacy service. *Research in Social and Administrative Pharmacy*, 16(2). <https://doi.org/10.1016/j.sapharm.2019.05.008>
- Friedman, R. S., Rhodes, J. R., Dean, A. J., Law, E. A., Santika, T., Budiharta, S., Hutabarat, J. A., Indrawan, T. P., Kusworo, A., Meijaard, E., St. John, F. A. V., Struebig, M. J., & Wilson, K. A. (2020). Analyzing procedural equity in government-led community-based forest management. *Ecology and Society*, 25(3). <https://doi.org/10.5751/ES-11710-250316>
- Gitinavard, H., Shirazi, M. A., & Fazel Zarandi, M. H. (2020). Sustainable feedstocks selection and renewable products allocation: A new hybrid adaptive utility-based consensus model. *Journal of Environmental Management*, 264. <https://doi.org/10.1016/j.jenvman.2020.110428>
- Goh, S. K., Sam, C. Y., & Goh, K.-L. (2024). Are real interest rates stationary? New evidence from the multivariate ARDL unit root test. *Applied Economics Letters*, 1–5. <https://doi.org/10.1080/13504851.2024.2332520>
- Gregory, A. J., Atkins, J. P., Midgley, G., & Hodgson, A. M. (2020). Stakeholder identification and engagement in problem structuring interventions. *European*

- Halbe, J., Holtz, G., & Ruutu, S. (2020). Participatory modeling for transition governance: Linking methods to process phases. *Environmental Innovation and Societal Transitions*, 35. <https://doi.org/10.1016/j.eist.2020.01.008>
- Haryono, B. S., Drosopolino, Sholihah, Q., & Lenggono, K. A. (2022). THE ROLE OF ACTORS IN THE IMPLEMENTATION NETWORK OF COMMUNITY EMPOWERMENT POLICIES IN FOREST MANAGEMENT: A CASE STUDY OF THE FORESTS OF YOGYAKARTA, INDONESIA. *Journal of Southwest Jiaotong University*, 57(3). <https://doi.org/10.35741/issn.0258-2724.57.3.32>
- Hermawan, S., & Astuti, W. (2021). Analysing several ASEAN countries' policy for combating marine plastic litter. *Environmental Law Review*, 23(1). <https://doi.org/10.1177/1461452921991731>
- Hurley, A., & Lee, T. (2021). Delayed ratification in environmental regimes: Indonesia's ratification of the ASEAN agreement on transboundary haze pollution. *Pacific Review*, 34(6). <https://doi.org/10.1080/09512748.2020.1801816>
- Islam, M. S., Lovelock, B., & Coetzee, W. J. L. (2023). Liberating sustainability indicators: developing and implementing a community-operated tourism sustainability indicator system in Boga Lake, Bangladesh. *Journal of Sustainable Tourism*, 31(7). <https://doi.org/10.1080/09669582.2021.1928147>
- Jager, N. W., Newig, J., Challies, E., & Kochskämper, E. (2021). Erratum: Pathways to Implementation: Evidence on How Participation in Environmental Governance Impacts on Environmental Outcomes (2021) DOI: 10.1093/jopart/muz034). In *Journal of Public Administration Research and Theory* (Vol. 31, Issue 3). <https://doi.org/10.1093/jopart/muab006>
- Jing Chen, Chenxi Tian, & Xuan Gou. (2023). An Empirical Study on the Correlation between Stock Prices and Financial Indexes Based on Regression Analysis—Take the Education Industry as an Example. *Academic Journal of Business & Management*, 5(10). <https://doi.org/10.25236/AJBM.2023.051006>
- Karyani, E., & Maulina, V. (2021). *ESG and Performance: Effect of Government Ownership and Green Bond Issuer*. <https://doi.org/10.4108/eai.14-9-2020.2304405>
- Khalilzadeh, M., Kebriyaii, O., & Rezaei, R. (2023). Identification and selection of stakeholder engagement strategies: case study of an Iranian oil and gas construction project. *International Journal of Construction Management*, 23(3). <https://doi.org/10.1080/15623599.2021.1889749>



- Krasnoshtanova, N. (2023). Sustainability of Local Communities in a New Oil and Gas Region: The Case of Eastern Siberia. *Sustainability (Switzerland)*, 15(12). <https://doi.org/10.3390/su15129293>
- Kurniasari, L., Purnomo, E. P., & Salsabila, L. (2020). Kolaborasi Antara Pt Gas Negara Dengan Pemerintah Kota Yogyakarta Dalam Mewujudkan Smart City. *Jurnal Noken: Ilmu-Ilmu Sosial*, 5(1). <https://doi.org/10.33506/jn.v5i1.775>
- Larkin, A., Hoolohan, C., & McLachlan, C. (2020). Embracing context and complexity to address environmental challenges in the water-energy-food nexus. *Futures*, 123. <https://doi.org/10.1016/j.futures.2020.102612>
- Liao, J. C. (2022). Talking Green, Building Brown: China-ASEAN Environmental and Energy Cooperation in the BRI Era. *Asian Perspective*, 46(1). <https://doi.org/10.1353/apr.2022.0001>
- Limenta, M. (2022). Toward an ASEAN-EU FTA: Examining the Trade and Sustainable Development Chapter in the Prospective Indonesia-EU CEPA. *Legal Issues of Economic Integration*, 49(2). <https://doi.org/10.54648/LEIE2022009>
- Marshall, A. I., Kantamaturapoj, K., Kiewnin, K., Chotchoungchatchai, S., Patcharanarumol, W., & Tangcharoensathien, V. (2021). Participatory and responsive governance in universal health coverage: An analysis of legislative provisions in Thailand. *BMJ Global Health*, 6(2). <https://doi.org/10.1136/bmjgh-2020-004117>
- Mawa, C., Babweteera, F., & Tumusiime, D. M. (2022). Conservation Outcomes of Collaborative Forest Management in a Medium Altitude Semideciduous Forest in Mid-western Uganda. *Journal of Sustainable Forestry*, 41(3–5). <https://doi.org/10.1080/10549811.2020.1841006>
- Mawa, C., Tumusiime, D. M., & Babweteera, F. (2021). Are community forests delivering livelihood benefits? Insights from Uganda. *Forests Trees and Livelihoods*, 30(2). <https://doi.org/10.1080/14728028.2021.1904010>
- Muryanto, Y. T., Tuhana, T., & Ciptorukmi, A. S. (2020). REVITALIZATION OF REGIONAL-OWNED ENTERPRISE (BUMD) GOVERNANCE THROUGH THE PARTICIPATION IN OIL AND GAS MANAGEMENT BY USING GROSS SPLIT MECHANISM. *Yustisia Jurnal Hukum*, 9(1). <https://doi.org/10.20961/yustisia.v9i1.33702>
- Mwanyoka, I., Selestine, W. E., & Nuhu, S. (2019). EIA Practices in the Natural Gas Extraction Sector in Tanzania: Does Local Community Contribution Matter? *Journal of Environmental Assessment Policy and Management*, 21(3). <https://doi.org/10.1142/S1464333219500157>
- Nguyen Linh, & Sarah Gilleski. (2022). Vietnam Issues the National Strategy on Climate Change by 2050 and the Action Plan on Methane Emissions Reduction by 2030. In *U.S. DEPARTMENT OF AGRICULTURE*.

- Nguyen, M.-H., Nguyen, H. T. T., Pham, T.-H., Nguyen, Q.-Y. T., & Vuong, Q. H. (2020). On the 50-Year Research Landscape of Entrepreneurial Finance: A Sign of Western Ideological Homogeneity? *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3612240>
- Nkiinebari Patrick PhD, N., & Kate Chukwunonso, E. (2022). Stakeholders Management Indicators: The Business Sustainability Inference. *International Journal of Multidisciplinary Research and Analysis*, 05(10), 2789–2803. <https://doi.org/10.47191/ijmra/v5-i10-30>
- Partelow, S., Schlüter, A., Armitage, D., Bavinck, M., Carlisle, K., Gruby, R. L., Hornidge, A. K., Le Tissier, M., Pittman, J. B., Song, A. M., Sousa, L. P., Văidianu, N., & Van Assche, K. (2020). Environmental governance theories: A review and application to coastal systems. *Ecology and Society*, 25(4). <https://doi.org/10.5751/ES-12067-250419>
- Peteru, S., Duchelle, A. E., Stickler, C., Durbin, J., Luque, C., & Komalasari, M. (2021). Participatory Use of a Tool to Assess Governance for Sustainable Landscapes. *Frontiers in Forests and Global Change*, 4. <https://doi.org/10.3389/ffgc.2021.507443>
- Phoumin, H., Kimura, F., & Arima, J. (2021). Asean's energy transition towards cleaner energy system: Energy modelling scenarios and policy implications. *Sustainability (Switzerland)*, 13(5). <https://doi.org/10.3390/su13052819>
- Priadi, S. N. (2021). *The Success of Managing Participating Interest (PI) in Cepu Block in Increasing Regional Revenue InEast Java*. <https://doi.org/10.29118/ipa21-bc-99>
- Purnomo, E. P., Agustiyara, Nurmandi, A., Dewi, A., Rosa, E. M., Bayu, A. H., & Erviana, R. (2022). ASEAN Policy Responses to COVID-19 Pandemic: Adaptation and Experimentation Policy: A Study of ASEAN Countries Policy Volatility for COVID-19 Pandemic. *SAGE Open*, 12(1). <https://doi.org/10.1177/21582440221082145>
- Qurbani, I., Sumarno, T., & Cassy, R. (2020). Regional Economic Development Strategy: Increasing Local Generated Domestic Revenue of the Regional-Owned Enterprises in the Oil and Gas Sector. *Brawijaya Law Journal*, 7(1), 70–81. <https://doi.org/10.21776/ub.blj.2020.007.01.05>
- Ramanadhan, S., Alemán, R., Bradley, C. D., Cruz, J. L., Safaeinili, N., Simonds, V., & Aveling, E. L. (2024). Using Participatory Implementation Science to Advance Health Equity. In *Annual Review of Public Health* (Vol. 45, Issue 1). <https://doi.org/10.1146/annurev-publhealth-060722-024251>
- Ring, J. E. (2021). Operationalizing Sustainable Development, Stakeholder Theory, Corporate Social Responsibility to Improve Community Engagement

- Outcomes. *Journal of Sustainable Development*, 15(1).  
<https://doi.org/10.5539/jsd.v15n1p1>
- Rivai, A. N. A., & Luneto, R. (2022). SECURING NATIONAL AND REGIONAL ENERGY: INDONESIA'S POLICY IN THE TRANS-ASEAN GAS PIPELINE PROJECT. *Jurnal Pertahanan: Media Informasi Ttg Kajian & Strategi Pertahanan Yang Mengedepankan Identity, Nasionalism & Integrity*, 8(1).  
<https://doi.org/10.33172/jp.v8i1.1549>
- Sadat, A. (2020). *Framework for Collaborative Governance of Sustainable Economic Development*. <https://doi.org/10.2991/assehr.k.200529.207>
- Salamanca-Cano, A. K., & Durán-Díaz, P. (2023). Stakeholder Engagement around Water Governance: 30 Years of Decision-Making in the Bogotá River Basin. *Urban Science*, 7(3). <https://doi.org/10.3390/urbansci7030081>
- Salazar, V. (2023). From Practices to Praxis: ASEAN's Transnational Climate Governance Networks as Communities of Practice. *Journal of Current Southeast Asian Affairs*, 42(2). <https://doi.org/10.1177/18681034231167443>
- Setiawan, B., Purnamasari, E., & Ulum, M. B. (2020). Macroeconomic Indicators and Stock Market Development on Economic Growth: Empirical Evidence from ASEAN Countries. *SRIWIJAYA INTERNATIONAL JOURNAL OF DYNAMIC ECONOMICS AND BUSINESS*. <https://doi.org/10.29259/sijdeb.v3i4.271-282>
- Shahvi, S., Mellander, P. E., Jordan, P., & Fenton, O. (2021). A Fuzzy Cognitive Map method for integrated and participatory water governance and indicators affecting drinking water supplies. *Science of the Total Environment*, 750. <https://doi.org/10.1016/j.scitotenv.2020.142193>
- Sitienei, J., Manderson, L., & Nangami, M. (2021). Community participation in the collaborative governance of primary health care facilities, Uasin Gishu County, Kenya. *PLoS ONE*, 16(3) March 2021).  
<https://doi.org/10.1371/journal.pone.0248914>
- Suzuki, S. (2021). Can ASEAN offer a useful model? Chairmanship in decision-making by consensus. *Pacific Review*, 34(5).  
<https://doi.org/10.1080/09512748.2020.1727553>
- Thananusak, T., & Suriyankietkaew, S. (2023). Unpacking Key Sustainability Drivers for Sustainable Social Enterprises: A Community-Based Tourism Perspective. *Sustainability (Switzerland)*, 15(4). <https://doi.org/10.3390/su15043401>
- Watson Todd, R. (2022). Participatory budgeting for public involvement in environmental sustainability at a Thai university. *Qeios*.  
<https://doi.org/10.32388/bktxz9>

- Wu, N., Xu, Y., Xu, L., & Wang, H. (2020). The graph model for conflict resolution with consensus fuzzy preferences and its application to environmental sustainable development. *Journal of Intelligent and Fuzzy Systems*, 39(5). <https://doi.org/10.3233/JIFS-190990>
- Zeng, X., Yang, X., Zhong, S., Wang, Z., Ding, Y., Meng, D., & Gao, K. (2023). Comprehensive Evaluation of Resource and Environmental Carrying Capacity at a National Scale: A Case Study of Southeast Asia. *Sustainability (Switzerland)*, 15(7). <https://doi.org/10.3390/su15075791>
- Zhafira, N. A., & Choiriyah, I. U. (2022). Community Participation in the Village Owned Enterprise Program in Sidoarjo Regency. *Indonesian Journal of Public Policy Review*, 19. <https://doi.org/10.21070/ijppr.v19i0.1260>



# Environmental Impacts of Oil and Gas Exploration and Exploitation

Chapter

6

Andini Putri Titasari, Kurnia Tri Hermawan

The significant environmental impact of oil and gas exploration and the importance of implementing an ISO 14001-based Environmental Management System to reduce it. The implementation of Environmental Management System (EMS) is effective in improving environmental compliance and a company's reputation, despite the cost and logistics challenges.

## 6.1. Environmental Impact of Oil and Gas Exploration and Exploitation

Oil and gas exploration and exploitation have a significant impact on the environment, ranging from water, air, soil pollution, to habitat degradation. Major impacts include water pollution caused by oil spills and formation waters contaminated with toxic chemicals, as well as emissions of harmful gases such as carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), and nitrogen oxides (NO<sub>x</sub>) during flare gas combustion processes and drilling activities. In addition, drilling activities also trigger habitat fragmentation and threaten biodiversity, especially in areas with endemic species that are vulnerable to environmental changes (Anifowose et al., 2016). This pollution process occurs because in exploration, wastes such as drilling sludge, produced water, and gas emissions are generated and released into the environment without adequate treatment. The use of techniques such as fracking (hydraulic fracturing) in shale gas exploitation, for example, adds to the impact on the environment, such as an increased risk of groundwater contamination due to the injection of hazardous chemicals and the release of toxic gases that have the potential to increase health risks for humans and living things around them ((Ferrarez et al., 2020). This environmental pollution can occur due to the lack of strict regulations and the implementation of optimal environmental management by the oil and gas industry. In some cases, oil and gas companies often ignore effective environmental management standards and focus more on short-term economic gains. Governments and environmental agencies also have an important role in oversight, but there is often a lack of strong law enforcement or effective cooperation between industry and government, leading to an increase in the potential for negative impacts on the environment (Elbisy, 2016). These impacts take place along with exploration and exploitation activities, be it in the early stages of drilling, during

production operations, to post-production when areas have been abandoned without sufficient cultivation or recovery. This environmental recovery can be very slow, especially for vulnerable ecosystems such as coral reefs or mangrove forests around offshore drilling areas (Cordes et al., 2016). Oil and gas exploration and exploitation have a long-term impact on the environment, which requires a strict regulatory approach and good environmental management so that environmental damage can be reduced.

Approaches to environmental management in the oil and gas industry are increasingly diverse and innovative to reduce environmental impact. One common approach is the implementation of an EMS such as ISO 14001 which aims to regulate and minimize pollution through emission and waste control, as well as ensure continuous monitoring of environmental impacts resulting from upstream oil and gas activities, especially in the offshore sector (Dahab, 2020). In addition, artificial intelligence (AI)-based technologies are increasingly being used in oil and gas environmental management to improve efficiency and environmental risk monitoring. AI technology can help analyze operational data in real-time and identify patterns that have the potential to cause negative impacts, allowing for early mitigation of pollution or ecosystem damage (Chutcheva et al., 2022). Furthermore, the development of a diversification strategy and ecosystem protection is another step taken. For example, the implementation of compensation and conservation strategies, where companies take into account carbon and water footprints, and use assessment matrixes to determine the impact of their activities on the environment. This matrix is useful in making decisions related to mitigating impacts on water, soil, and air resources, as well as in planning more sustainable actions (Guerrero-Martin et al., 2023). The value-based approach is also becoming popular. This approach not only focuses on economic performance indicators, but also integrates social, ecological, and ethical aspects in management decisions. This approach increases corporate social responsibility for the environment and helps drive the adoption of innovative technologies that are more environmentally friendly (Dmytruk, 2023). These approaches demonstrate the oil and gas industry's commitment to adapting to sustainability demands and minimizing environmental impacts more effectively.

Oil and gas exploration and exploitation in areas such as Wajo Regency and Riau Islands Province have major impacts on the environment, including water, air, and soil pollution as well as the degradation of coastal ecosystems such as mangroves and coral reefs that are important for biodiversity. In these areas, oil and gas activities can exacerbate the risk of coastal abrasion and contaminate marine habitats that are crucial for local communities that depend on these natural resources. Therefore, this document highlights the importance of implementing an EMS based on the ISO 14001 standard to minimize the negative impact of the oil and gas industry in Wajo Regency and Riau Islands Province, in order to support the

sustainability and protection of local ecosystems. The EMS is a framework that aims to control the environmental impact of operational activities, including in the oil and gas industry. EMS, especially those that refer to the ISO 14001 standard, assists companies in managing waste and emissions, as well as ensuring that each company's activities comply with applicable environmental regulations (Muzanni et al., 2022). EMS was first widely applied in the last two decades, mainly to meet the needs of companies in achieving environmental sustainability while complying with increasingly stringent international regulations (Dahab, 2020). EMS is important because it ensures companies can reduce pollution and manage natural resources efficiently. It is also important to build a company's reputation for meeting ESG (Environmental, Social, and Governance) standards that are increasingly sought after by investors and other stakeholders (Nazarova & Tikhomirov, 2022).

The EMS mechanism includes several steps, including environmental strategy planning, implementation of operational processes, monitoring, evaluation of results, and continuous improvement. With this step, the company can continue to improve environmental impact management as operational activities develop (Tverytnykova et al., 2020). Many parties are involved in the implementation of EMS, such as company management, environmental technicians, independent auditors, as well as government and community agencies. All of these parties play a role in ensuring that every environmental standard and regulation is met and that violations can be dealt with immediately (Liao, 2022). Effective EMS has a positive impact on reducing pollution, improving energy efficiency, and increasing company compliance with regulations, which ultimately strengthens the company's image and increases investment value (Chutcheva et al., 2022). However, there are significant challenges in the implementation of EMS, including high operational costs, the need for ongoing staff training, and logistical challenges, especially in remote areas such as the natural gas sector in Amazonas, Brazil (Pires & Lima, 2022). These barriers must be overcome in order for EMS to be implemented properly and provide maximum environmental benefits.

### **6.1.2. Environmental strategy planning**

In environmental strategy planning, organizations need to set clear environmental goals, identify risks, and define specific mitigation measures in accordance with standards such as ISO 14001. Good planning includes an analysis of the impact of company activities on ecosystems and natural resources, as well as the preparation of scenarios to overcome potential risks, especially in the context of oil and gas exploration activities in sensitive areas (Fadyeyeva, 2023).

Environmental strategy planning using the ISO 14001 standard is a systematic approach in setting clear environmental goals and targets. The ISO 14001 standard was first introduced in 1996 and has continued to evolve, with the most recent revision

in 2015 emphasizing continuous improvement and integration into the company's key management strategy (Jasim Resen & Sadiq AbdulRazzaq, 2022). This planning is important because it helps companies identify environmental risks, comply with regulations, and improve the company's image in the eyes of investors and stakeholders who care about environmental sustainability (Helmina et al., 2022). The strategic planning mechanism begins with an analysis of relevant environmental aspects, then sets targets and develops management procedures to achieve those targets. This process also involves all relevant departments to ensure that these environmental goals are thoroughly implemented in the company's operational activities (Dahab, 2020). This planning typically involves company management, environmental engineers, and external experts to measure and assess environmental risks and impacts. The implementation of this environmental strategy planning has positive impacts, such as reducing pollution levels, better waste management, and increasing energy efficiency. In addition, the implementation of ISO 14001 is also able to increase the company's value and attract investors' attention, especially after international pressure to implement post-Paris Agreement sustainability standards (Margaret et al., 2024). However, there are challenges in its implementation, including the need for sufficient financial resources, ongoing training for staff, and barriers in terms of company culture that may not support change toward sustainability. In addition, the implementation of this standard also requires good inter-departmental coordination and full support from top management to overcome resistance to change (Mansour & Alsulamy, 2021). Environmental strategy planning based on ISO 14001 plays a major role in helping companies achieve long-term sustainability goals, although it requires a high level of commitment and adequate resources to overcome the challenges in its implementation.

Various practices in the implementation of ISO 14001 in the oil and gas industry have shown the importance of sustainability indicators to improve environmental performance. One of the main practices is the integration of EMSs with production systems to reduce carbon emissions, waste, and energy consumption. In the case of gas giants, the integration of digital data with ISO 50001 and the use of digital energy management tools allow the measurement of KPIs, such as energy savings and greenhouse gas (GHG) emission reductions, which supports transparency and efficiency in reducing environmental impacts (Rossi et al., 2022). In addition, indicators such as the level of compliance with environmental regulations and the effectiveness of waste management have been used as a measure of the success of the implementation of ISO 14001. Research in the Middle East shows that companies that adopt ISO 14001 are better able to optimize waste management and improve their environmental assessments, thus demonstrating a positive relationship between environmental performance and ISO 14001 compliance (Jasim Resen & Sadiq AbdulRazzaq, 2022). Other practices include the development of eco-economic



indicators, such as the costs and benefits of sustainability efforts. In Russia, these indicators include efficiency in waste reduction and increased environmental social responsibility, which can be measured through improved cost savings and a company's reputation in the eyes of stakeholders (Huseynov, 2021). These practices use indicators that assess both environmental and operational aspects, such as energy efficiency, emission reduction, and waste management, as well as financial impact to strengthen the company's sustainability performance.

ISO 14001 is an international standard that serves to establish environmental management parameters and systems for organizations that want to reduce their environmental impact. This standard provides a framework for protecting the environment through emission control, waste management, and energy efficiency. The monitored parameters include energy consumption, the amount of waste generated, and air pollution, which must be continuously improved by certified companies (Kojra et al., 2020). ISO 14001 was first introduced in 1996 and updated in 2015 to integrate a risk-based approach. This update is very important because it increases the flexibility of companies in identifying environmental risks and implementing more effective mitigation measures (Budi et al., 2020). The importance of this standard is as a tool to demonstrate the company's commitment to sustainability and to meet the demands of consumers and investors who are increasingly concerned about the environment. The implementation mechanism includes identification of environmental aspects, evaluation of potential impacts, implementation of management procedures, and periodic performance evaluations. All departments within the organization are involved in its implementation, including top management who is responsible for ensuring compliance with standards and periodic performance reviews (Gustia et al., 2021). The impact includes reduced pollution, improved resource use efficiency, and regulatory compliance. However, the main challenges are high implementation costs, the need for ongoing training, and internal resistance in some organizations that are less supportive of the change toward sustainability (Alnavis et al., 2021). ISO 14001 helps companies achieve better sustainability, although it requires a strong commitment and adequate resources to address these challenges. The visualization in the form of a diagram (figure 6.1.) illustrates the set of key steps that make up the ISO 14001 framework for implementation in various industry sectors, where this process is designed to enable organizations to systematically navigate and optimize the management of their environment, ensuring a consistent commitment to sustainability. The standard includes planning, execution, performance evaluation, management review, and continuous improvement cycles, which are integrated to ensure environmental compliance, reduce negative impacts, and improve resource efficiency.

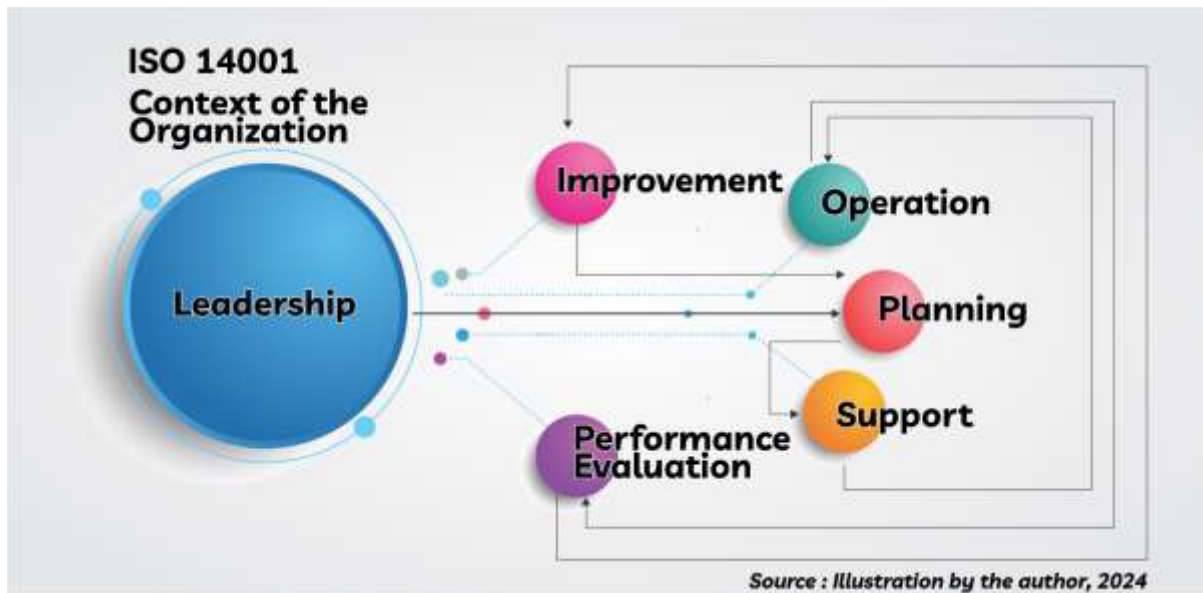


Figure 6.1. ISO 14001 Framework

The ISO 14001 implementation process involves several key stages that are structured to ensure effective environmental management:

1. **Determination of Organizational Context**—This initial step involves determining internal and external factors that can affect the company's environmental goals. Organizations must identify the needs of relevant parties and prepare the basis for the development of an EMS (Maryeska et al., 2020).
2. **Planning and identification of environmental aspects**—At this stage, the company identifies the environmental aspects and impacts resulting from its activities, such as emissions, waste, and energy use. The company then sets environmental goals and actions to be taken to achieve these goals (Budi et al., 2020).
3. **System Implementation and Operationalization**—The Company implements an EMS in accordance with established procedures, including monitoring, controlling, and managing identified environmental aspects. Examples of implementation include waste management and reduction of energy consumption to improve environmental performance (Rementsov, 2020).
4. **Performance Measurement and Evaluation**—Evaluation is conducted by comparing actual results against environmental goals that have been set. The use of performance indicators such as emission levels and waste management is the basis for evaluation and identification of areas that need improvement (Kojra et al., 2020).
5. **Continuous Improvement and Internal Audit**—This stage includes corrective actions and system improvements based on audit and evaluation findings. This process aims to improve the efficiency and sustainability of the system, ensuring compliance with the standards that apply continuously (Vanessa Stelzenmüller et al., 2020).

ISO 14001 helps organizations to develop an environmental framework that not only reduces negative impacts on the environment but also improves operational efficiency and reputation in the global market. In the early stages, companies start with a deep understanding of environmental risks and related stakeholders. Organizational context reports provide the basis for environmental planning. Planning, after setting emission reduction targets, companies prepare emission mitigation plans. These targets help focus on measurable improvements. Implementation, the use of environmentally friendly technology is integrated into the production process to reduce energy consumption and emissions, which is reflected in waste and emission monitoring data. Measurement, monthly audits are carried out to measure performance against targets. These audits identify areas of improvement, which are then used to decide on next steps. Matrix of stages and performance indicators of ISO 14001 implementation (table 6.1.)

Table 6.1. Matrix of stages and performance indicators of ISO 14001 implementation.

| ISO 14001 Stages                       | Simulation of Company Activities.                                                                                                                              | Expected Results.                                                                   | Performance Indicators (KPIs)                                                         |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Determining the Organizational Context | Companies analyze internal (such as resources and skills) and external (government regulations, market needs) factors.                                         | Understand the main environmental risks and influencing external factors.           | Number of stakeholders identified, risk analysis report                               |
| Planning                               | The company identifies carbon emissions as a major environmental impact. Set a target of 15% emission reduction within 1 year.                                 | The creation of a carbon emission mitigation plan to prevent environmental impacts. | Percentage reduction in carbon emissions, number of identified environmental aspects  |
| Implementation and Operationalization  | The company applies environmentally friendly technology in the production process, conducts waste management, and documents procedures.                        | Reduce the impact of waste and emissions during the operational process.            | Reduction in waste volume and energy consumption per month                            |
| Performance Measurement and Evaluation | The company conducts monthly audits to check whether carbon emissions and waste are reduced according to the target, as well as make corrections if necessary. | Identify achievements and areas for improvement.                                    | Audit frequency, level of compliance with environmental targets                       |
| Continuous Improvement                 | Based on the evaluation, the company added a more efficient waste treatment system and provided sustainability training to staff.                              | Improvement of environmental performance and staff awareness of sustainability.     | Audit satisfaction level, number of sustainability training, cost of impact reduction |

Source : author's analysis, 2024

Continuous Improvement, based on the results of the audit, the company added systems and provided advanced training to ensure that all employees support sustainability practices. This simulation shows how companies can achieve ISO 14001 targets in a structured and sustainable way.

### **6.1.3. Implementation of operational processes**

The implementation of operational processes involves the implementation of environmental policies into the company's daily practices. This includes waste monitoring and management, reduction of greenhouse gas emissions, and the use of environmentally friendly technologies in the production process, as recommended in research on the implementation of environmental management systems in the supply chain (Chen & Ye, 2020). A real-time monitoring system is also implemented to ensure that operational activities remain in line with the environmental targets that have been set.

Operational implementation in waste management, emission reduction, and the use of environmentally friendly technology aims to create more efficient and sustainable operational processes. This technology utilizes real-time monitoring to ensure compliance with environmental standards and improve operational effectiveness. This implementation includes steps in managing waste, reducing carbon emissions, and utilizing environmentally friendly technologies. According to a study on waste management with modern technology at the Bantar Gebang Integrated Waste Management Site (TPST), the concept of waste management with high technology can optimize urban waste management in a more environmentally friendly manner (Larasati & Puspaningtyas, 2020). This implementation has been widely implemented in various countries since global awareness of climate change and the impact of pollution increased sharply in the early 2000s. The importance of implementing environmentally friendly technology lies in its ability to reduce the negative impact of industrial operations on the environment, as demonstrated in effective hospital waste management according to health and environmental standards (Amir & Nurhakiki, 2021). Emission reduction and good waste management are indispensable to maintain environmental sustainability and public health.

The implementation mechanism includes the application of digital waste and emission monitoring technology to maintain compliance with environmental regulations, as well as the use of technology to manage waste in a recyclable way. For example, vermicomposting technology in agricultural waste can turn waste into useful products and increase the income of local communities (Abri et al., 2021). This implementation involves various parties such as local governments, companies, environmental organizations, and local communities. Private sector participation is also important in maintaining the sustainability of waste management and other environmentally friendly programs (Larasati & Puspaningtyas, 2020). This implementation is expected to reduce emissions, manage waste more effectively, and provide economic benefits through recycling and selling environmentally friendly products. Real-time monitoring technology increases transparency and accountability in environmental management. Challenges in this implementation include a lack of public understanding and a lack of adequate infrastructure support.

Another obstacle is the high cost of technology development and coordination between related parties that is not optimal (Turiman et al., 2021). The implementation of waste management and emission reduction with environmentally friendly technology is important to maintain environmental sustainability and health.

Some of the sustainability practices that have been implemented in ASEAN countries for example, systematic studies identify three main practices in sustainable manufacturing: sustainable product development, sustainable manufacturing performance, and environmental assessment and monitoring. This implementation includes the integration of holistic industrial processes to protect the environment and society. The indicators used are the level of environmental assessment, energy efficiency, and waste reduction (Qureshi et al., 2020). Malaysia has adopted Good Regulatory Practice to achieve environmental sustainability with the aim of reducing industrial pollution. Important indicators include the level of achievement of the Sustainable Development Goals (SDGs), carbon emission reduction, and the level of compliance with environmental regulations (Zulkifli et al., 2020). ASEAN countries are implementing ESG approaches to support sustainable economic growth. Studies show that environmental, social, and good governance scores are positively correlated with the achievement of the SDGs. The main indicators are ESG scores, economic growth rates, and SDGs achievement rates (Sadiq et al., 2023). ASEAN, with its great potential for solar energy, continues to increase the use of renewable energy. Countries such as Indonesia and Malaysia have taken steps to improve the renewable energy mix through solar energy policies. Important indicators are increasing solar energy capacity, reducing carbon emissions, and implementing advanced energy storage systems (Pandey et al., 2022). The implementation of various sustainability practices in ASEAN shows that success is determined by the involvement of all stakeholders, as well as the importance of continuous assessment and monitoring to achieve environmental and economic targets. These sustainability practices result in improved environmental quality, increased corporate compliance with regulations, positive contributions to sustainable economic growth, and accelerated the transition to clean energy in the ASEAN region. These results show that sustainable efforts in ASEAN not only contribute to the achievement of the SDGs, but also strengthen regional competitiveness in a sustainable manner.

#### **6.1.4. Environmental strategy supervision**

Supervision is an important component that involves periodic monitoring of activities and evaluation of target achievement. The use of Key Performance Indicators (KPIs) can help companies monitor compliance with standards and detect environmental problems early, so that corrective steps can be taken immediately (Dahalan et al., 2023). Supervision in the context of modern business is a process that involves continuous monitoring and evaluation of the achievement of set targets and

standards. The use of KPIs is one of the methods that has proven effective in monitoring compliance with standards and detecting environmental problems early. The development of KPIs itself has been an important part of management since the emergence of the need to measure performance quantitatively in various industries, with this concept growing rapidly in the 20th century until now, where its application has expanded to fields such as construction, energy, and the environment (Angelakoglou et al., 2023).

The use of KPIs in surveillance is critical because it allows companies to immediately identify issues that require corrective action, reduce operational risks, and improve compliance with environmental regulations and standards. KPIs provide measurable and concrete guidance in this monitoring, so that companies can respond quickly to potential problems, maintain efficiency, and optimize long-term results (Zarzycka & Krasodomska, 2021). KPI-based monitoring mechanisms typically involve the selection of indicators relevant to environmental and business objectives, continuous data collection, and in-depth analysis through an integrated monitoring system. This mechanism is often implemented in cross-departmental collaboration, including environmental audit teams and project managers, who are tasked with ensuring these indicators are accurate and relevant to the company's sustainability goals (Yurtay et al., 2023). The various parties involved in this oversight include management, environmental auditors, and external stakeholders such as regulators and local communities concerned about environmental impacts. All of these parties collaborate to ensure that the KPIs used can provide transparent and accurate results, as well as support the implementation of better environmental policies (Dahalan et al., 2023).

The positive impacts of KPI-based monitoring include increased compliance with environmental regulations, optimization of operational performance, and reduction of the risk of environmental damage that has the potential to harm the company financially and reputationally. However, the challenges in its implementation are the often-considerable cost of implementation and maintenance of monitoring systems, as well as resistance to changes from internal parties who are less familiar with this data-driven method (Saihi et al., 2022). KPI-based oversight is an essential step in ensuring a company's compliance with environmental standards and performance improvements, despite the operational challenges and costs that need to be managed effectively. The stages of implementing KPIs in environmental performance supervision and standard compliance as a reference can be divided into the following stages:

1. Identify Goals and Needs. In the early stages, companies need to understand the strategic objectives and environmental needs they want to achieve, as well as the

regulations that must be complied with. This is important to ensure that the KPIs formed are relevant to these objectives (Angelakoglou et al., 2023).

2. **Selection of Relevant Indicators.** The selection of KPIs should be based on criteria that are relevant, measurable, and easy to understand. Indicators such as greenhouse gas emissions, energy consumption, and compliance with environmental standards are often prioritized. This selection can involve consulting with various stakeholders to get the right indicators (Zarzycka & Krasodomska, 2021).
3. **Data Collection and Continuous Monitoring.** KPI monitoring systems need to be built to collect data in real-time or periodically. Technologies such as sensors and monitoring software are often used to automatically integrate and monitor data, which is then compiled in a centralized system (Yurtay et al., 2023).
4. **Data Analysis and Interpretation.** Once the data is collected, an analysis is conducted to evaluate performance and identify areas that need improvement. This analysis aims to determine deviations from the target and provide input for the management team in making decisions related to corrective steps (Saihi et al., 2022).
5. **Corrective Action and Continuous Improvement.** Based on the results of the analysis, corrective actions are applied if there is a discrepancy with the target. This step could include adjustments in operational processes, additional training, or technological upgrades to further reduce environmental impacts ((Dahalan et al., 2023).
6. **Reporting and Performance Review.** The results of KPI monitoring and evaluation are regularly reported to internal and external stakeholders. This reporting allows transparency and accountability in achieving environmental targets, as well as providing feedback for future monitoring system improvements (Neri et al., 2021).

Through this stage, KPIs are not only a monitoring tool, but also encourage continuous improvement in environmental performance and compliance. KPIs can be simulated in table 6.2. Successful implementation of KPIs in various sectors, e.g. Modern Manufacturing, the implementation of KPIs in manufacturing allows the measurement of production efficiency and quality control. KPIs such as machine downtime, number of defective products, and order fulfillment rates have helped manufacturing companies improve performance and response to production challenges. This monitoring makes it easier for companies to adjust strategies and improve process efficiency with greater transparency in day-to-day operations (Nesterova & Pristaya, 2023). Sustainable Supply Chain Management, in the furniture industry, KPIs are used to improve sustainability in the supply chain. By updating and monitoring KPIs in real-time through SCM software, companies can evaluate indicators related to environmental impact, resource consumption, and carbon

emissions. These practices reduce performance gaps in the supply chain and support the company's global sustainability goals (Yurtay et al., 2023).

Table 6.2. KPI quantitative analysis series

| KPI Stages                            | Description                                                                                                        | Example Data Results                                                                                                                                                        |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Identify KPIs and Targets             | Determine the main KPIs and targets to be achieved, such as carbon emissions and energy consumption                | KPIs: Carbon Emissions (tons CO <sub>2</sub> ), Energy Consumption (MWh)                                                                                                    |
|                                       |                                                                                                                    | Target: -10% carbon emissions, -5% energy consumption per year                                                                                                              |
| Historical Data Collection            | Collect data from the last 5 years to find out the baseline of performance                                         |                                                                                                                                                                             |
| Modeling Next Year's Target           | Create a projected reduction target according to the annual target for the following year                          | 2023 Carbon Emission Target: 820 tons–<br>(820 x 0.10) = 738 tons of CO <sub>2</sub>                                                                                        |
|                                       |                                                                                                                    | 2023 Energy Consumption Target: 1,800 MWh–(1,800 x 0.05) = 1,710 MWh                                                                                                        |
| Simulation of Achievement Scenarios   | Scenario analysis based on optimal, moderate, and suboptimal conditions                                            |                                                                                                                                                                             |
| Analysis Varies KPI                   | Calculate the variance of the target and the outcome of the scenario to see the effectiveness of the actions taken |                                                                                                                                                                             |
| Evaluate Effectiveness and Efficiency | The conclusion of the effectiveness of each scenario in achieving the target                                       | Optimal Scenario: Highest effectiveness, excellent efficiency                                                                                                               |
|                                       |                                                                                                                    | Moderate Scenario: On-target, efficient                                                                                                                                     |
|                                       |                                                                                                                    | Less than Optimal Scenario: Needs improvement                                                                                                                               |
| Reporting and Recommendations.        | Create reports for management based on the above analysis.                                                         | Report achievements, variances, and recommendations for improvement. For example: Strengthening the use of technology in the energy sector to make efficiency more optimal. |

Source : author's analysis, 2024

Construction and Health Infrastructure, in the health building construction sector, KPIs are applied to measure factors such as building quality, budget, and completion time. KPIs such as cost escalation and approved project scheduling help ensure project success and client satisfaction, with effective monitoring of progress and proactive handling of project changes (Bhattara, 2021). Water Utilities in Developing Countries, KPIs are also used by water utility companies in developing countries to manage service quality, control costs, and expand access. Through KPIs, such as water quality, operational costs, and customer complaints, utility companies can improve operations and ensure compliance with applicable regulations (Berg, 2020). Environmental Management in Road Construction, in road construction projects, KPIs are applied to ensure comprehensive environmental monitoring, including soil erosion control, waste management, and public safety. By monitoring these indicators, road construction projects can minimize negative environmental impacts and improve compliance with environmental management plans (Dahalan et al., 2023).



#### **6.1.5. Evaluation of Environmental Strategy results**

Evaluation of results is carried out periodically to assess the effectiveness of the implemented environmental strategy. This evaluation includes measuring the impact of activities on the environment, such as carbon emissions or land degradation. The results of this evaluation are then used to prepare an adequate sustainability report, which further becomes the basis for future strategy adjustments (Khansa & Widiastuti, 2022). Periodic evaluation of environmental strategies is an important step that aims to assess the effectiveness of the strategies that have been implemented and ensure the optimal achievement of environmental sustainability goals. This evaluation includes measuring the impact of activities such as carbon emissions and land degradation to find out how much these activities contribute to environmental damage. This evaluation began to grow in line with increasing awareness of climate change and environmental degradation, especially since the last few decades where this issue has become a global concern. This step is important because the data from the evaluation results is used as a basis to rearrange the strategy to better suit environmental needs and future sustainability goals (Khansa & Widiastuti, 2022). Environmental evaluation mechanisms typically involve a wide range of stakeholders, including governments, companies, researchers, and the public. Data from these activities are used to compile adequate and accurate sustainability reports. The impact includes improving the quality of life of the community, restoring damaged ecosystems, and reducing negative impacts on the environment. Challenges in this evaluation process include limitations in accurate data, stakeholder involvement, and the need for evaluation methods that can provide a comprehensive picture of environmental conditions. In addition, consistent supervision and implementation are often difficult to implement on a wide scale (Wantu & Apripari, 2023). This practice has been carried out in several references that can be used as references.

The results that can be learned from various environmental strategy implementation practices show that collaborative and community-based approaches are very effective in increasing environmental awareness and concern. The Waste-Free Zone Program in Lombok, for example, has succeeded in instilling environmentally wise behavior through the Context, Input, Process, Product (CIPP) evaluation approach, which has been proven to increase citizens' awareness of the importance of maintaining cleanliness and reducing waste. The training on introducing carbon stocks to teachers in Central Java also showed that a basic understanding of the importance of carbon stocks can be conveyed through simple education that further encourages students to be more concerned about the impact of carbon and climate change. In Karawang, the sustainable food land protection program highlights the importance of stakeholder commitment and in-depth

technical analysis to protect agricultural land from land conversion, despite political and technical challenges that are often obstacles.

Table 6.3. Practice of implementing periodic evaluations on environmental strategies

| Practice                                                               | Description.                                                                                                                                                                                                                                             |
|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Waste-Free Area (KBS) Program (Hariska et al., 2022)                   | The program in Central Lombok applies the CIPP approach to assess the effectiveness of waste-free areas, encouraging environmentally wise behavior in the community. The success rate is quite high in building environmental awareness among residents. |
| Introduction to Tree Carbon Stock (Santhyami et al., 2022)             | Simple tree carbon stock measurements were carried out for climate change mitigation, with the training of science and biology teachers in Central Java. It helps environmental education in schools to increase carbon awareness among students.        |
| Sustainable Food Agricultural Land (LP2B) (Wicaksono, 2020)            | The program in Karawang focuses on protecting food farmland from land conversion. Implementation faces challenges in stakeholder commitment and spatial analysis in the early stages.                                                                    |
| Educational Trash Can Design ((Leony et al., 2023)                     | The research that designed an educational trash can to form the character of love for the environment in elementary school students in Parepare, succeeded in increasing students' awareness of environmental cleanliness.                               |
| Corporate Social Responsibility (CSR) (Kalamika & Khabiburohman, 2020) | CSR implementation by PT. Borobudur Temple Tourism Park, which involves the community through the Partnership and Community Development Program, aims to improve social welfare through environmental and social responsibility.                         |

Source : author search, 2024

The design of an educational trash can in an elementary school in Parepare has succeeded in increasing children's awareness of environmental cleanliness, showing that a persuasive approach from an early age can shape the character of environmental love in the younger generation. The CSR program implemented by PT. The Temple Tourism Park also proves that the involvement of the private sector in sustainability efforts can provide direct benefits for the welfare of the surrounding community and create a sustainable positive environmental impact. From these various practices, it can be concluded that collaboration between governments, communities, educational institutions, and the private sector is essential in the implementation of sustainable environmental strategies, with periodic evaluation and education as the key to the success of these programs.

#### **6.1.6. Continuous improvement Environmental Strategy**

Continuous improvement ensures that environmental strategies are updated in line with technological and regulatory developments (table 6.4.). Companies need to conduct periodic analyses of management processes and adopt new, more effective and efficient practices. These changes may also include adjustments in the use of artificial intelligence-based technologies to improve environmental sustainability (Chutcheva et al., 2022). The importance of implementing continuous improvement in environmental strategies lies in the need for companies to remain relevant in the face of dynamic developments in environmental regulations and

technology. This step helps companies adapt to market demands and increasingly higher standards for sustainability, so that they can improve their performance and competitiveness (Hassan et al., 2018). This implementation should be carried out periodically to ensure that the strategies implemented are in accordance with the latest developments. For example, research shows that technological innovation driven by environmental regulations can drive increased green production and company performance in the long term (Ouyang et al., 2020) and increase competitiveness through innovative green technologies (Lin & Chen, 2020).

Table 6.4. Environmental Sustainability Implementation Practices

| Practice                                                                       | Implementation Description.                                                                                                                                                        |
|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Continuous Improvement in Environmental Sustainability (Galli, 2020)           | The continuous improvement model improves environmental performance and value for stakeholders by emphasizing employee engagement and regular evaluation of operational practices. |
| Systems and Improvement Teams in Companies (Bernal-Torres et al., 2021)        | Continuous improvement is implemented through a team that involves regular training and evaluation, focusing on improving financial and operational aspects.                       |
| Implementation of Kaizen in the Health Sector (Morell-Santandreu et al., 2020) | The application of Kaizen identifies low-value activities and optimizes processes to improve economic and social efficiency.                                                       |
| Lean-Green Manufacturing (Abualfaraa et al., 2020)                             | The lean-green approach reduces environmental impact through production efficiency that balances economic, environmental, and social performance.                                  |
| Green Management in Supply Chains (Sánchez-Flores et al., 2020)                | Green management in the supply chain improves sustainable performance through environmentally sound selection of materials, production, and logistics.                             |
| Metal Plastic Recycling Program (Walls et al., 2023)                           | The program recycles metal plastic waste into high-quality materials, reducing waste and costs, and improving sustainability.                                                      |
| Sustainable Project Management (Ferrarez et al., 2023)                         | Sustainability-focused project management practices include environmental efficiency and social responsibility in the project process.                                             |

The main impacts obtained include improved company environmental performance, operational cost savings, and improved product quality, which in turn increases customer satisfaction as well as the company's reputation as a sustainable entity (Galli, 2020). In the long run, companies that implement this strategy tend to be more competitive because they can attract more customers and retain an environmentally conscious workforce (Wang & Liu, 2020). The management of these initiatives is usually carried out by the company's environmental management in collaboration with various parties, including the operations, technology, and marketing divisions. Actual implementation in the field usually involves an operational workforce that is empowered to follow procedures that have been adapted based on continuous analysis, as well as implement new practices in daily activities (Savino & Mazza, 2014). The implementation of continuous improvement in environmental strategies is very important for companies to improve their competitiveness and environmental performance. In addition, this adaptation not

only supports business sustainability, but also has a positive impact on the environment and customer satisfaction.

The results that can be learned from this continuous improvement practice show that the implementation of an integrated sustainability strategy in business processes has a significant positive impact on the company, both in environmental, economic, and social aspects. A study by (Galli, 2020) shows that continuous improvement involving the entire team and regular training can improve a company's operational performance and value for stakeholders. In addition, the application of the Kaizen method in the health sector, as described by (Morell-Santandreu et al., 2020), has succeeded in identifying worthless activities and optimizing efficiency, having a positive impact on the economy and society, although its contribution to environmental sustainability is still limited. Lean-Green Manufacturing practices, as explained by (Abualfaraa et al., 2020), play a role in maintaining a balance between economic efficiency and environmental impact by reducing waste and resource use. The implementation of the metal plastic recycling program carried out by (Walls et al., 2023) shows that recycling initiatives not only reduce costs and waste, but can also achieve significant reductions in environmental impact. Project management that considers environmental efficiency and social responsibility, as outlined by (Ferrarez et al., 2020), creates a foundation for cross-functional collaboration and ensures sustainability in every step of the project. Overall, these practices show that a sustainability approach that focuses on continuous improvement provides sustainable benefits for companies by generating efficiencies, reducing costs, improving environmental performance, and strengthening the company's image in the face of global sustainability challenges.

## **6.2. Review of environmental degradation cases in coastal areas and mitigation strategies.**

Environmental degradation in coastal areas is a serious problem that is closely related to human activities, such as urbanization, infrastructure development, and industrial and agricultural activities that trigger pollution. This phenomenon causes damage to important coastal ecosystems, including mangroves, coral reefs, and aquatic vegetation, which serve as carbon sinks, habitat providers, and coastal protectors from erosion and natural disasters (Nichols et al., 2019). The importance of mitigation strategies for environmental degradation in the region is gaining international attention as the threat of climate change increases that exacerbate erosion, sea level rise, and stronger hurricanes (Howard et al., 2017). Mitigation and adaptation in maintaining coastal ecosystems have been a priority since the last decade. Mitigation measures such as the application of mangrove vegetation, coastal "greenbelt" systems, and the use of bioengineering structures are increasingly being developed to prevent further damage and aid the ecosystem restoration process

(Ayyam et al., 2019). The use of natural restoration methods such as "living shorelines" is also increasingly recommended as an alternative solution to hard structures such as sea walls that often contribute to the destruction of natural habitats (Scyphers et al., 2019).

Implementation of coastal environmental mitigation requires cooperation between stakeholders, including governments, local communities, scientists, and non-governmental organizations, aiming to reduce environmental pressures through policies, funding, and public awareness that support conservation and sustainable management. Challenges include limited funding, coordination between agencies, and sometimes lack of local community participation in conservation project planning (Yu et al., 2019). The impacts of coastal degradation without effective mitigation efforts can be widespread, including deterioration of water quality, increased flood risk, and loss of biodiversity that harms the well-being of coastal communities and biodiversity globally (Grogan & Mallin, 2021). The main challenges in the mitigation process include the complexity of ecosystems that require a multidisciplinary approach as well as policy and financial constraints that are often obstacles to the implementation of ecological-based mitigation strategies (Hoggart et al., 2015). The implementation of environmental mitigation strategies in coastal areas requires a holistic approach and cross-sectoral support to ensure sustainability and success in addressing increasing environmental degradation. Practices that have been implemented in mitigating environmental degradation in coastal areas have become a spotlight in the scientific realm.

The results of various coastal degradation mitigation practices show the effectiveness of ecosystem-based approaches and community participation in restoring and protecting coastal areas. The "living shorelines" strategy is also effective in encouraging property owners to adopt natural solutions that strengthen the ecological and aesthetic resilience of the beach (Scyphers et al., 2019). The "Blue Carbon" program has been successfully implemented in various countries with carbon finance support, helping to maintain carbon-sinking ecosystems and reducing local emissions through the protection and planting of mangroves and seagrass (Wylie et al., 2016). In China, the implementation of ecological offsets on coastal wetlands demonstrates the importance of replacing lost ecosystems with similar conservation measures to maintain the region's biodiversity and carbon storage capacity (Yu et al., 2019). A participatory approach in coastal adaptation planning shows that the active involvement of local communities and stakeholders can result in strategies that are sustainable and appropriate to local social, economic, and environmental needs (Lima et al., 2023). Overall, these practices indicate that ecosystem-based solutions and community inclusion are effective approaches to sustainable coastal mitigation.

Table 6.5. Mitigation of environmental degradation in coastal areas

| Mitigation Practices                           | Description                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| "Living Shorelines"                            | Implementation of natural vegetation and substrate as a substitute for concrete walls to reduce abrasion. The coastline offers natural protection that is in harmony with the surrounding ecosystem and is encouraged through incentives for coastal property owners to move away from concrete structures (Scyphers et al., 2019) |
| Formation of the Coastal Greenbelt             | The use of special vegetation such as mangroves along the coastline to capture carbon emissions and reduce the impact of global warming (Mandal et al., 2021)                                                                                                                                                                      |
| Dune Reconstruction and Sand Filling           | Strategies such as the construction of dunes close to the coastline and the replacement of sand to reduce abrasion in degraded areas. This has succeeded in extending the life of the coastline and reducing the frequency of repairs (Costa et al., 2023)                                                                         |
| Blue Carbon Projects                           | Blue carbon conservation programs with mangrove and seagrass planting, as well as the protection of carbon-sequestering ecosystems to reduce coastal carbon footprint. Examples of this program are carried out in Kenya, India, Vietnam, and Madagascar with support from carbon finance mechanisms (Wylie et al., 2016).         |
| Ecological Offsets in Coastal Wetlands         | The ecological offset program in China by restoring and conserving wetlands to replace ecosystems degraded by development, where these offsets serve to increase carbon stocks and prevent the loss of natural habitats (Yu et al., 2019).                                                                                         |
| A Participatory Approach to Coastal Adaptation | Participation of local communities and stakeholders in identifying adaptation strategies such as integrated management of coastal zones to address abrasion and climate change. This involves assessing social, economic, and environmental impacts to achieve long-term outcomes (Lima et al., 2023).                             |

Source : author search, 2024

The role of BUMD in Indonesia in the management of the oil and gas sector and its efforts to maintain a balance between economic development and environmental sustainability (table 6.5.). In regions such as the Riau Islands and Wajo Regency, BUMD has an important role in promoting sustainable environmental policies, one of which is through the Participating Interest (PI) policy of 10%. This policy allows regions to participate directly in the supervision of oil and gas activities, ensuring those practices adhere to strict environmental standards (Hasiholan et al., 2023). BUMD also implements an Environmental Management System such as ISO 14001 which supports improving operational efficiency while reducing environmental impact, similar to the natural ecosystem approach in coastal mitigation. This international standard ensures sustainable environmental management, where every operational aspect is checked to be in line with environmental regulations (Muzanni et al., 2022).

Furthermore, the active involvement of local communities in resource management is an important part of the sustainability strategy implemented by BUMD. This collaborative approach is similar to the practice of mitigation of "living shorelines" in coastal areas, where community participation increases transparency and collective commitment to environmental conservation. This involvement not only helps in environmental conservation, but also increases social acceptance of projects run by BUMDs (Wardana et al., 2023). BUMD also implements environmental

taxation to reduce the negative impact of exploration and production activities on the ecosystem. This tax encourages companies to adopt environmentally friendly technologies, thereby reducing air, soil, and water pollution. This tax policy reflects mitigation efforts in coastal areas aimed at reducing the impact of damage to marine ecosystems due to industrial activities (Samusevych & Horodetska, 2023).

However, the implementation of BUMD policies in the oil and gas sector is not free from challenges, especially in terms of coordination and regulatory sanctions. Although PI policies have given regions a greater role, their effectiveness is often limited due to a lack of oversight and sanctions for violations of those policies in some areas. Similar obstacles are also encountered in coastal environmental mitigation, where coordination and funding challenges often hinder the achievement of optimal sustainability (Wahyudi, 2022). The importance of a sustainable approach to the management of the oil and gas sector by BUMDs through cross-sector collaboration, the implementation of environmental standards, and the involvement of local communities to ensure that the exploitation of natural resources is carried out while maintaining the balance of the ecosystem and the welfare of the community.

Therefore, options are needed for strategies that can be implemented by Wajo Regency and Riau Islands Province in mitigating coastal environmental degradation (table 6.6.). An ecosystem-based approach to coastal environmental degradation mitigation means that each strategy is designed to work in harmony with the natural functioning of the ecosystem. Instead of relying on hard structures such as concrete or metal that can disrupt the balance of habitats, this approach utilizes natural components, such as mangroves, seagrasses, and coral reefs, which naturally function to protect the coast from erosion, reduce abrasion, and absorb carbon. With this approach, coastal habitats are maintained and even strengthened, as every component of coastal ecosystems, from vegetation to fauna, plays a complementary role in maintaining ecosystem stability. In addition, this approach is more durable and can reduce maintenance costs, as natural ecosystems have a sustainable regeneration capacity. Multi-stakeholder involvement in this strategy is also crucial because the success of mitigation and environmental conservation programs cannot rely entirely on one party alone. By involving the government, local communities, companies, non-governmental organizations (NGOs), and academics, each party can contribute according to their capacity.

The government plays a role in setting regulations and policies, companies support finance and implement environmentally friendly business practices, NGOs focus on advocacy and education, while academics provide research and green technology innovations. Most importantly, local communities are involved in this process because they are the most affected and have in-depth knowledge of the local environment. With this collaborative and sustainable approach, mitigation efforts are

expected to be not only more effective but also accepted by the community, as well as build collective awareness to preserve the coast in the long term.

Table 6.6. Mitigation of coastal environmental degradation

| Strategy                                                  | Description                                                                                                                                                                                                                                                                                                                                      | Parties Involved.                                                                                                 |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Restoration of Mangrove Ecosystems and Coral Reefs        | Carrying out mangrove rehabilitation and coral reef restoration to protect coastal areas from abrasion, while increasing biodiversity. These efforts include replanting damaged mangrove areas and rehabilitating coral reefs by developing "reef balls" or other artificial structures to support marine ecosystems.                            | Local governments, the Marine and Fisheries Service, environmental NGOs, and local communities.                   |
| Implementation of "Living Shorelines"                     | Using natural vegetation such as mangroves and other coastal vegetation as a natural barrier to protect the coastline from erosion. This approach maintains the ecological integrity of the coast rather than the use of hard structures such as sea walls that tend to damage habitats.                                                         | Local governments, coastal property owners, local communities, and related agencies in environmental management.  |
| Implementation of the Greenbelt System on the Coast       | Developing a coastal "greenbelt" with the planting of special vegetation along the coast to reduce the impact of erosion and protect coastal areas from the threat of natural disasters such as hurricanes and rising sea levels.                                                                                                                | Forestry Service, Regional Disaster Management Agency (BPBD), local communities, and coastal land managers.       |
| Strengthening Environmental Tax Policy                    | Impose environmental taxes on industries that have a major impact on the coastal environment, including oil and gas activities, to encourage the adoption of green technologies. This tax can also be allocated to fund coastal restoration projects and other conservation activities in the region.                                            | Local governments, Regional Revenue Agencies, oil and gas companies, and environmental organizations.             |
| Implementation of the Coastal Carbon Offset Program       | Encourage companies to invest in carbon offset programs through coastal ecosystem restoration. This program aims to absorb carbon emissions by conserving or restoring important habitats such as mangroves that function as natural carbon sinks.                                                                                               | Local governments, private companies (BUMD), NGOs, and international institutions related to carbon conservation. |
| Local Community Education and Engagement                  | Conducting environmental awareness training and campaigns for coastal communities related to the importance of maintaining and preserving the coastal environment. Community involvement can increase the success of environmental conservation projects and reduce destructive activities, such as waste disposal and illegal mangrove logging. | The Education Office, NGOs, community leaders, and local coastal communities.                                     |
| Strengthening Coastal Zoning and AMDAL Policies           | Implement and strengthen coastal zoning regulations and environmental impact analysis (EIA) to ensure that coastal development activities are in line with sustainability principles. This policy can regulate protected areas, restricted use areas, as well as areas open for commercial activities with strict conditions.                    | Local governments, the Licensing and Environment Office, BUMD, and the private sector operating in coastal areas. |
| Application of Bioengineering Technology in the Coastline | Utilizing bioengineering technology to strengthen the natural structure of coastlines without disrupting ecosystems. Techniques such as "geotextile tubes" or "natural fiber rolls" can be used to reinforce coastal substrates.                                                                                                                 | Local governments, research institutions, environmentally friendly construction companies, and academics.         |

Source : author's analysis, 2024



In the context of efforts to mitigate coastal environmental degradation, the following are the preparations that need to be made by the Regional Government, the Licensing and Environment Office, BUMD, and the private sector to increase the effectiveness and sustainability of mitigation programs, the role of the Regional Government is to establish local policies and regulations that support the preservation of coastal ecosystems. The government needs to develop an integrated coastal area zoning plan, adjusting to national policies and community needs. For example, ecosystem-based mitigation approaches that involve the protection of coastal natural vegetation such as mangroves can reduce the risk of erosion and the impact of natural disasters on local communities. In addition, the government needs to educate and hold socialization to the public about the importance of preserving the coast, especially for communities in vulnerable areas.

The Licensing and Environment Office is responsible for overseeing the implementation of the EIA and ensuring that every development project in coastal areas has taken into account its ecological impact. The agency needs to strengthen regulations and update licensing standards to better support ecosystem-based mitigation. One of the challenges identified is the need for a science-based approach to support informed decision-making and long-term monitoring of environmental impacts. Collaboration with research institutions and environmental experts will enrich the data needed for scientific evidence-based mitigation.

BUMDs, especially those engaged in oil, gas, or other industries on the coast, need to implement sustainability policies that integrate environmental risk assessment and mitigation systems. BUMDs are also expected to invest in blue carbon programs that can reduce the company's carbon footprint by involving the conservation of mangroves and seagrass beds as natural carbon sinks. The program can also support national initiatives to reduce greenhouse gas emissions (Howard et al., 2017). The private sector, such as infrastructure developers and tourism companies, must ensure their projects adhere to the principles of sustainable development. In addition, the private sector needs to support training and education for local communities to increase understanding of the importance of conservation and safeguarding coastal ecosystems. This readiness requires cross-sector coordination and synergy between government policies, regulatory supervision, the application of mitigation technology by BUMDs, and private sector compliance with environmental standards. This will not only reduce damage to the coastal environment, but also help in maintaining ecosystem sustainability and increasing community resilience to climate change and natural disasters in the future.

### **6.3. Conclusion**

The environmental impact resulting from the exploration and exploitation of oil and gas (oil and gas), as well as the importance of implementing an EMS to reduce

environmental damage. Special emphasis is placed on the ISO 14001 standard as an environmental management guide that can control emissions, waste, and other negative impacts of oil and gas industry activities. The use of this standard aims to ensure compliance with increasingly stringent environmental regulations and improve the company's reputation in the eyes of the public and investors. Oil and gas exploration and exploitation have great potential to pollute the environment, such as water, soil, and air pollution resulting from drilling activities, gas combustion, and the use of chemicals in fracking. Therefore, the implementation of EMS based on ISO 14001 is essential to minimize environmental impact and meet global sustainability standards. The program not only assists companies in managing environmental risks but also provides a competitive advantage and a positive reputation in the global market.

The importance of the company's commitment to implementing EMS in accordance with ISO 14001, the involvement of various parties in environmental monitoring, and increased coordination between the private sector and the government in managing the environmental impact of the oil and gas industry. In addition, the need for continuous education and training for company staff regarding environmental standards is also highlighted as an important step in maintaining sustainability. The implementation of EMS in the oil and gas industry has helped reduce pollution, improve energy efficiency, and ensure regulatory compliance. The implementation of EMS also shows that companies can achieve better environmental performance and increase the value of investment. However, challenges such as high costs, the need for continuous training, and logistical challenges in remote areas remain obstacles to its implementation. For further studies, more in-depth research is needed on the long-term effectiveness of EMS implementation in the oil and gas sector, as well as how this system can be adapted to technological developments and environmental needs. Further studies can also include an analysis of the social impact of oil and gas activities and how they affect the well-being of the surrounding community, so that a holistic approach in environmental management can be achieved.

## Reference

- Abri, A., Alamsyah, A. C., & Sanusi, S. (2021). Penerapan Teknologi Vermicomposting Dalam Pengelolaan Limbah Pertanian Di Desa Massila Kabupaten Bone. *Jurnal Ilmiah Ecosystem*, 21(3). <https://doi.org/10.35965/eco.v21i3.1249>
- Abualfaraa, W., Salonitis, K., Al-Ashaab, A., & Ala'raj, M. (2020). Lean-green manufacturing practices and their link with sustainability: A critical review. *Sustainability (Switzerland)*, 12(3). <https://doi.org/10.3390/su12030981>
- Alnavis, N. B., Martono, D. N., & Hamzah, U. S. (2021). RECOMMENDATIONS FOR IMPROVING THE ISO 14001 CERTIFICATION BASED ON THE COMPANY'S PERCEPTION ANALYSIS OF THE CERTIFICATION OBSTACLES AND BENEFITS. *Jurnal Kesehatan Lingkungan*, 13(3). <https://doi.org/10.20473/jkl.v13i3.2021.132-141>
- Amir, R., & Nurhakiki. (2021). Studi Gambaran Environment Cost Dalam Pengelolaan Lingkungan Di Rumah Sakit Umum Lasinrang Kabupaten Pinrang. *Journal of Health Educational Science And Technology*, 4(1). <https://doi.org/10.25139/htcv4i1.3595>
- Angelakoglou, K., Chatzigeorgiou, E., Lampropoulos, I., Giourka, P., Martinopoulos, G., & Nikolopoulos, N. (2023). Monitoring the Sustainability of Building Renovation Projects—A Tailored Key Performance Indicator Repository. *Buildings*, 13(8). <https://doi.org/10.3390/buildings13082046>
- Anifowose, B., Lawler, D. M., van der Horst, D., & Chapman, L. (2016). A systematic quality assessment of Environmental Impact Statements in the oil and gas industry. *Science of the Total Environment*, 572. <https://doi.org/10.1016/j.scitotenv.2016.07.083>
- Ayyam, V., Palanivel, S., & Chandrakasan, S. (2019). Adaptation and Mitigation Strategies for Coastal Areas. In *Coastal Ecosystems of the Tropics - Adaptive Management*. [https://doi.org/10.1007/978-981-13-8926-9\\_12](https://doi.org/10.1007/978-981-13-8926-9_12)
- Berg, S. V. (2020). Performance Assessment Using Key Performance Indicators (KPIs) for Water Utilities: A Primer. *Water Economics and Policy*, 6(2). <https://doi.org/10.1142/S2382624X20500010>
- Bernal-Torres, C. A., Paipa-Galeano, L., Jarrah-Nezhad, Y., Agudelo-Otálora, L. M., & Millán, J. (2021). Continuous improvement and business sustainability in companies of an emerging market: Empirical analysis. *Journal of Industrial Engineering and Management*, 14(4). <https://doi.org/10.3926/jiem.3610>
- Bhattara, S. K. (2021). Analysis of Key Performance Indicators in Health Building Construction in Nepal. *Journal of Advanced Research in Civil and*

- Environmental Engineering*, 08(3 & 4), 18–30.  
<https://doi.org/10.24321/2393.8307.202107>
- Budi, I. Y., Karuniasa, M., & Nurcahyo, R. (2020). Effectiveness of ISO 14001: 2015 implementation in small and medium enterprises (case study: A laundry machine industry SME in Bantul Yogyakarta). *IOP Conference Series: Earth and Environmental Science*, 423(1). <https://doi.org/10.1088/1755-1315/423/1/012010>
- Chutcheva, Y. V., Kuprianova, L. M., Seregina, A. A., & Kukushkin, S. N. (2022). Environmental management of companies in the oil and gas markets based on AI for sustainable development: An international review. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.952102>
- Cordes, E. E., Jones, D. O. B., Schlacher, T. A., Amon, D. J., Bernardino, A. F., Brooke, S., Carney, R., DeLeo, D. M., Dunlop, K. M., Escobar-Briones, E. G., Gates, A. R., Génio, L., Gobin, J., Henry, L. A., Herrera, S., Hoyt, S., Joye, M., Kark, S., Mestre, N. C., ... Witte, U. (2016). Environmental impacts of the deep-water oil and gas industry: A review to guide management strategies. In *Frontiers in Environmental Science* (Vol. 4, Issue SEP). <https://doi.org/10.3389/fenvs.2016.00058>
- Costa, G. P., Marino, M., Cáceres, I., & Musumeci, R. E. (2023). Effectiveness of Dune Reconstruction and Beach Nourishment to Mitigate Coastal Erosion of the Ebro Delta (Spain). *Journal of Marine Science and Engineering*, 11(10). <https://doi.org/10.3390/jmse11101908>
- Dahab, O. A. (2020). Importance of Environmental Management Systems in Ensuring Continual Environmental Protection in Offshore Upstream Oil and Gas Industry. *Examines in Marine Biology & Oceanography*, 3(3). <https://doi.org/10.31031/eimbo.2020.03.000565>
- Dahalan, N. H., Rahman, R. A., Ahmad, S. W., & Che Ibrahim, C. K. I. (2023). Public monitoring of environmental management plan implementation in road construction projects: key performance indicators. *Journal of Engineering, Design and Technology*. <https://doi.org/10.1108/JEDT-06-2023-0225>
- Dmytruk, V. (2023). Development of methodological approaches of value-based management at oil and gas extraction enterprises. *Economic Analysis*, 33(1). <https://doi.org/10.35774/econa2023.01.288>
- Elbisy, M. S. (2016). Environmental management of offshore gas platforms in Abu Qir Bay, Egypt. *KSCE Journal of Civil Engineering*, 20(4). <https://doi.org/10.1007/s12205-015-0146-1>
- Fadyeyeva, I. (2023). STABILIZATION MEASURES TO IMPROVE THE ECONOMIC AND ENVIRONMENTAL MANAGEMENT OF OIL AND GAS EXTRACTION

- ENTERPRISES. *Herald of Khmelnytskyi National University. Economic Sciences*, 318(3), 145–150. <https://doi.org/10.31891/2307-5740-2023-318-3-22>
- Ferrarez, R. P. F., Valle, C. G. B. do, Alvarenga, J. C., Dias, F. da C., Vasco, D. A., Guedes, A. L. A., Chinelli, C. K., Haddad, A. N., & Soares, C. A. P. (2023). Key Practices for Incorporating Sustainability in Project Management from the Perspective of Brazilian Professionals. *Sustainability* (Switzerland), 15(11). <https://doi.org/10.3390/su15118477>
- Ferrarez, R. P. F., Vargas, R. V., Alvarenga, J. C., Chinelli, C. K., Costa, M. de A., de Oliveira, B. L., Haddad, A. N., & Soares, C. A. P. (2020). Sustainability indicators to assess infrastructure projects: Sector disclosure to interlock with the global reporting initiative. *Engineering Journal*, 24(6). <https://doi.org/10.4186/ej.2020.24.6.43>
- Galli, B. J. (2020). How to Effectively Implement Continuous Improvement for Environmental Sustainability. *International Journal of Applied Logistics*, 11(1). <https://doi.org/10.4018/ijal.2021010103>
- Grogan, A. E., & Mallin, M. A. (2021). Successful mitigation of stormwater-driven nutrient, fecal bacteria and suspended solids loading in a recreational beach community. *Journal of Environmental Management*, 281. <https://doi.org/10.1016/j.jenvman.2020.111853>
- Guerrero-Martin, C. A., Ortega-Ramírez, A. T., Rodríguez, P. A. P., López, S. J. R., Guerrero-Martin, L. E., Salinas-Silva, R., & Camacho-Galindo, S. (2023). Analysis of Environmental Sustainability through a Weighting Matrix in the Oil and Gas Industry. *Sustainability* (Switzerland), 15(11). <https://doi.org/10.3390/su15119063>
- Gustia, R., Martono, D. N., & Hamzah, U. S. (2021). Environmental performance evaluation of applying iso 14001 in laboratory. *Proceedings of the International Conference on Industrial Engineering and Operations Management*. <https://doi.org/10.46254/an11.20210770>
- Hariska, B. M., Suharyani, S., & Herlina, H. (2022). IMPLEMENTASI PROGRAM KAWASAN BEBAS SAMPAH DALAM MENINGKATKAN PERILAKU ARIF LINGKUNGAN DI DUSUN BAJOK KOPANG LOMBOK TENGAH. *Transformasi: Jurnal Penelitian Dan Pengembangan Pendidikan Non Formal Informal*, 7(2). <https://doi.org/10.33394/jtni.v7i2.4885>
- Hassan, M. G., Akanmu, M. D., & Bahaudin, A. Y. (2018). The moderating effect of environmental regulation and policy on the relationship between continuous process improvement and organizational performance: An empirical analysis. *International Journal of Engineering and Technology(UAE)*, 7(2). <https://doi.org/10.14419/ijet.v7i2.15.11367>

- Helmina, M. R. A., Sutomo, I., & Respati, N. W. (2022). Empirical Examination of Green Industry Strategy through ISO-14001 on Firm Value: Mediating Roles of Profitability and Leverage. *International Journal of Sustainable Development and Planning*, 17(5). <https://doi.org/10.18280/ijdsdp.170505>
- Hoggart, S., Hawkins, S. J., Bohn, K., Airoidi, L., van Belzen, J., Bichot, A., Bilton, D. T., Bouma, T. J., Colangelo, M. A., Davies, A. J., Ferrario, F., Firth, L. B., Galván, C., Hanley, M., Heurtefeux, H., Lara, J. L., Rodriguez, I. L., Maza, M., Eizaguirre, B. O., ... Thompson, R. C. (2015). Ecological Approaches to Coastal Risk Mitigation. In *Coastal Risk Management in a Changing Climate*. <https://doi.org/10.1016/B978-0-12-397310-8.00004-X>
- Howard, J., Sutton-Grier, A., Herr, D., Kleypas, J., Landis, E., Mcleod, E., Pidgeon, E., & Simpson, S. (2017). Clarifying the role of coastal and marine systems in climate mitigation. *Frontiers in Ecology and the Environment*, 15(1). <https://doi.org/10.1002/fee.1451>
- Huseynov, A. (2021). Environmental and economic indicators of sustainable development of enterprises of oil and gas complexes. *SHS Web of Conferences*, 92. <https://doi.org/10.1051/shsconf/20219208009>
- Jasim Resen, E., & Sadiq AbdulRazzaq, M. (2022). An Evaluation of Environmental Performance According to The International Standard (ISO14001: 2015) in a Field East of Baghdad / A Case Study in the Midline Oil Company. *Journal of Economics and Administrative Sciences*, 28(134). <https://doi.org/10.33095/jeas.v28i134.2420>
- Kalamika, A. M., & Khabiburohman, A. (2020). BEST PRACTICE IMPLEMENTASI CORPORATE SOCIAL RESPONSIBILITY (CSR) DALAM MENINGKATKAN KESEJAHTERAAN MASYARAKAT (Studi Kasus Pelaksanaan Program Kemitraan dan Bina Lingkungan PT. Taman Wisata Candi (TWC) Borobudur, Prambanan dan Ratu Boko). *WELFARE: Jurnal Ilmu Kesejahteraan Sosial*, 9(1). <https://doi.org/10.14421/welfare.welfare.2020.091-01>
- Khansa, A. D. T., & Widiastuti, T. (2022). KAUSALITAS PERTUMBUHAN EKONOMI, ENERGI TERBARUKAN DAN DEGRADASI LINGKUNGAN PADA NEGARA ORGANISASI KERJASAMA ISLAM. *Jurnal Ekonomi Syariah Teori Dan Terapan*, 9(1). <https://doi.org/10.20473/vol9iss20221pp118-130>
- Kojra, F. R., Sukanta, S., & Kusnadi, K. (2020). ANALYSIS OF THE APPLICATION OF THE ENVIRONMENTAL MANAGEMENT SYSTEM BASED ON STANDARDS IN THE INTERNATIONAL REQUIREMENTS OF ISO 14001. *Journal of Community Based Environmental Engineering and Management*. <https://doi.org/10.23969/jcbeem.v4i2.2948>

- Larasati, N., & Puspaningtyas, A. (2020). Manajemen Tempat Pengelolaan Sampah Terpadu Bantar Gebang dengan Konsep Collaborative Governance. *CHANNEL: Jurnal Komunikasi*, 8(1). <https://doi.org/10.12928/channel.v8i1.15752>
- Leony, F., Amir, R., & Putri Rusman, A. D. (2023). Desain Tempat Sampah Edukatif Dan Persuasif Membentuk Karakter Cinta Lingkungan Bagi Anak Sekolah Dasar. *Journal of Health Educational Science And Technology*, 6(1). <https://doi.org/10.25139/htc.v6i1.4924>
- Liao, J. C. (2022). Talking Green, Building Brown: China-ASEAN Environmental and Energy Cooperation in the BRI Era. *Asian Perspective*, 46(1). <https://doi.org/10.1353/apr.2022.0001>
- Lima, M., Coelho, C., Alves, F., & Vizinho, A. (2023). PARTICIPATORY APPROACH TO ASSESS COASTAL EROSION MITIGATION AND CLIMATE CHANGE ADAPTATION MEASURES. *Coastal Engineering Proceedings*, 37. <https://doi.org/10.9753/icce.v37.management.145>
- Lin, B., & Chen, X. (2020). Environmental regulation and energy-environmental performance—Empirical evidence from China's non-ferrous metals industry. *Journal of Environmental Management*, 269. <https://doi.org/10.1016/j.jenvman.2020.110722>
- Mandal, S., Islam, M. S., Biswas, M. H. A., & Akter, S. (2021). Modeling the optimal mitigation of potential impact of climate change on coastal ecosystems. *Heliyon*, 7(7). <https://doi.org/10.1016/j.heliyon.2021.e07401>
- Mansour, M., & Alsulamy, S. (2021). Evaluating association between implementation of ISO 14031 guidelines and ISO 14001 certification by industrial sector in Saudi Arabia. *Journal of Environmental Engineering and Landscape Management*, 29(1). <https://doi.org/10.3846/jeelms.2021.14123>
- Margaret, I., Schoubben, F., & Verwaal, E. (2024). When do investors see value in international environmental management certification of multinational corporations? A study of ISO 14001 certification after the Paris Agreement. *Global Strategy Journal*, 14(1). <https://doi.org/10.1002/gsj.1490>
- Maryeska, C. P., Jati, D. R., & Pramadita, S. (2020). Analisis Transisi Penerapan Sistem Manajemen Lingkungan ISO 14001 Versi 2015 (Studi Kasus : PT.AZ) (Transition Analysis on Application of The Environmental Management System ISO 14001 2015 Version (Case Study : PT. AZ)). *Jurnal Teknologi Lingkungan Lahan Basah*, 8(1). <https://doi.org/10.26418/jtllb.v8i1.39119>
- Morell-Santandreu, O., Santandreu-Mascarell, C., & García-Sabater, J. (2020). Sustainability and kaizen: Business model trends in healthcare. *Sustainability (Switzerland)*, 12(24). <https://doi.org/10.3390/su122410622>

- Muzanni, A., Soesilo, T. E. B., Martono, D. N., Hamzah, U. S., Berkademi, W., & Febraldo, D. (2022). Review of Environmental Management System Implementation in the Oil and Gas Company in Indonesia. *IOP Conference Series: Earth and Environmental Science*, 1111(1). <https://doi.org/10.1088/1755-1315/1111/1/012018>
- Nazarova, V. V., & Tikhomirov, E. D. (2022). The impact of environmental performance of oil and gas companies on their financial performance. *Moscow University Economics Bulletin*, 5. <https://doi.org/10.38050/01300105202258>
- Neri, A., Cagno, E., Lepri, M., & Trianni, A. (2021). A triple bottom line balanced set of key performance indicators to measure the sustainability performance of industrial supply chains. *Sustainable Production and Consumption*, 26. <https://doi.org/10.1016/j.spc.2020.12.018>
- Nesterova, S., & Pristaya, V. (2023). KEY PERFORMANCE INDICATORS (KPI) AS A MEASUREMENT OF INTERNAL BUSINESS PROCESSES ON MODERN MANUFACTURING. *Business Navigator*, 2(72). <https://doi.org/10.32782/business-navigator.72-9>
- Nichols, C. R., Zinnert, J., & Young, D. R. (2019). Degradation of coastal ecosystems: Causes, impacts and mitigation efforts. In *Coastal Research Library* (Vol. 27). [https://doi.org/10.1007/978-3-319-75453-6\\_8](https://doi.org/10.1007/978-3-319-75453-6_8)
- Ouyang, X., Li, Q., & Du, K. (2020). How does environmental regulation promote technological innovations in the industrial sector? Evidence from Chinese provincial panel data. *Energy Policy*, 139. <https://doi.org/10.1016/j.enpol.2020.111310>
- Pandey, A. K., Kalidasan, B., Reji Kumar, R., Rahman, S., Tyagi, V. V., Krismadinata, Said, Z., Salam, P. A., Juanico, D. E., Ahamed, J. U., Sharma, K., Samykano, M., & Tyagi, S. K. (2022). Solar Energy Utilization Techniques, Policies, Potentials, Progresses, Challenges and Recommendations in ASEAN Countries. In *Sustainability (Switzerland)* (Vol. 14, Issue 18). <https://doi.org/10.3390/su141811193>
- Pires, D. R., & Lima, A. A. de. (2022). The logistical challenges to implement the environmental management system in a natural gas company in the North Region. *International Journal of Advanced Engineering Research and Science*, 9(9). <https://doi.org/10.22161/ijaers.99.16>
- Qureshi, M. I., Khan, N., Qayyum, S., Malik, S., Sanil, H. S., & Ramayah, T. (2020). Classifications of sustainable manufacturing practices in ASEAN region: A systematic review and bibliometric analysis of the past decade of research. In *Sustainability (Switzerland)* (Vol. 12, Issue 21). <https://doi.org/10.3390/su12218950>



- Rementsov, A. A. (2020). IMPLEMENTATION OF AN ENVIRONMENTAL MANAGEMENT SYSTEM (ISO 14001; ISO14005) AT ENERGY COMPANIES, THE MAIN ADVANTAGES AND ASSOCIATED RISKS. *Scientific Journal ECONOMIC SYSTEMS*, 13(1), 135–142. <https://doi.org/10.29030/2309-2076-2020-13-1-135-142>
- Rossi, G., Cadei, L., Bitetti, M., Gerardi, R., Vaccari, D., Ghetti, M., Forte, M., Collura, L., & Ricci, A. (2022). Energy and Ghg Management of a Giant Oilfield: A New Digital Way to Face Challenge and Certify the Results. *Society of Petroleum Engineers - ADIPEC 2022*. <https://doi.org/10.2118/210962-MS>
- Sadiq, M., Ngo, T. Q., Pantamee, A. A., Khudoykulov, K., Thi Ngan, T., & Tan, L. P. (2023). The role of environmental social and governance in achieving sustainable development goals: evidence from ASEAN countries. *Economic Research-Ekonomska Istrazivanja*, 36(1). <https://doi.org/10.1080/1331677X.2022.2072357>
- Saihi, A., Ben-Daya, M., & As'ad, R. (2022). An Investigation of Sustainable Maintenance Performance Indicators: Identification, Expert Validation and Portfolio of Future Research. *IEEE Access*, 10. <https://doi.org/10.1109/ACCESS.2022.3224450>
- Samusevych, Y., & Horodetska, M. (2023). Environmental taxation impact on the development of Ukrainian mining industry. *Economic Herald of SHEI USUCT*, 17(1), 98–107. <https://doi.org/10.32434/2415-3974-2022-17-1-98-107>
- Santhyami, Roziaty, E., & Suparti, S. (2022). Pengenalan Konsep Stok Karbon Pohon sebagai Usaha Mitigasi Perubahan Iklim Kepada Guru IPA dan Biologi se Jawa Tengah. *Sasambo: Jurnal Abdimas (Journal of Community Service)*, 4(1). <https://doi.org/10.36312/sasambo.v4i1.566>
- Savino, M. M., & Mazza, A. (2014). Toward environmental and quality sustainability: An integrated approach for continuous improvement. *IEEE Transactions on Engineering Management*, 61(1). <https://doi.org/10.1109/TEM.2013.2288495>
- Scyphers, S., Beck, M., Haner, J., Keeler, A., Landry, C., Webb, B., & Grabowski, J. (2019). Designing Effective Incentives to Reverse Coastal Habitat Degradation along Residential Shorelines. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3443243>
- Turiman, T., Dai, R. M., & Sari, D. S. (2021). Implementasi Kebijakan Penerapan Pola Pengelolaan Keuangan Badan Layanan Umum Daerah (PPK-BLUD) Puskesmas Di Kabupaten Bandung. *Responsive*, 4(2). <https://doi.org/10.24198/responsive.v4i2.31923>
- Tverytnykova, E., Drozdova, T., & Demidova, Y. (2020). ENVIRONMENTAL MANAGEMENT AS A COMPONENT OF AN INTEGRATED MANAGEMENT SYSTEM FOR GAS

- CONDENSATE AND OIL PROCESSING ENTERPRISES. *Advanced Information Systems*, 4(1). <https://doi.org/10.20998/2522-9052.2020.1.06>
- Vanessa Stelzenmüller, Antje Gimpel, Jonas Letschert, Casper Kraan, & Ralf Döring. (2020). Impact of the use of offshore wind and other marine renewables on European fisheries. *European Parliament, Policy Department for Structural and Cohesion Policies, Brussels*. <https://tethys.pnnl.gov/sites/default/files/publications/Stelzenmuller-et-al-2020.pdf>
- Wahyudi, W. (2022). Effectiveness And Supervision Of Participating Interest By The Bpma: A Legal Analysis. *Kanun Jurnal Ilmu Hukum*, 24(2). <https://doi.org/10.24815/kanun.v24i2.28237>
- Walls, C., Choi, B.-K., Putri, A. R. K., Bernal-Osorio, A., D'Souza, A., Khadse, H., Ghorri, M., Rossa, J., Varute, S., & Beck, G. (2023). Recycling of Metallized Plastic as a Case Study for a Continuous Sustainability Improvement Process. *Sustainability*, 15(20). <https://doi.org/10.3390/su152014737>
- Wang, G., & Liu, S. (2020). Is technological innovation the effective way to achieve the “double dividend” of environmental protection and industrial upgrading? *Environmental Science and Pollution Research*, 27(15). <https://doi.org/10.1007/s11356-020-08399-8>
- Wantu, F. M., & Apripari, A. (2023). Musyawarah Lingkungan Hidup sebagai Strategi Penyelesaian Kerusakan Lingkungan di Desa Tupa. *DAS SEIN: Jurnal Pengabdian Hukum Dan Humaniora*, 3(1). <https://doi.org/10.33756/jds.v0i0.16787>
- Wardana, D., Wijaya, M., & Al Hafis, R. I. (2023). Enhancing Collaborative Governance in Managing Grand Forest Park in Riau, Indonesia. *Journal of Contemporary Governance and Public Policy*, 4(2). <https://doi.org/10.46507/jcgpp.v4i2.208>
- Wicaksono, A. (2020). Implementasi Program Lahan Pertanian Pangan Berkelanjutan (LP2B) Kabupaten Karawang: Studi Kasus Penetapan Luas Baku Sawah. *Jejaring Administrasi Publik*, 12(1). <https://doi.org/10.20473/jap.v12i1.23315>
- Wylie, L., Sutton-Grier, A. E., & Moore, A. (2016). Keys to successful blue carbon projects: Lessons learned from global case studies. *Marine Policy*, 65. <https://doi.org/10.1016/j.marpol.2015.12.020>
- Yu, S., Cui, B., Xie, C., Ma, X., Man, Y., & Ning, Z. (2019). Ecological Offsetting in China's Coastal Wetlands: Existing Challenges and Strategies for Future Improvement. *Chinese Geographical Science*, 29(2). <https://doi.org/10.1007/s11769-019-1024-4>
- Yurtay, Y., Yurtay, N., Demirci, H., Zaimoglu, E. A., & Goksu, A. (2023). Improvement and Implementation of Sustainable Key Performance Indicators in Supply Chain

- Management: The Case of a Furniture Firm. *IEEE Access*, 11. <https://doi.org/10.1109/ACCESS.2023.3271138>
- Zarzycka, E., & Krasodomska, J. (2021). Environmental key performance indicators: the role of regulations and stakeholder influence. *Environment Systems and Decisions*, 41(4). <https://doi.org/10.1007/s10669-021-09825-z>
- Zulkifli, N., Najid, N. A., Mohd Noor, R., Abdul Rahim, A. F., & Yaacob, N. A. (2020). Achieving Environmental Sustainability through Good Regulatory Practice (GRP). In *Charting a Sustainable Future of ASEAN in Business and Social Sciences*. [https://doi.org/10.1007/978-981-15-3859-9\\_42](https://doi.org/10.1007/978-981-15-3859-9_42)



# Technology and Innovation for Environmental Protection in Oil and Gas Management

Husnah Rahman, Gema Bangsawan

Green technology innovation and sustainable business models to reduce environmental impact in the oil and gas sector. Its focus on the application of technologies such as Carbon Capture and Storage (CCS) and the Eco-Innovation Maturity Model shows how oil and gas companies can improve energy efficiency while meeting sustainability targets.

## **7.1. Environmental Protection Technology and Innovation in Oil and Gas Management**

In the context of oil and gas management, technology and innovation for environmental protection are essential to maintain environmental sustainability while meeting energy needs. Some of the relevant theories and important aspects in this regard include the industrial ecological approach, the theory of sustainable innovation, and the theory of corporate social responsibility (CSR). Industrial ecology emphasizes on the closed cycle of materials in industry to reduce waste, while the theory of sustainable innovation links the adoption of green technology to the competitiveness of companies. CSR plays a role in creating social and environmental value in addition to economic benefits (Kutepova & Iakovleva, 2022; VIKTOROVA & LAGUTENKOV, 2022). The importance of green technology in oil and gas lies in several things: reducing emissions, optimizing resources, and improving energy efficiency. Digital technologies such as the Internet of Things (IoT) are used for real-time monitoring of emissions and energy efficiency, so that they are able to quickly improve oil and gas production strategies (Wanasinghe et al., 2020). In addition, innovations in drilling techniques and waste management are important to minimize the environmental impact of drilling waste (Shkitsa et al., 2020). This innovation occurred due to pressure from environmental regulations as well as global market demands that encouraged companies to improve energy efficiency and reduce environmental impact. Innovative initiatives such as emission monitoring technology and the use of renewable energy are encouraging oil and gas companies to switch to greener and greener business models (Ivanova, 2023). Stakeholders who play a role in this condition include the government, oil and gas companies, research institutions,

and local communities. Governments play a role in regulation, while companies are responsible for implementing green innovation, and communities exert social pressure for sustainable practices to be implemented (Zhuravska et al., 2023). The development of this innovation has intensified since 2020, in line with the increasing global awareness of environmental protection in the oil and gas industry and the commitment to carbon neutral targets.

### 7.1.1. Industrial ecological approach

Industrial ecology emerged as a response to serious threats facing the world in the late 20th century, such as the scarcity of natural resources and high levels of pollution. This theory is rooted in the understanding that linear industrial approaches—which generate excessive waste and utilize natural resources without a sustainable cycle—are no longer adequate in the face of environmental challenges. The industrial ecology approach seeks to integrate the principles of natural ecosystems into industrial systems, viewing industry as part of an interconnected ecosystem, which can utilize the leftover production or waste of one industry as raw materials for another industry (figure 7.1.).

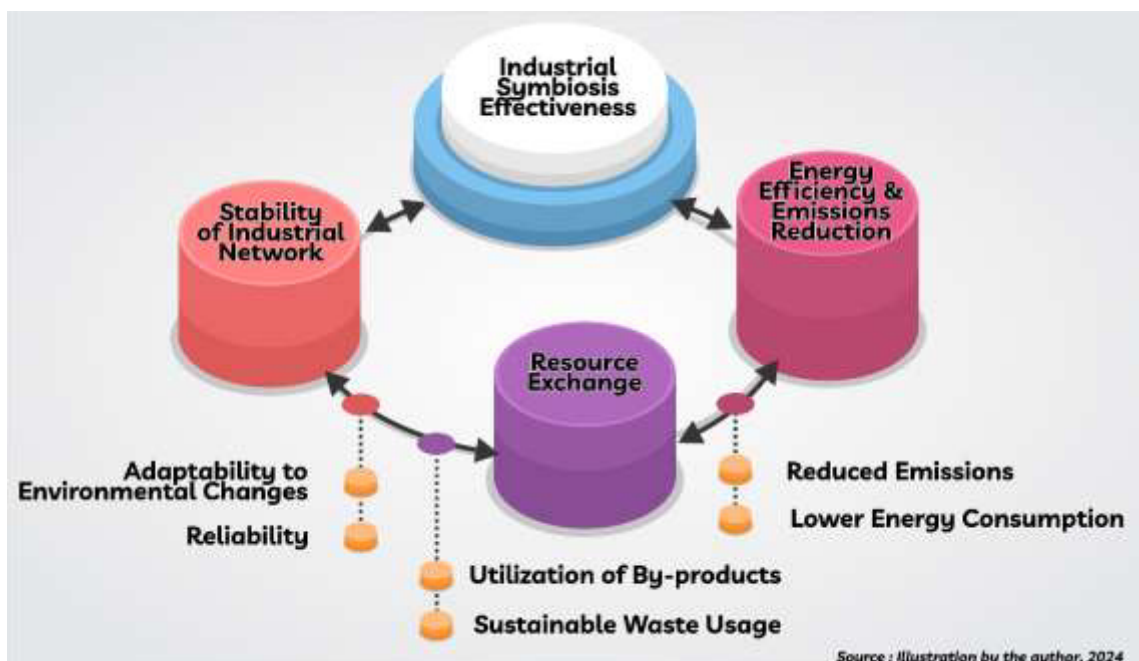


Figure 7.1. The effectiveness of industrial symbiosis

The principles applied from natural ecosystems to industrial systems in industrial ecology include the concept of closed cycles, which utilize leftover materials from one process as inputs to other processes, similar to how natural ecosystems minimize waste. In addition, the concept of diversity is adopted to reduce dependence on a single resource or process, resulting in greater industrial resilience, as in nature that relies on various species to support stable ecosystems (Santoso et al., 2014). In

the industrial symbiosis, there are several important indicators that determine the effectiveness of collaboration between industries. First, the intensity of resource exchange is the main indicator, namely the extent to which industries can use waste or by-products from each other in a sustainable manner. Second, energy efficiency and emission reduction are other important indicators.

Table 7.1. Industrial symbiosis effectiveness practices

| Industrial Symbiosis Practices                                                                              | Practice Description.                                                                                                                       | Effectiveness Indicators                                             |
|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| Utilization of Organic Waste for Biofertilizers (Tanzil et al., 2023)                                       | Using organic waste such as zeolite combined with vermicompost to increase the yield of mycorrhizal inoculum.                               | 1. Effective nutrient content for plants                             |
|                                                                                                             |                                                                                                                                             | 2. Consistency in colonization of high roots                         |
|                                                                                                             |                                                                                                                                             | 3. Reduction of dependence on chemical fertilizers                   |
| Combination of Probiotics and Phytoremediation in Aquaculture (Saputra et al., 2021)                        | A combination of probiotics and phytoremediation to improve water quality and eel growth.                                                   | 1. Nitrogen and phosphorus degradation rate                          |
|                                                                                                             |                                                                                                                                             | 2. Fish survival percentage                                          |
|                                                                                                             |                                                                                                                                             | 3. High feed use efficiency                                          |
| Adsorption of Textile Liquid Waste Using Chitosan and Tea Grounds (Suwazan & Nurhidayanti, 2021)            | Utilizing a combination of chitosan and activated carbon from tea grounds to lower lead levels in liquid waste.                             | 1. Heavy metal removal efficiency (Pb)                               |
|                                                                                                             |                                                                                                                                             | 2. Improvement of pore structure quality in adsorbents               |
|                                                                                                             |                                                                                                                                             | 3. Decrease in Pb concentration according to environmental standards |
| Management of Belang-Belang Special Economic Zone (SEZ) (Hasnawati et al., 2022)                            | The use of the Belang-Belang SEZ in Indonesia, connecting industries to increase regional productivity and economy.                         | 1. Accessibility and infrastructure level                            |
|                                                                                                             |                                                                                                                                             | 2. Increased industrial productivity                                 |
|                                                                                                             |                                                                                                                                             | 3. Scale of production units                                         |
| Utilization of Industrial Waste for Integrated Agriculture (Faradila & Kakinaka, 2020)                      | Utilizing factory waste as fertilizer in integrated agricultural systems in other Association of Southeast Asian Nations (ASEAN) countries. | 1. Effectiveness of waste as plant nutrition                         |
|                                                                                                             |                                                                                                                                             | 2. Reduction of dependence on chemical fertilizers                   |
|                                                                                                             |                                                                                                                                             | 3. Improving the quality of agricultural products                    |
| Karawang Industrial Symbiosis System (Nurkhaerani & Debora, 2023)                                           | Waste and wastewater management in the Karawang industrial estate to support the sustainability of the local ecosystem.                     | 1. Efficiency of drainage system and spatial planning                |
|                                                                                                             |                                                                                                                                             | 2. Water absorption coefficient                                      |
|                                                                                                             |                                                                                                                                             | 3. Flood risk reduction                                              |
| Implementation of Phytoremediation and Probiotics in Aquaculture, Kebumen, Indonesia (Saputra et al., 2021) | The use of phytoremediation with probiotics to improve the growth and quality of eel.                                                       | 1. Effective nitrogen and phosphorus degradation                     |
|                                                                                                             |                                                                                                                                             | 2. High fish survival rate                                           |
|                                                                                                             |                                                                                                                                             | 3. Optimal feed efficiency                                           |
| Vannamei Shrimp Cultivation Using Probiotics, Maros, Indonesia (Gunarto & Hendrajat, 2008)                  | Application of fermented probiotics to increase the yield of vannamei shrimp cultivation in a semi-intensive manner.                        | 1. Stable and good water quality                                     |
|                                                                                                             |                                                                                                                                             | 2. High daily growth rate                                            |
|                                                                                                             |                                                                                                                                             | 3. Optimal shrimp survival and biomass                               |
| Use of Compost from Empty Bunches of Oil Palm, Malaysia (Santi et al., 2019)                                | The use of compost from oil palm waste to increase the productivity of soybean plants on ex-mining land.                                    | 1. The effectiveness rate of root nodules is high                    |
|                                                                                                             |                                                                                                                                             | 2. Improving the quality of crop yields                              |
|                                                                                                             |                                                                                                                                             | 3. Reduction of dependence on inorganic fertilizers                  |

Source: author's search, 2024.

The lower the energy consumption and emissions resulting from collaboration, the better the performance of the industrial symbiosis. Third, the stability of the industrial network, which reflects the regularity and dependence between the industries in the system, is also important to ensure a durable and adaptive system to environmental changes (Rachmansyah et al., 2023). This model aims to create a closed-loop cycle, which seeks to reduce emissions and waste by recycling between production processes (Santoso et al., 2014). In its implementation, industrial ecology involves integration between industries, such as in the example of agro-industries that have successfully used cow industrial waste as a source of raw materials for fertilizer and biogas energy. This implementation model practically involves the concept of industrial symbiosis, where industries connected in one network utilize each other's by-products to create an efficient and environmentally friendly production process (Rachmansyah et al., 2023). The initial idea of industrial ecology as a modern concept was first sparked by Robert Frosch and Nicholas Gallopoulos in the late 1980s, which was then further developed as awareness of the global ecological crisis increased. This approach continues to evolve to date, with real application in various sectors further expanding the scope of industrial sustainability around the world, the practice of this approach has emerged in several literature that can be used together (table 7.1.)

These practices show how industries in the ASEAN region are leveraging industrial symbiosis to improve sustainability, with key indicators being increased production output, resource efficiency, and improved environmental quality. Practices (table 7.1.) show that indicators of effectiveness in industrial symbiosis include quality of final results, emission reduction, and efficient use of resources. This indicator supports the sustainability of the production process and shows the effectiveness of the industrial symbiosis in minimizing environmental impacts through more efficient use of resources.

The practice of industrial symbiosis in the ASEAN region provides a number of valuable lessons related to industrial efficiency and sustainability. One of the key lessons is the optimization of local resources and the utilization of industrial waste, which is seen in the use of compost from palm oil waste in Malaysia and the application of probiotics in fish farming in Indonesia. This approach reduces reliance on new raw materials and utilizes waste as a useful resource, creating a more sustainable circular economy system. In addition, industrial symbiosis improves product quality and operational efficiency, as seen in a combination of phytoremediation and probiotics that maintain water quality while improving fish health and growth. These measures not only reduce production costs, but also support economic sustainability in the long-term. In addition, this symbiotic practice shows how strengthening local ecosystems can be achieved through collaboration between industries. By sharing resources and utilizing by-products with each other,

industrial estates become more resilient to economic fluctuations and support the stability of local ecosystems. The use of eco-friendly technologies, such as probiotics and phytoremediation, helps to reduce the negative impact on the environment without sacrificing product quality. This collaboration between industries adds to operational effectiveness, providing mutually beneficial benefits that strengthen industrial and environmental resilience. These approaches mimic natural ecosystems where waste from one process becomes an input to another, reducing dependence on new resources and forming the foundation of a more efficient and sustainable industry.

In the ASEAN region, the practice of industrial symbiosis is driving significant advancements in resource optimization and sustainability. By repurposing industrial waste, such as palm oil by-products in Malaysia and probiotics in Indonesian fish farming, industries can reduce their dependence on new raw materials and contribute to a circular economy. This approach not only enhances product quality and operational efficiency but also supports economic sustainability in the long term. For example, in Malaysia, palm oil waste is efficiently utilized in mushroom cultivation and as animal feed, effectively optimizing waste resources (Azman et al., 2023). In Indonesia, the use of probiotics in aquaculture improves fish health and growth, demonstrating an innovative application of waste for productivity enhancement (Xie et al., 2024). Economically, the repurposing of waste reduces production costs, promoting financial sustainability (Hwang et al., 2022), while environmentally, integrating eco-friendly technologies like phytoremediation mitigates ecological impacts and helps maintain product quality (Herrador & Van, 2024). However, despite these benefits, challenges persist in fully implementing circular economy strategies across all ASEAN nations, especially in countries that are less advanced in this area, such as Brunei and Laos (Herrador & Van, 2024).

### **7.1.2. Sustainable innovation theory approach**

Sustainable innovation is increasingly essential in tackling the global environmental crisis, as it integrates social and environmental values into core business strategies. This shift is largely driven by rising consumer awareness, stringent regulations, and growing stakeholder pressures, which collectively urge businesses to adopt sustainable practices for a competitive advantage. Innovation plays a crucial role in sustainable entrepreneurship, enabling businesses to prioritize societal well-being and environmental stewardship. Through collaborative initiatives and adaptive strategies, companies can overcome challenges, creating growth opportunities that align economic prosperity with social equity and environmental protection (Ayandibu & Ayandibu, 2024). CSR policies further enhance sustainable development by integrating social, environmental, and economic responsibilities into business strategies. Companies like Unilever and Tesla illustrate how CSR initiatives



not only boost reputation but also drive long-term profitability and innovation (Kumar & Sinha, 2024). Additionally, green innovation and technology adoption are crucial for sustainable business models, particularly in Asia. These practices, often driven by regulatory policies and consumer demand, allow businesses to conserve resources and improve operational efficiency, thereby gaining a competitive advantage and advancing economic goals (Rahman & Shah, 2023). However, while sustainable innovation is gaining traction, some argue that its current pace may not be sufficient to address pressing environmental challenges. The key challenge lies in balancing immediate economic pressures with long-term sustainability goals, which calls for a deeper commitment from all stakeholders involved.

The sustainable innovation model includes multi-stage approaches such as the Cambridge Business Model Innovation Process (CBMIP) model, which aims to help companies bridge the gap between the design and implementation of sustainable business ideas. This model emphasizes small-scale prototypes and experiments as a first step to evaluate the feasibility, desirability, and sustainability of innovation before it is applied more widely (Baldassarre et al., 2020). The CBMIP model was introduced as an approach to support continuous innovation through the direct integration of new tools and techniques into business model processes, with a focus on feasibility and sustainability in their implementation. This model is a response to the challenge of environmentally friendly business innovation but often fails to be implemented on a large scale, despite its great potential in addressing sustainability issues (Kashyap & Salunkhe, 2022). The CBMIP includes several important stages designed to analyze the market needs, technical feasibility, user wants, and the social and environmental benefits of each business idea. This process involves designing an initial business model, testing prototypes on a small scale, and evaluating ongoing impacts.

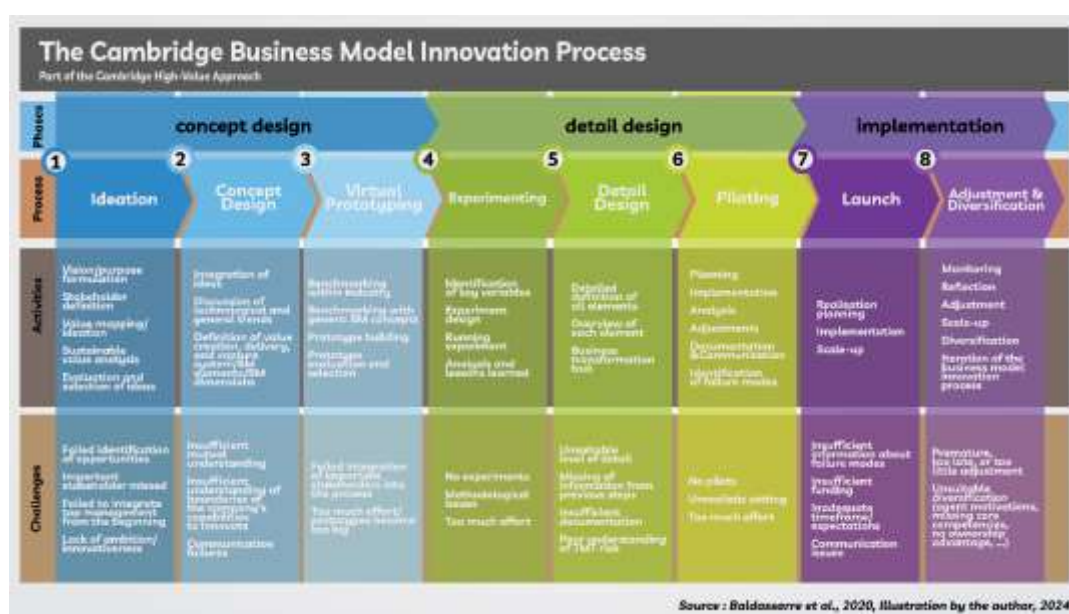


Figure 7.1. CBMIP

The CBMIP not only serves as a guide for the business model innovation process, but also helps identify tools that can be integrated to solve challenges that may arise in the process. Through the implementation of CBMIP, it is hoped that the company can create a business model that is more profitable, sustainable, and provides value to the environment and the wider community.

CBMIP has several advantages that can be used as a reference for using this method, at least consisting of:

1. Structured and systematic approach: CBMIP provides clear step-by-step guidance for business model innovation, from ideation to launch and evaluation. This makes it easier for companies to develop concrete steps to achieve a sustainable business model.
2. With a focus on sustainability, CBMIP is specifically designed to help companies create business models that pay attention to social and environmental impacts, making it suitable for companies that want to meet their sustainability goals and CSR.
3. Adaptability and iterative nature, the CBMIP process is cyclical, allowing companies to return to previous stages if needed. This provides flexibility for companies to adjust their business models as market conditions change or feedback from early implementation.
4. Supporting the use of modern tools and techniques, CBMIP utilizes various tools and techniques such as Business Model Canvas, Value Mapping Tool, and prototype techniques to help visualize and develop business models. This can help companies in designing more mature concepts before launch.
5. Real case studies, the use of CBMIP in startups (such as Favalley) show how this framework can be applied in real situations. This increases the relevance and credibility of CBMIP as a practical guide.

Meanwhile, CBMIP also has weaknesses that are important to consider in utilizing this model, including

1. With large resource requirements, the implementation of CBMIP can require significant time and resources, especially in the experimental and prototyping stages. This can be a challenge for small companies or startups with limited resources.
2. Limitations of generalization because CBMIP is developed from specific cases and iterative processes, its application may not be appropriate for all types of companies or industries. This model is more suitable for organizations that have clear sustainability goals and can face limitations in adapting to different industries.

3. Risks in the experimental and pilot stages of the market, the experimental and pilot stages require testing concepts on a small scale, which can sometimes not always provide accurate results for the broader market. The results of this trial can be misleading if not followed by an in-depth analysis.
4. Design-implementation gaps, although CBMIP is designed to bridge this gap, there is still a risk that the results from the design phase cannot be effectively implemented in the field. Factors such as changing market needs or organizational limitations can hinder full implementation.
5. Limitations of supporting tools, although CBMIP covers a wide range of tools, some stages may require additional tools or methods that are not included in this framework, especially if the company faces unique or complex challenges.

CBMIP offers robust and sustainability-focused guidance, but it requires sufficient adjustments and resources to be successfully implemented in practice. For companies that are able to allocate resources and have a strong commitment to sustainability, CBMIP can be an effective tool to achieve sustainable business model innovation. In its implementation, CBMIP requires the involvement of stakeholders throughout the company's value chain, including management teams, innovators, as well as external parties such as consumers and regulators. The impact is significant, helping to reduce the risk of innovation failure by bringing innovation closer to market from the early stages and linking business value to sustainability goals. CBMIP has been proven to increase the effectiveness of implementing a more environmentally friendly business model and be able to reduce the gap between innovation design and implementation (Kashyap & Salunkhe, 2022). The use of CBMIP helps companies experiment and validate sustainable business models before making large investments. Studies show that the use of this model supports companies in introducing sustainable innovation with a lower failure rate, as well as accelerating adaptation to changes in environmental regulations and the demand of environmentally conscious consumers (Baldassarre et al., 2020). CBMIP has proven to be an effective step in making sustainable innovation the core of the company's business strategy, strengthening its competitive position and supporting the achievement of the company's sustainable development goals.

The practice of using the CBMIP model and the indicators used to evaluate its implementation in various organizations, as shown in table 7.2. The implementation of CBMIP in various industries shows results that are in line with its fundamental principles of supporting environmental sustainability, business flexibility, and stakeholder engagement. First, CBMIP effectively improves environmental sustainability through the adoption of circular business models and waste reduction, as seen in electronics and event management companies that implement recycling

innovations and efforts to reduce carbon emissions (Peralta & Salama, 2021; Pollard et al., 2021).

Table 7.2. Internship Model CBMIP

| Practice                                                                                              | Relevant Indicators                                                             | Description                                                                                                                                          |
|-------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Business Model Innovation in MSMEs in Spain (Ibarra et al., 2020)                                     | Long-term managerial orientation, collaborative capabilities                    | Using CBMIP to adapt innovative business models to MSMEs to compete in a dynamic business environment                                                |
| Innovative Business Models for the Chinese Market (Yu & Wang, 2023)                                   | Financial performance level (ROA, ROE), operational efficiency                  | The application of BMI to improve the performance of companies in the Chinese GEM market with financial-based performance indicators                 |
| Implementation in the Electronics Industry (Clauss et al., 2020)                                      | Growth efficiency, increased revenue                                            | Modifying business models through CBMIP to achieve growth and increased efficiency in the electronics business                                       |
| Implementation of CBMIP in Electronics Companies (Pollard et al., 2021)                               | Increased value of recycled products, reduction of production waste             | Develop a circular economy business model to improve sustainability with indicators focusing on recycling outcomes and production process efficiency |
| Sustainable Business Model Innovation in Event Management Companies (Peralta & Salama, 2021)          | Effectiveness of stakeholder engagement, carbon emission levels from activities | Integrating eco-innovation in event management to achieve sustainability goals, including sustainability indicators and stakeholder engagement       |
| Implementation of CBMIP for Retail Omni-Channel Digital Transformation (Do Vale et al., 2021)         | Omni-channel technology adoption rate, customer satisfaction                    | Using CBMIP to switch to a more flexible omni-channel retail model, improving customer satisfaction                                                  |
| IoT-Based Business in Internet Service Providers (Hanafizadeh et al., 2021)                           | Use of IoT technology, revenue from new services                                | Using CBMIP to shape IoT-based business models in providing innovative services such as connectivity and cloud to ISPs                               |
| Business Experiments to Overcome the Design-Implementation Gap in Startups (Baldassarre et al., 2020) | Financial viability, environmental sustainability                               | Prototype of a business model to improve product sustainability, tested through a pilot project                                                      |

Source: author search, 2024

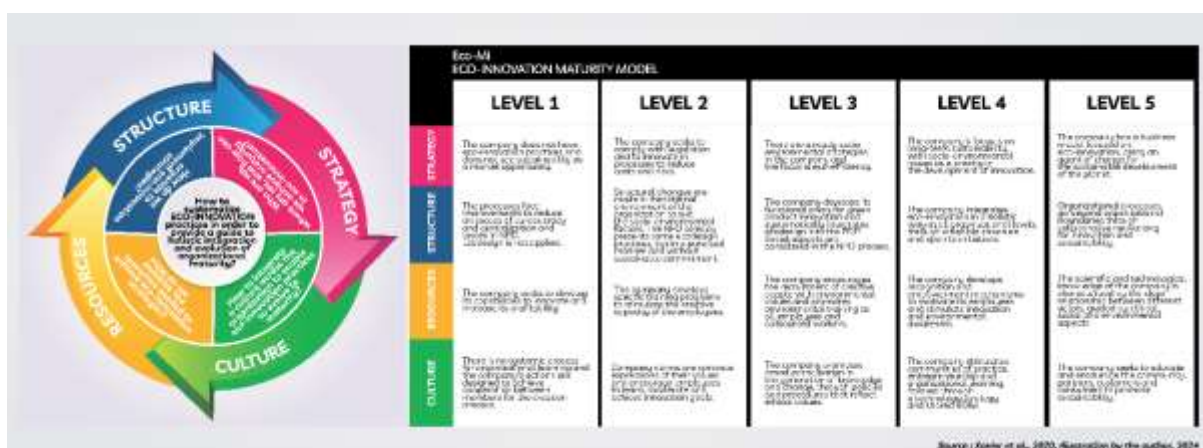
In addition, the CBMIP process emphasizes small-scale prototype experimentation to ensure the feasibility and sustainability impact of the business model before it is fully implemented. This practice helps retail companies and startups test omni-channel models as well as sustainability products at an early stage, minimizing the risk of greater implementation failures (Baldassarre et al., 2020; Do Vale et al., 2021). CBMIP also facilitates flexibility and adaptability, which is important for companies in the face of technological developments and market changes. For example, internet service providers (ISPs) use CBMIP to integrate IoT technology and increase the value of the services offered, thereby helping them meet customer needs and maintain competitiveness (Hanafizadeh et al., 2021). Efficiency and operational improvements are also a tangible result of the implementation of CBMIP, especially in lowering costs and increasing customer satisfaction, as experienced by electronics companies and ISPs that strengthen their technology-based services (Pollard et al.,

2021). Stakeholder engagement is another important aspect of CBMIP, ensuring that the innovation process receives broad support as well as creating a more positive social impact. This is evident in the event management industry that implements CBMIP to integrate eco-innovation and strengthen collaboration with various parties to achieve broader sustainability goals (Peralta & Salama, 2021). Overall, these results confirm that CBMIP can lead the company to achieve a sustainable business model that not only improves efficiency and innovation, but also creates value for the environment and society, in line with the main objectives of this innovation process.

The implementation of this sustainable innovation generally includes cross-sector collaboration and financial support specifically designed to sustain green innovation in the long-term. A dynamic approach to business model design allows companies to adapt their innovation strategies to adapt to environmental and social changes. Information technology support also plays an important role in creating more sustainable business value and accelerating the company's transition to a green economy (Cantele et al., 2020; Hba et al., 2020). Continuous innovation is an important element to support the long-term sustainability of companies as well as increase their competitiveness in the global market. These models allow companies to operate responsibly, reduce their environmental footprint, and create shared value for society and the environment.

### 7.1.3. Pendekatan Eco-Innovation Maturity model (Eco-Mi)

In addition to CBMIP, the Eco-Innovation Maturity Model (Eco-Mi) is designed to support the development and improvement of organizational maturity levels in implementing eco-innovation practices, overcoming various implementation obstacles that companies often face (Xavier et al., 2020).



Gambar 7.3. Eco-Innovation Maturity Model

Figure 7.3. showcasing the Eco-Innovation Maturity Model (Eco-Mi), a model that aims to assess and guide companies on their journey to maturity in eco-

innovation. The model identifies five levels of eco-innovation maturity defined based on four main areas: Strategy, Structure, Resources, and Culture. The strategy Area includes the company's commitment to eco-innovation, from simply meeting regulations to integrating sustainability as a core part of its business model. The structure includes changes in the organization to adopt eco-design practices and sustainable innovation. Resources focuses on employee skill development as well as training that promotes environmental awareness. Finally, Culture involves the formation of values and policies that support social and environmental responsibility. Each level of maturity in this model indicates the company's progress toward higher sustainability. At Level 1, the company does not have an eco-innovation initiative and only focuses on improving simple processes. At Level 2, companies begin to comply with environmental regulations to reduce risk. At Level 3, environmental efficiency is a priority with the implementation of eco-design in product development. At Level 4, the company begins to implement long-term sustainability by integrating eco-innovation at all levels of the organization. Finally, Level 5 indicates a company that puts eco-innovation at the core of its business model and acts as an agent of change toward sustainability. The middle of the image shows how strategy, Structure, Resources, and Culture are intertwined, with the main goal of this model, which is "How to improve eco-innovation practices to achieve higher individual and organizational eco-innovation maturity?" The circular flow emphasizes the importance of continuous improvement in these four areas to achieve eco-innovation maturity. This model reflects the company's transition from basic compliance to becoming a leader in sustainability with a transformative business model.

The Eco-Innovation Maturity Model (Eco-Mi) offers advantages and disadvantages that are important to consider in its implementation in organizations. The advantages that can be conveyed include

1. Eco-Mi provides a structured framework for assessing organizations' progress toward sustainability, guiding them through five distinct levels of eco-innovation maturity. This helps companies to identify their current position and plan steps forward.
2. The model emphasizes development in four critical areas—strategy, Structure, Resources, and Culture. In this way, Eco-Mi ensures that eco-innovation is not only focused on one aspect, but includes comprehensive changes in all aspects of the organization.
3. By directing companies toward more mature eco-innovation, this model encourages companies to integrate sustainability as part of their core strategies and business models, which can improve the company's reputation and competitiveness in an increasingly environmentally conscious global market.

4. Eco-Mi is not only an evaluation tool, but it also provides a clear development path, helping organizations understand areas that need improvement and supporting continuous innovation.
5. Eco-Mi can be used by different types and sizes of organizations. This allows organizations to tailor the implementation of eco-innovation according to their resources and capacity.

The Eco-Innovation Maturity Model has great potential to help organizations on their journey to better sustainability. However, its implementation requires adaptation according to the company's needs as well as a long-term commitment to be truly effective. The flexibility of this model is a strength, but the lack of industry specifications and difficulties in quantitative measurements can be obstacles that need to be overcome. Meanwhile, the disadvantages of Eco-Mi are

1. This model is quite common, some companies may find it difficult to apply it directly without adjusting the indicators or parameters to the specific needs of their industry, for example the difference between the manufacturing and service industries.
2. Some aspects of this model, especially in the area of Culture and strategy, may be difficult to quantitatively measure. For example, assessing changes in organizational Culture in support of sustainability can be subjective and difficult to measure with numbers.
3. The implementation of eco-innovation to reach the highest level of maturity can take years and requires a large allocation of resources. This can be a challenge for small companies or those with limited budgets.
4. Companies may experience a "dead end" at some level due to structural limitations or organizational Culture that are difficult to change. This can hinder the company's progress in reaching a higher level.
5. This model focuses more on the internal development of the organization and may pay less attention to the impact of eco-innovation on the ecosystem or community outside the organization, which is also an important element of sustainability.

Practices that refer to the Eco-Innovation Maturity Model (Eco-Mi), which has been implemented in various sectors with relevant performance indicators (table 7.3.). The practice of implementing the Eco-Innovation Maturity Model (Eco-Mi), several key results can be learned about its impact in various industries. First, Eco-Mi has been proven to help companies improve environmental sustainability, as seen in the homeopathic pharmaceutical industry in Brazil and automotive in Indonesia, where companies have successfully reduced their environmental impact through sustainable production methods and eco-friendly product innovations (Al-Shami &

Rashid, 2022; Barbieri & Santos, 2020). Second, this model helps companies improve operational efficiency and competitiveness through optimizing resource use and reducing costs, as seen in the implementation of Eco-Mi in Brazil's industrial cluster and the technology sector in Malaysia which is facing dynamic market changes (Mercado-Caruso et al., 2020).

Tabel 7.3. Ex-Eco-Innovation Maturity Model (Eco-Me)

| Practice                                                                              | Relevant Indicators                                                      | Description                                                                                                                                                                       |
|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The use of Eco-Mi in increasing the maturity of companies (Xavier et al., 2020)       | The level of eco-innovation implementation, operational effectiveness    | Eco-Mi is implemented to support the development of ecological innovations in the company to increase the maturity of the organization in terms of sustainability                 |
| Small and Medium Manufacturing Industries in China (Geng et al., 2021)                | Improved environmental performance, regulatory compliance                | Eco-innovation practices are applied in manufacturing SMEs to improve environmental performance and regulatory compliance                                                         |
| Green Manufacturing Models in the Automotive industry (Shukla & Adil, 2021)           | Reduced carbon footprint, energy efficiency                              | This model emphasizes green innovation with maturity stage orientation in carbon reduction and efficient energy                                                                   |
| Eco-Innovation Management Information System (Munodawafa & Johl, 2022)                | Eco-innovation performance data collection, sustainability reports       | Eco-Innovation Management Information System (EiMIS) was developed to make it easier for companies to report on eco-innovation performance                                        |
| Homeopathic Pharmaceutical industry in Brazil (Barbieri & Santos, 2020)               | Reduction of environmental impact, development of new production methods | The Eco-Mi model is applied to develop sustainable production methods in the homeopathic pharmaceutical industry with a product life cycle assessment approach                    |
| Industry Cluster with a Focus on Green Innovation (Mercado-Caruso et al., 2020)       | Increased competitiveness, efficient use of resources                    | Application of Eco-Mi in industrial clusters to improve eco-innovation competence and reduce costs through analysis of internal and external factors                              |
| Fishbone Model for Sustainable Development in the Energy industry (Toha et al., 2020) | Environmental and social performance, achievement of SDGs                | Using the fishbone model to link green innovation activities to the SDGs, supporting better environmental management                                                              |
| Indonesian Automotive industry (Al-Shami & Rashid, 2022)                              | Eco-friendly product performance, supply chain sustainability            | The Eco-Mi model is applied in the development of environmentally friendly automotive products, with the role of environmental management strategies and technology collaboration |

Source: author search, 2024

In addition, Eco-Mi helps companies be more adaptive to market changes by providing innovation models that align with consumer needs and dynamic competitive pressures, as seen in the Malaysian technology industry. Furthermore, Eco-Mi enables companies to support the achievement of the Sustainable Development Goals (SDGs). An example is the fishbone model applied in the energy sector, where green innovation is associated with environmental sustainability targets and CSR, which strengthens the business's commitment to sustainable development (Toha et al., 2020).



## **7.2. Green technology in the oil and gas sector**

Green technology in the oil and gas sector emerged in response to increasing awareness of the environmental impact of the industry, especially on climate change and air pollution. This technology was developed to reduce carbon footprint, optimize resource use, and meet the demands of increasingly stringent environmental regulations in various countries. Some of the factors driving the adoption of green technologies in this sector include economic and social pressures to reduce carbon emissions, as well as the long-term economic benefits of more efficient green energy (Oruwari, 2023; Temizel et al., 2022). Approaches in green technology in the oil and gas sector are often based on the principles of sustainability and the integration of environmentally friendly technologies such as the use of renewable energy, heat recovery techniques, and CCS technologies. This approach focuses on reducing emissions through the use of alternative resources such as biomass, solar energy, and heat recovery generated from oil and gas processes (Temizel et al., 2022).

The CCS approach emerged in response to the increase in carbon dioxide (CO<sub>2</sub>) emissions from industrial activities and fossil fuel power plants that are fueling global warming and climate change. The technology is designed to capture carbon emissions at the source before the gas reaches the atmosphere, then store it in a safe place, such as an underground geological formation. CCS is important because it is considered a realistic and effective solution to reduce carbon emissions in large amounts, especially in heavy industrial sectors such as power plants, cement plants, and oil refineries that have high emission intensity (Chen, 2023; Ma et al., 2020). The description of this technology includes the main processes of carbon capture, transportation, and storage. CO<sub>2</sub> is typically captured through pre-combustion, post-combustion, or oxyfuel combustion techniques, which allow for the separation of carbon from other emissions. Once captured, CO<sub>2</sub> is compressed and transported via pipeline or ship to a secure underground storage location, such as a saline geological formation or a rock layer that has been emptied by oil or gas extraction (Pieri & Angelis-Dimakis, 2021). The CCS implementation model involves a thorough assessment of costs, optimal storage locations, and close monitoring of potential gas leak risks. In the development of CCS, multi-objective optimization strategies are often used to consider both economic aspects and environmental impacts, including the evaluation of the most efficient CO<sub>2</sub> transport routes and the determination of the best locations for carbon storage by minimizing global warming potential (GWP) impacts (Zhang et al., 2020). In addition, this technology still needs development to be more cost-effective, especially in locations that require long-distance CO<sub>2</sub> transportation (Wu et al., 2023). No one individual initiated CCS, but this technology is the result of collaboration between various researchers, governments, and international institutions. Organizations such as the International Energy Agency (IEA) have pushed for the development of CCS as an important step toward achieving

net-zero emissions targets. The development of this technology has been supported by research and investment in various demonstration projects, such as in Sleipner Field, Norway, which served as one of the first successful large-scale CCS projects and became a global implementation model (Torus et al., 2023).

Tabel 7.4. CCS Simulation

| Indicator Categories                  | Indicator                                   | Description                                                                 | Unit                    |
|---------------------------------------|---------------------------------------------|-----------------------------------------------------------------------------|-------------------------|
| Fishing Efficiency and Capacity       | CO <sub>2</sub> Capture Rate                | Percentage of CO <sub>2</sub> captured from the flue gas stream             | %                       |
|                                       | Storage Capacity                            | Total storage capacity available at the geological site                     | ton                     |
|                                       | Fishing Speed                               | CO <sub>2</sub> capture rate from industrial processes                      | tons/day                |
| Economy and Cost                      | Initial Investment Cost                     | Initial costs for CO <sub>2</sub> capture and storage infrastructure        | USD                     |
|                                       | Operational Costs                           | Operational costs per ton of CO <sub>2</sub> captured and stored            | USD/ton CO <sub>2</sub> |
|                                       | Marginal Cost of Emission Reduction         | Additional cost per ton to reduce CO <sub>2</sub> emissions                 | USD/ton CO <sub>2</sub> |
| Risk and Safety                       | Risk of CO <sub>2</sub> Leakage             | Percentage of possible CO <sub>2</sub> leakage from storage                 | %                       |
|                                       | Impact of Leakage on Ecosystems             | Risk of leakage impact on the surrounding environment                       | score                   |
|                                       | Long-Term Storage Security                  | Evaluation of geological formation stability and infrastructure security    | score                   |
| Infrastructure and Transportation     | CO <sub>2</sub> Transportation Distance     | Average distance from the point of capture to the storage location          | Miles                   |
|                                       | Transportation Capacity                     | CO <sub>2</sub> transport capacity from capture to storage                  | tons/day                |
|                                       | Transportation Energy Intensity             | Energy required to transport CO <sub>2</sub>                                | kWh/ton CO <sub>2</sub> |
| Environmental and Social Impact       | Carbon Footprint Reduction                  | Total CO <sub>2</sub> emission reductions achieved                          | tons of CO <sub>2</sub> |
|                                       | GWP                                         | Potential reduction of global warming                                       | score                   |
|                                       | Social Acceptance and Policy Support        | Public perception and policy support for CCS                                | score                   |
| Technical and Operational Reliability | Infrastructure Availability                 | Percentage of uptime of overall planned time                                | %                       |
|                                       | Technical Effectiveness                     | The effectiveness of capture and storage technology in achieving the target | score                   |
|                                       | Storage Infrastructure Corrosion Resistance | Assessment of infrastructure resilience to corrosion                        | score                   |

Source: author's analysis, 2024

The following is a table of indicators needed to simulate CCS, a technology designed to capture and store carbon dioxide (CO<sub>2</sub>) from industrial activities to reduce greenhouse gas emissions. Each indicator in this table has an important role in evaluating the effectiveness, cost efficiency, risk, and operational sustainability of the CCS. The indicators are grouped into several categories that include technical, economic, safety, environmental, and social aspects, all of which serve to provide a comprehensive picture of the implementation and sustainability of CCS in the

industrial sector. Using this table, industry players, governments, and researchers can measure various important aspects of the implementation of CCS holistically and identify areas that need improvement or optimization. Table 7.4. can also be used as a guide in decision-making related to investment, location selection, and the implementation of policies that support the success and efficiency of the CCS system in various scenarios.

The description of green technology includes new techniques and methods to reduce pollution, optimize resource use, and improve production efficiency. For example, heat recovery technology is applied to the oil refining process, while solar energy is used in crude oil exploration. In addition, CCS technologies are being developed to capture carbon emissions from the production process and store them underground to prevent atmospheric pollution (Weixiang & Chunpeng, 2023). This green technology model and implementation includes the integration of green technology into existing oil and gas production systems, such as the use of renewable energy in certain processes, supply chain optimization, as well as the development of green management and employee training for environmental awareness. The government also plays an important role in encouraging regulations and policies that support green technology (Karkhova, 2022; Yakovlev & Berezhnov, 2021). This green technology was not developed by a single individual, but is the result of collaboration between researchers, oil and gas companies, and policymakers. Several approaches, such as the social life cycle assessment applied in Alberta, Canada, have shown the importance of the government's role in supporting the implementation of green technologies by developing policies that consider social and economic aspects (Hannouf et al., 2020). Green technology in the oil and gas sector is a response to the global need for more sustainable and environmentally friendly industrial practices, with the implementation of innovations and policies that support sustainability.

### **7.3. Application of Technology and Innovation in the Oil and Gas Sector**

The various innovations refer to (Kementerian Lingkungan Hidup dan Kehutanan, 2023) (table 7.5) that has been developed in the industrial sector, each classified based on a specific innovation category. Each innovation aims to improve efficiency, reduce environmental impact, and promote sustainability through reducing waste, emissions, and energy use. This category of innovation includes the improvement of processes, products and sub-systems, to the utilization of renewable energy and automation technologies, all of which contribute to the creation of more optimal and efficient value chains. These innovations not only support business objectives such as cost savings and operational efficiency but also advance the sustainability agenda with an eco-innovation approach, industrial symbiosis, and a more sustainable business model innovation process.

Table 7.5. Category: Innovation and benefits of the Industrial sector in 2022-2023

| Categories Innovation                | Examples of Innovation                                                  | Benefits Details.                                                                                                                   |
|--------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Process Improvement                  | Connector Spill Protection                                              | Reduce groundwater pollution by containing oil spills.                                                                              |
|                                      | Spec-Cap di Limited Company Pertamina Lubricants                        | Reduce downtime by up to 90.66%.                                                                                                    |
| Product Enhancement                  | Utilization of Rubber Waste                                             | Using waste rubber for public facilities, reducing waste and CO <sub>2</sub> emissions.                                             |
| Sub-system changes                   | Biofloc System for Catfish Farming                                      | Saves water use and reduces waste.                                                                                                  |
|                                      | Fuel Delivery on Demand                                                 | Optimizing the use of refueler energy to reduce CO <sub>2</sub> eq emissions.                                                       |
|                                      | Refueler EATS, Distop                                                   | Improve the operational efficiency of fuel distribution and energy refueling.                                                       |
| Value Chain Optimization             | Rearranging Supply Pump for Aircraft Refueling                          | Electrical energy efficiency and operational cost savings.                                                                          |
| Reverse Logistics                    | GEMPI (Energy Saving Generator)                                         | Converts kinetic energy into electricity for refuelers, saving electricity.                                                         |
| Emission Reduction                   | Gas Evacuation Tools, PowerSync Generator Controller                    | Reduce emissions from previously inefficient operating systems.                                                                     |
| Energy Savings                       | Zeotrap Emission Reduction, Renewable Energy Lighting Program           | Reducing energy use through energy-saving technologies and automated devices.                                                       |
| Wastewater Management                | Budidaya Ikan Lele Bioflok, Membrane Pump Fuel Oil (BBM) Ex-Oil Catcher | Saves water use and reduces liquid waste to the environment.                                                                        |
| Utilization of New Technologies      | Mushroom Beetle Automatic Watering System                               | Optimizing water and energy use through automation and efficiency technologies.                                                     |
|                                      | Technology Faucet Micromesh                                             | Improve water and energy use efficiency.                                                                                            |
| Reduced Energy Use                   | GEMPI (Energy Saving Generator)                                         | Converting the kinetic energy of the refueler into electricity, reducing State Electricity Company (namely PLN's) power dependence. |
| Production Process Optimization      | Floating Eijkbout                                                       | Securing fuel distribution with better time efficiency and safety.                                                                  |
| Waste and Emission Reduction         | 3R Program for Decomposer Utilization (3R Warriors)                     | The use of organic waste for maggot cultivation and compost fertilizer, reducing waste generation.                                  |
| Improved Water Efficiency            | Substitusi Water Wall                                                   | Save water in the fire extinguishing process with fire blanket, reduce water wastage.                                               |
| Use of Renewable Energy              | Solar Power Plant for Apollo Melon Cultivation                          | Energy saving on the production and treatment of melon peel waste for methane emission reduction.                                   |
| Emission and Waste Reduction         | Robot Tank Sweeper (ROSTER)                                             | Reduce water use in tank cleaning and lower waste load.                                                                             |
| Energy Savings                       | Program Zeotrap Emission Reduction                                      | Reduce CO <sub>2</sub> emissions through an automated system with zeolite materials.                                                |
| Operational Process Optimization     | Program Fuel Delivery on Demand                                         | Save refueling with digital-based BBMP order confirmation.                                                                          |
| Water Use Efficiency                 | Solar Panel-Based Catfish Biofloc System                                | Saving water and increasing the productivity of catfish farming.                                                                    |
| Utilization of Automation Technology | Injek Mertabak (Injek Merchaptan Tabung Kuning)                         | Optimize the gas injection process with nitrogen gas, reduce energy waste.                                                          |

Source: (Kementerian Lingkungan Hidup dan Kehutanan, 2023)

The innovations listed are closely related to the effectiveness of the industrial symbiosis, the CBMIP, and the Eco-Innovation Maturity Model (Eco-Mi), especially in the context of sustainability and operational efficiency. The effectiveness of industrial symbiosis

is reflected in innovations such as the Utilization of Rubber Waste and the 3R Program for the Utilization of Decomposers (3R Pendekar), where waste from one production process is reused as material in another process. This approach encourages more efficient and sustainable industrial integration, reducing emissions and environmental waste. In relation to the CBMIP, many innovations such as Fuel Delivery on Demand and Energy Saving Generator (namely GEMPI) demonstrate innovative thinking that involves creating and testing new business models to increase business value while minimizing environmental impact. The CBMIP process prioritizes business model updates that take sustainability into account as part of the added value, where energy efficiency and emission reduction are at the core of more innovative business development. This approach aligns well with the principles of eco-industrial parks, which focus on resource exchange and energy management to optimize performance (Lo et al., 2023). In industrial symbiosis, rubber waste is repurposed to minimize landfill usage, while the 3R Program emphasizes sustainable material use through reducing, reusing, and recycling. Meanwhile, circular business model innovations like on-demand fuel delivery help to reduce excess inventory and waste, enhancing efficiency. Another example, the Energy Saving Generator (GEMPI), demonstrates how innovative business models can prioritize both sustainability and energy efficiency (Pitis et al., 2023). The Eco-Innovation Maturity Model (Eco-Mi) provides a framework to assess the maturity of eco-innovations, guiding companies toward sustainable practices that optimize their performance (Rahmani et al., 2024). While these innovations present a viable path to sustainability, challenges persist in widespread adoption, particularly in finding a balance between costs and environmental benefits in more traditional industries (Maldonado-Guzmán et al., 2023).

Meanwhile, the Eco-Innovation Maturity Model (Eco-Mi) serves as an indicator of the maturity of environmentally friendly innovations within the company, which is reflected in innovations such as Zeotrap Emission Reduction and Biofloc System for Catfish Farming. These innovations show gradual improvements in resource efficiency, waste reduction, and the adoption of renewable energy, which are in line with the level of maturity in Eco-Mi. These innovations not only have an impact on a better environment but also indicate the industry's readiness to implement more advanced and sustainable technologies on a wider scale.

Thus, these three models support the optimization of innovation with an integrative and sustainability approach that supports industrial symbiosis, business model updates, and increasing the level of eco-innovation maturity in the industry.

From various studies on the effectiveness of models such as the CBMIP, Eco-Innovation Maturity Model (Eco-Mi), and the industrial symbiosis approach, there are several important results that can be studied in the context of sustainability and industrial operational efficiency. First, the Eco-Innovation Maturity Model (Eco-Mi) approach shows that the level of eco-innovation maturity in a company can support the integration of more sustainable environmentally friendly practices. This Eco-Mi model helps companies to recognize and overcome organizational obstacles in the overall implementation of eco-innovation, especially in managing resources efficiently and reducing environmental emissions and waste (Xavier et al., 2020). In relation to CBMIP, the study shows that sustainability-enabled business model innovations, such as Fuel Delivery on Demand and GEMPI (Energy Saving Generator), are examples of innovative thinking that involves creating new business models to increase value while minimizing environmental impact. This model provides the flexibility

to incorporate innovations focused on reducing emissions and improving energy efficiency in cleaner product lifecycles and production processes (Kashyap & Salunkhe, 2022). On the other hand, the concept of industrial symbiosis offers opportunities to improve resource efficiency through the integration of the industrial and urban sectors, where waste from one process can be used as an input for another. This approach has been proven to improve environmental efficiency at the level of certain sectors, for example in China's urban industry which shows a moderate increase in environmental efficiency with the application of industrial symbiosis (Bian et al., 2020). The implementation of these models in various sectors has shown tangible benefits in operational efficiency and sustainability. These strategies lead to the integration of green innovations at the organizational level, maximizing added value for the company while maintaining environmental sustainability at every stage of production.

The main challenges in implementing sustainability models such as the CBMIP, the Eco-Innovation Maturity Model (Eco-Mi), and the industrial symbiosis are divided into several categories. First, at the organizational and financial level, many companies face limitations in resource allocation and difficulty in allocating funds to meet the additional costs arising from sustainability investments. For example, high research and development (R&D) costs are an obstacle for small and medium-sized companies, especially in regions with limited supporting infrastructure (Ansari & Kant, 2021). In addition, technological and collaboration constraints often hinder the adoption of industrial symbiosis. Limitations in technology, such as limitations in creating information and technology platforms that are compatible between companies, become barriers to effective symbiotic implementation, which is also complicated by the high cost of implementing new technologies (Yang et al., 2022). In terms of policies and regulations, inconsistent regulations and lack of support from the government make it difficult for companies to switch to a more environmentally friendly circular business model. In developing countries, such as Pakistan, the lack of regulations and policies related to industrial symbiosis slows down progress toward a sustainable industrial ecosystem (Akhtar et al., 2022). To achieve optimal sustainability through innovative models, companies must overcome obstacles in organizational, financial, technological, and regulatory aspects. This requires further support from government policies and cross-sector collaboration to accelerate the adoption and efficiency of sustainability in the industry.

For the adoption of sustainability models such as the Eco-Innovation Maturity Model (Eco-Mi), the CBMIP, and industrial symbiosis, there are several strategies that can be implemented at various levels. First, a holistic eco-innovation approach has been shown to significantly improve resource efficiency. This approach integrates products, processes, and organizations in a single framework, which allows companies to improve their economic-environmental performance simultaneously (Castiglione et al., 2021). Second, the implementation of small prototypes or pilot projects can be a solution to bridge the gap between the design and implementation of sustainable business models. This strategy allows organizations to test the feasibility and viability of new business models on a small scale before they are fully implemented (Baldassarre et al., 2020). In addition, the use of digital platforms and industry 4.0 tools strengthens collaboration between companies in an industrial symbiosis. These tools enable real-time data exchange and the identification of efficient collaboration opportunities within the scope of the circular economy, thereby reducing emissions and accelerating waste reuse (Aquilani et al., 2019). Finally, frameworks

that support stakeholder engagement at the company level to the sector level, such as collaboration in the form of industrial symbiosis in large industrial cities, can improve resource efficiency on a broader scale (Bian et al., 2020). The implementation of these measures allows companies to not only improve operational sustainability but also strengthen their competitiveness in an increasingly sustainability-oriented global market.

#### **7.4. Conclusion**

Chapter 7 discusses important issues in the implementation of environmentally friendly technologies in the oil and gas (oil and gas) sector through innovations such as emission reduction technologies, renewable energy utilization, and waste management systems. The main issues raised are the challenges in the adoption of sustainable technologies, especially related to the costs and infrastructure required to effectively reduce environmental impacts. Obstacles such as limited resources, technology, and policies are also in the spotlight. From this Chapter 7, it can be concluded that sustainability approaches through green technologies such as CCS and industrial ecology are able to improve energy efficiency and reduce emissions. The integration of the CBMIP and Eco-Innovation Maturity Model (Eco-Mi) in the oil and gas business also shows great potential in reducing environmental impact while supporting economic growth.

An important recommendation was the need for collaboration between the government, industry, and communities to support the adoption of green technology. It is recommended that oil and gas companies adopt sustainable business models by utilizing new technologies, such as IoT for emission monitoring and energy efficiency, as well as capacity building for the implementation of CBMIP and Eco-Mi. The novelty in Chapter 7 lies in a comprehensive approach that combines green technology with a sustainability-oriented business strategy, thus enabling the reduction of environmental impact while maintaining operational efficiency. For future studies, the document recommends further research on cost optimization and improvement of CCS technology, as well as the application of industrial symbiosis in a broader local context. This is expected to support long-term sustainability goals by balancing economic growth and environmental conservation.

## Reference

- Akhtar, N., Bokhari, S. A., Martin, M. A., Saqib, Z., Khan, M. I., Mahmud, A., Zaman-Ul-haq, M., & Amir, S. (2022). Uncovering Barriers for Industrial Symbiosis: Assessing Prospects for Eco-Industrialization through Small and Medium-Sized Enterprises in Developing Regions. *Sustainability (Switzerland)*, 14(11). <https://doi.org/10.3390/su14116898>
- Al-Shami, S., & Rashid, N. (2022). A holistic model of dynamic capabilities and environment management system towards eco-product innovation and sustainability in automobile firms. *Journal of Business and Industrial Marketing*, 37(2). <https://doi.org/10.1108/JBIM-04-2020-0217>
- Ansari, Z. N., & Kant, R. (2021). A plithogenic based neutrosophic analytic hierarchy process framework to analyse the barriers hindering adoption of eco-innovation practices in supply chain. *International Journal of Sustainable Engineering*, 14(6). <https://doi.org/10.1080/19397038.2021.1998842>
- Aquilani, B., Piccarozzi, M., Silvestri, C., & Gatti, C. (2019). *Achieving Environmental Sustainability Through Industry 4.0 Tools*. <https://doi.org/10.4018/978-1-7998-1419-1.ch003>
- Ayandibu, A. O., & Ayandibu, E. O. (2024). *The Role of Innovation in Sustainable Entrepreneurship* (pp. 205–221). <https://doi.org/10.4018/979-8-3693-7322-4.ch010>
- Azman, N. F., Katahira, T., Nakanishi, Y., Chisyaki, N., Uemura, S., Yamada, M., Takayama, K., Oshima, I., Yamaguchi, T., Hara, H., & Yamauchi, M. (2023). Sustainable oil palm biomass waste utilization in Southeast Asia: Cascade recycling for mushroom growing, animal feedstock production, and composting animal excrement as fertilizer. *Cleaner and Circular Bioeconomy*, 6. <https://doi.org/10.1016/j.clcb.2023.100058>
- Baldassarre, B., Konietzko, J., Brown, P., Calabretta, G., Bocken, N., Karpen, I. O., & Hultink, E. J. (2020). Addressing the design-implementation gap of sustainable business models by prototyping: A tool for planning and executing small-scale pilots. *Journal of Cleaner Production*, 255. <https://doi.org/10.1016/j.jclepro.2020.120295>
- Barbieri, R., & Santos, D. F. L. (2020). Sustainable business models and eco-innovation: A life cycle assessment. *Journal of Cleaner Production*, 266. <https://doi.org/10.1016/j.jclepro.2020.121954>
- Bian, Y., Dong, L., Liu, Z., & Zhang, L. (2020). A sectoral eco-efficiency analysis on urban-industrial symbiosis. *Sustainability (Switzerland)*, 12(9). <https://doi.org/10.3390/su12093650>



- Cantele, S., Moggi, S., & Campedelli, B. (2020). Spreading sustainability innovation through the co-evolution of sustainable business models and partnerships. *Sustainability (Switzerland)*, 12(3). <https://doi.org/10.3390/su12031190>
- Castiglione, C., Yazan, D. M., Alfieri, A., & Mes, M. (2021). A holistic technological eco-innovation methodology for industrial symbiosis development. *Sustainable Production and Consumption*, 28. <https://doi.org/10.1016/j.spc.2021.09.002>
- Chen, S. (2023). Review of Carbon Capture, Utilization, Transportation and Storage. *Advances in Economics, Management and Political Sciences*, 29(1). <https://doi.org/10.54254/2754-1169/29/20231382>
- Clauss, T., Bouncken, R. B., Laudien, S., & Kraus, S. (2020). Business Model Reconfiguration and Innovation in SMEs: A Mixed-Method Analysis from the Electronics Industry. *International Journal of Innovation Management*, 24(2). <https://doi.org/10.1142/S1363919620500152>
- Do Vale, G., Collin-Lachaud, I., & Lecocq, X. (2021). Micro-level practices of bricolage during business model innovation process: The case of digital transformation towards omni-channel retailing. *Scandinavian Journal of Management*, 37(2). <https://doi.org/10.1016/j.scaman.2021.101154>
- Geng, D., Lai, K. hung, & Zhu, Q. (2021). Eco-innovation and its role for performance improvement among Chinese small and medium-sized manufacturing enterprises. *International Journal of Production Economics*, 231. <https://doi.org/10.1016/j.ijpe.2020.107869>
- Hanafizadeh, P., Hatami, P., Analoui, M., & Albadvi, A. (2021). Business model innovation driven by the internet of things technology, in internet service providers' business context. *Information Systems and E-Business Management*, 19(4). <https://doi.org/10.1007/s10257-021-00537-0>
- Hannouf, M., Assefa, G., & Gates, I. (2020). From social hotspots to policies for successful implementation of environmentally better technologies? The example of social life cycle assessment of oil and gas technologies in Alberta, Canada. *Environmental Science and Policy*, 110. <https://doi.org/10.1016/j.envsci.2020.05.002>
- Hba, R., Idrissi, M. A. J., El Ghaib, M. K., & El Manouar, A. (2020). ICT sustainable management: Towards a better alignment with the sustainable development strategy. *International Journal of Advanced Technology and Engineering Exploration*, 7(71). <https://doi.org/10.19101/IJATEE.2020.762062>
- Herrador, M., & Van, M. L. (2024). Circular economy strategies in the ASEAN region: A comparative study. *Science of the Total Environment*, 908. <https://doi.org/10.1016/j.scitotenv.2023.168280>

- Hwang, J. Z. H., Andiappan, V., & Ng, D. K. S. (2022). Promoting Circular Economy Between Palm Oil Sector with Multiple Industries. *IOP Conference Series: Materials Science and Engineering*, 1257(1). <https://doi.org/10.1088/1757-899x/1257/1/012005>
- Ibarra, D., Bigdeli, A. Z., Igartua, J. I., & Ganzarain, J. (2020). Business model innovation in established SMEs: A configurational approach. *Journal of Open Innovation: Technology, Market, and Complexity*, 6(3). <https://doi.org/10.3390/JOITMC6030076>
- Ivanova, T. (2023). Digital technologies in oil and gas production as a tool to ensure optimal energy efficiency and sustainability. *E3S Web of Conferences*, 419. <https://doi.org/10.1051/e3sconf/202341901007>
- Karkhova, S. (2022). Implementation of the principles of green logistics in the oil and gas sector. *Russian Journal of Resources, Conservation and Recycling*, 9(2). <https://doi.org/10.15862/07ecor222>
- Kashyap, S. K., & Salunkhe, V. J. (2022). THE PROCESSES, CHALLENGES AND IMPLEMENTATION IN THE SUSTAINABLE BUSINESS MODEL INNOVATION. *JOURNAL OF INTERNATIONAL BUSINESS AND ECONOMY*, 23(1). <https://doi.org/10.51240/jibe.2022.1.4>
- Kementerian Lingkungan Hidup dan Kehutanan. (2023). Best Practices Sektor Migas Distribusi Proper Periode 2022 - 2023. In *Direktorat Jenderal Pengendalian pencemaran Dan Kerusakan Lingkungan*. [https://proper.menlhk.go.id/propercms/uploads/magazine/docs/inovasi/magazineBest\\_Practice\\_Sektor\\_Migas\\_Distribusi.pdf](https://proper.menlhk.go.id/propercms/uploads/magazine/docs/inovasi/magazineBest_Practice_Sektor_Migas_Distribusi.pdf)
- Kumar, R., & Sinha, K. (2024). Impact of CSR Innovation Policy on Sustainable Development. *Integrated Journal for Research in Arts and Humanities*, 4(2), 149–157. <https://doi.org/10.55544/ijrah.4.2.25>
- Kutepova, P. S., & Iakovleva, P. E. (2022). Analysis of the application of environmental innovations by oil and gas sector enterprises. *Collection of Scientific Articles*, 110–122. <https://doi.org/10.52897/978-5-7310-5861-2-2022-16-1-110-122>
- Lo, S. F., Lu, W. M., Chang, C. W., Hung, S. W., & Yang, L. L. (2023). An efficiency-driven approach for global ecological industrial parks. *Journal of Cleaner Production*, 424. <https://doi.org/10.1016/j.jclepro.2023.138837>
- Ma, X., Zhang, X., & Tian, D. (2020). Farmland degradation caused by radial diffusion of CO<sub>2</sub> leakage from carbon capture and storage. *Journal of Cleaner Production*, 255. <https://doi.org/10.1016/j.jclepro.2020.120059>
- Maldonado-Guzmán, G., Garza-Reyes, J. A., & Pinzón-Castro, S. Y. (2023). Green innovation and firm performance: the mediating role of sustainability in the

- automotive industry. *Management of Environmental Quality: An International Journal*, 34(6). <https://doi.org/10.1108/MEQ-02-2023-0058>
- Mercado-Caruso, N., Segarra-Oña, M., Ovallos-Gazabon, D., & Peiró-Signes, A. (2020). Identifying endogenous and exogenous indicators to measure eco-innovation within clusters. *Sustainability (Switzerland)*, 12(15). <https://doi.org/10.3390/su12156088>
- Munodawafa, R. T., & Johl, S. K. (2022). Design and Development of an Eco-Innovation Management Information System to Accelerate Firms' Digital Transformation Strategy. *IEEE Access*, 10. <https://doi.org/10.1109/ACCESS.2022.3163248>
- Oruwari, H. O. (2023). Green Technological Approach for Sustainable Operations of Oil and Gas Industry. *Society of Petroleum Engineers - SPE Nigeria Annual International Conference and Exhibition, NAIC 2023*. <https://doi.org/10.2118/217178-MS>
- Peralta, A., & Salama, M. (2021). Sustainable Business Model Innovation for Event Management. In *Event Project Management*. <https://doi.org/10.23912/9781911635734-4771>
- Pieri, T., & Angelis-Dimakis, A. (2021). Model Development for Carbon Capture Cost Estimation. *Clean Technologies*, 3(4). <https://doi.org/10.3390/cleantechnol3040046>
- Pitis, Dr. C., Carr, D., Rasmussen, G., & Walstra, C. (2023). New Approach Towards Sustainability – The Global Efficiency Concept (GEff). *Journal of Environmental Science and Engineering Technology*, 11. <https://doi.org/10.12974/2311-8741.2023.11.04>
- Pollard, J., Osmani, M., Cole, C., Grubnic, S., & Colwill, J. (2021). A circular economy business model innovation process for the electrical and electronic equipment sector. *Journal of Cleaner Production*, 305. <https://doi.org/10.1016/j.jclepro.2021.127211>
- Rachmansyah, M. F., Pribadi, R., & Suyadi, S. (2023). Faktor Spasial, Ekologi, dan Sosial Ekonomi untuk Penilaian Kondisi Ekosistem Mangrove Studi Kasus: Segara Anakan. *Buletin Oseanografi Marina*, 12(2). <https://doi.org/10.14710/buloma.v12i2.47793>
- Rahman, E. Z., & Shah, S. H. A. (2023). The importance of green innovation and technologies for sustainable business in Asia: Issues and challenges of the contemporary sustainable business models. In *Entrepreneurship and Green Finance Practices: Avenues for Sustainable Business Start-ups in Asia*. <https://doi.org/10.1108/978-1-80455-678-820231009>
- Rahmani, A., Bonyadi Naeini, A., Mashayekh, J., Aboojafari, R., Daim, T., & Yalcin, H. (2024). Green innovation for a greener future: A meta-analysis of the impact

- on environmental performance. *Journal of Cleaner Production*, 460, 142547. <https://doi.org/10.1016/j.jclepro.2024.142547>
- Santoso, H., Susanty, A., & Putriasih, J. (2014). REKAYASA EKOLOGI INDUSTRI DALAM MENDUKUNG PEMBANGUNAN AGRO ECO-INDUSTRIAL PARK SKALA PEDESAAN. *J@TI UNDIP: JURNAL TEKNIK INDUSTRI*, 9(2). <https://doi.org/10.12777/jati.9.2.117-124>
- Shkitsa, L., Yatsyshyn, T., Lyakh, M., & Sydorenko, O. (2020). Innovative approaches to the formation of environmental safety at the objects of oil and gas production. *IOP Conference Series: Materials Science and Engineering*, 749(1). <https://doi.org/10.1088/1757-899X/749/1/012009>
- Shukla, G. P., & Adil, G. K. (2021). "A four-stage maturity model of green manufacturing orientation with an illustrative case study." *Sustainable Production and Consumption*, 26. <https://doi.org/10.1016/j.spc.2021.01.009>
- Temizel, C., Yegin, C., Bahar Hosgor, F., Aydin, H., & Kabir, S. (2022). Exploring Green Energy Applications in the Oil and Gas Industry. *Society of Petroleum Engineers - SPE Canadian Energy Technology Conference, CET 2022*. <https://doi.org/10.2118/208900-MS>
- Toha, M. A., Johl, S. K., & Khan, P. A. (2020). Firm's sustainability and societal development from the lens of fishbone eco-innovation: A moderating role of ISO 14001-2015 environmental management system. *Processes*, 8(9). <https://doi.org/10.3390/PR8091152>
- Torus, B., Arista, K. Y., Wulan, E. P., Lubis, M., Herawati, I., & Pranowo, W. (2023). 4D Seismic Inversion and Rock Physic Modeling to Monitor CO<sub>2</sub> Injection at Carbon Capture and Storage Project in The Utsira Formation, Sleipner Field, North Sea, Norway. *Journal of Earth Energy Engineering*, 12(2s). <https://doi.org/10.25299/jeee.2023.14088>
- VIKTOROVA, N. G., & LAGUTENKOV, A. A. (2022). Innovative technologies of the green economy in the oil and gas complex. *National Interests: Priorities and Security*, 15(5). <https://doi.org/10.24891/ni.18.5.961>
- Wanasinghe, T. R., Gosine, R. G., James, L. A., Mann, G. K. I., De Silva, O., & Warrian, P. J. (2020). The Internet of Things in the Oil and Gas Industry: A Systematic Review. *IEEE Internet of Things Journal*, 7(9). <https://doi.org/10.1109/JIOT.2020.2995617>
- Weixiang, C., & Chunpeng, W. (2023). Carbon Capture, Utilization and Storage (CCUS) in Tight Oil Reservoir. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/216110-MS>

- Wu, Y., Zhang, H., Wang, S., & Zhen, L. (2023). Mathematical Optimization of Carbon Storage and Transport Problem for Carbon Capture, Use, and Storage Chain. *Mathematics*, 11(12). <https://doi.org/10.3390/math11122765>
- Xavier, A., Reyes, T., Aoussat, A., Luiz, L., & Souza, L. (2020). Eco-innovation maturity model: A framework to support the evolution of eco-innovation integration in companies. *Sustainability* (Switzerland), 12(9). <https://doi.org/10.3390/su12093773>
- Xie, X., Fu, H., Zhu, Q., & Hu, S. (2024). Integrated optimization modelling framework for low-carbon and green regional transitions through resource-based industrial symbiosis. *Nature Communications*, 15(1), 3842. <https://doi.org/10.1038/s41467-024-48249-6>
- Yakovlev, V. A., & Berezhnov, D. A. (2021). Implementation of the greening process at oil and gas industry enterprises. *Journal of Physics: Conference Series*, 1889(3). <https://doi.org/10.1088/1742-6596/1889/3/032024>
- Yang, T., Liu, C., Côté, R. P., Ye, J., & Liu, W. (2022). Evaluating the Barriers to Industrial Symbiosis Using a Group AHP-TOPSIS Model. *Sustainability* (Switzerland), 14(11). <https://doi.org/10.3390/su14116815>
- Yu, F., & Wang, G. (2023). Assessing the Impact of Business Model Innovation on Firm Performance: Insights from the China Growth Enterprise Market. *International Business Research*, 16(4). <https://doi.org/10.5539/ibr.v16n4p51>
- Zhang, S., Zhuang, Y., Tao, R., Liu, L., Zhang, L., & Du, J. (2020). Multi-objective optimization for the deployment of carbon capture utilization and storage supply chain considering economic and environmental performance. *Journal of Cleaner Production*, 270. <https://doi.org/10.1016/j.jclepro.2020.122481>
- Zhuravska, N., Stefanovych, I., Stefanovych, P., & Nehrii, T. (2023). ENVIRONMENTAL SAFETY IN THE OIL AND GAS INDUSTRY. *Naukovyi Visnyk Donetskoho Natsionalnoho Tekhnichnoho Universytetu*, 1, 63–68. <https://doi.org/10.31474/2415-7902-2023-1-63-68>



# Public Health Around Oil and Gas Work Areas

Charles Conrad Rambung, Fitri Susiyanti

This chapter discusses the impact of oil and gas exploration and production on public health, particularly related to air and water pollution around the operating area. Mitigation approaches include strict regulation, clean technology, and cross-sector collaboration to minimize health risks.

## **8.1. Impact of oil and gas exploration and production on public health**

Oil and gas exploration and production have a significant impact on public health around the operating area, particularly in terms of air quality, water quality, and pollution exposure. Activities such as drilling, fracking, and oil and gas processing often produce waste in the form of polluted water and harmful gas emissions, which can pollute the surrounding environment. The wastewater produced in this process contains a variety of organic compounds, heavy metals, and radioactive substances that if not properly managed can contaminate drinking water sources and threaten public health, as found in studies in the United States and Nigeria that show an increased risk of respiratory diseases, kidney disorders, as well as cardiovascular disorders in the surrounding community (E. Hill & Ma, 2021; Raimi et al., 2022). Approaches that can be taken to mitigate this impact include the implementation of strict regulations related to oil and gas emissions and waste management, regular water and air quality monitoring, and the use of clean technology that can reduce pollution. For example, the use of wastewater in agricultural activities or water use engineering to reduce evaporation has been implemented in several regions to maintain the sustainability of water resources in semi-arid areas (Scanlon et al., 2020). This approach requires support from the government, industry, and the community. Opportunities from the implementation of this approach include improving the quality of life of the surrounding community, environmental conservation, and improving the reputation of the oil and gas industry in maintaining environmental sustainability. However, the challenges are technological limitations in oil and gas waste management, high implementation costs, and complex

coordination needs between various parties involved in monitoring and regulatory enforcement (Bonetti et al., 2022; Stolz & Griffin, 2022).

Various important theories can help understand the environmental and public health impacts of oil and gas exploration and production. One relevant approach is the cumulative environmental impact theory, which explains how repeated exposure to pollutants such as exhaust gases, heavy metals, and hydrocarbons causes cumulative health risks to surrounding communities (Orisakwe, 2021). In addition, environmental justice theories highlight the social injustices that occur when communities living near oil and gas exploration sites are more vulnerable to environmental pollution and health impacts, while they derive smaller economic benefits compared to oil and gas companies and governments (Watterson & Dinan, 2020). Systemic risk analysis theory is also increasingly used in evaluating potential health and environmental risks due to oil and gas activities, taking into account the uncertainty and complexity inherent in these activities. This approach offers modeling that can estimate risks in various phases of exploration, from drilling to production, and allows industry players and regulators to identify more effective mitigation measures (C. B. Hill et al., 2021). In the context of coastal areas, this theory is also applied to monitor long-term risks to marine ecosystems due to oil spills and offshore exploration activities (Martin et al., 2023). Finally, evidence-based assessment theory emphasizes the importance of comprehensive data to assess the health impacts of oil and gas activities, as shown by various studies documenting an increased risk of respiratory, cardiovascular, and reproductive diseases in communities near oil and gas sites (Apergis et al., 2021). This theory encourages collaboration between academics, medical practitioners, and policymakers to develop a comprehensive surveillance approach. By applying these theories, stakeholders can better understand and mitigate the negative impacts arising from the oil and gas industry, as well as optimize industry regulations and practices to protect public health and the environment.

## **8.2. Cumulative environmental impact theory**

The cumulative environmental impact theory (CIA) began to be developed as an approach to assessing environmental impacts resulting from various interrelated and sustainable human activities. This theory focuses on how the interaction between various activities such as development, exploration, and land use can worsen the overall condition of ecosystems, both on land and in the sea (Piet et al., 2021; Loiseau et al., 2021). The CIA's approach is becoming increasingly important in the context of a changing global environment influenced by industrial activities, such as oil and gas exploration. The main parameters in this theory include cumulative pressure on the environment, exposure level, sensitivity of ecosystem components, and vulnerability of affected areas. For example, the CIA's methods for the marine environment identify

stresses such as pollution, land use change, and urbanization as factors affecting coral reefs and other marine life (Loiseau et al., 2021). The process flow of the Cumulative Impact Assessment (CIA), an approach to evaluate the environmental impact of various interconnected human activities and has sustainable effects. In this process, several key stages are involved to ensure a thorough environmental impact analysis, involving a range of relevant environmental parameters (figure 8.1).

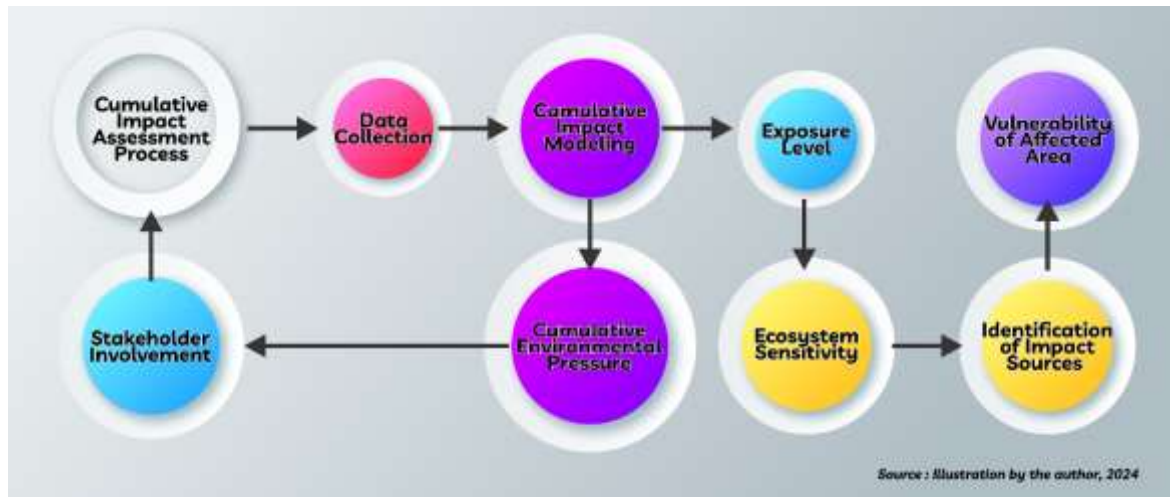


Figure 8.1. CIA process Flow

Figure 8.1. is a major stage in the CIA process. Starting from the CIA process, the first stage is data collection, which is the collection of data needed for assessment. The data that has been collected is used in the Identification of Impact Sources, which is the identification of sources that have an environmental impact. The next stage is cumulative impact modeling, which is cumulative impact modeling using software or Geographic Information Systems (GIS). From the results of this modeling, several important parameters such as cumulative environmental pressure, exposure level, ecosystem sensitivity, and vulnerability of affected area were produced. Figure 8.1. This shows the importance of Stakeholder Involvement, which is the involvement of stakeholders such as government, industry, and academia in the CIA process to ensure the appropriateness and sustainability of the analysis results. All of these elements work together to assess the cumulative impact of human activities on the environment more comprehensively.

This quantitative model also considers the spatial distribution of pressures, population dynamics, and specific pressure-reaction relationships based on existing ecological data (Piet et al., 2021). The process within the CIA typically involves several stages, such as collecting spatial data, identifying impact sources, and modeling cumulative impacts through software or GIS. For example, research in the North Sea shows how fishing activities and offshore power plants can impact ecosystems, where various components such as marine mammals, seafloor habitats, and seabirds



are used as impact indicators (Loiseau et al., 2021). The role of stakeholders, including government, academia, and industry, is crucial in the implementation of the CIA. Scientists contribute to the development of impact models, while regulators and industry use the CIA's results to determine policies or develop appropriate mitigation measures to reduce pressure on the environment (Antwi et al., 2023). The impact and results of the application of this theory can be seen in improving the accuracy of environmental management. The CIA allows for more ecosystem-based and data-driven management in developing more effective mitigation strategies to reduce overall environmental impacts. For example, the application of the CIA to ocean policy in Sweden shows the potential to reduce cumulative negative impacts by integrating environmental values in marine spatial planning decision-making (Hammar et al., 2020). With the CIA's approach, environmental management can better understand and manage the impacts of various human activities, thereby creating a more controlled and sustainable environmental impact.

CIA has various advantages in supporting data-based environmental management. The CIA allows for the identification of long-term impacts and indirect impacts of interconnected projects, as shown by a study on coral reefs on Moorea Island, where the CIA's analysis revealed significant impacts of land-based activities on previously under-detected marine ecosystems (Loiseau et al., 2021). Additionally, the CIA can cover a wide range of environmental parameters, such as exposure, ecosystem sensitivity, and vulnerability, which are important in ecosystem-based marine spatial planning to integrate impacts from different sectors holistically (Jonsson et al., 2021). However, the CIA faces complex process challenges and requires comprehensive data and multi-stakeholder participation. Studies in the United Kingdom show that the CIA often relies on assumptions that can obscure the validity of the results, especially if the required data is insufficient or the methods used are less accurate (Stockbridge et al., 2021). In addition, the results of the CIA analysis can be greatly influenced by changes in external conditions, such as climate change or increased human activity, which requires a dynamic approach to maintain the relevance of the results over time (Moldoveanu et al., 2023). As a result, intensive data collection is time-consuming and costly, especially to map impacts across regions and sectors, as seen in international studies on marine ecosystems and land use (Choi et al., 2021). Overall, while it requires a significant commitment in terms of resources and cross-sector collaboration, the CIA provides a more solid foundation for directing sustainable, evidence-based decisions for long-term environmental management.

Table 8.1. highlights its implementation and details some of the CIA's implementations in various sectors. These studies demonstrate the CIA's critical role in more holistic and evidence-based ecosystem-based planning, while illustrating emerging challenges related to process complexity, extensive data needs, and the cost and time required.

Table 8.1. Implementation of the CIA in various sectors

| Context                                                                              | Description of CIA Utilization.                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ecosystem-Based Marine Management (Hammar et al., 2020)                              | The CIA is used for marine spatial planning in Sweden by considering the cumulative impact of human activities on marine ecosystems. This approach supports more holistic decisions regarding ocean activities and impacts on ecosystems, with projections of environmental scenarios in the North Sea and Baltic Sea.    |
| Coral Reef Management (Loiseau et al., 2021)(Loiseau et al., 2021)                   | The CIA applied to a coral reef in Moorea, French Polynesia, to assess the cumulative stress of various land and sea activities. The results show the need to consider land-based activities in marine management plans.                                                                                                  |
| Evaluation of Collective Pressure in the European Union (Kirkfeldt & Andersen, 2021) | In the European Union's marine planning, the CIA is implemented to address collective pressure and ensure a good environmental status. The evaluation was carried out to minimize the impact sourced from sea and land interactions throughout European waters.                                                           |
| Offshore Energy Management in Australia (Miller, 2023)                               | The CIA is used in Australia's energy transition to evaluate the cumulative impact of offshore energy development. This analysis demonstrates the importance of standard CIA methods in ensuring environmental sustainability in the ever-growing marine energy sector.                                                   |
| Fisheries and Energy Management in the North Sea (Piet et al., 2021)                 | The CIA is applied with a quantitative method to outline the risk components of offshore fisheries and wind farms in the North Sea. These assessments support more accurate decision-making regarding impacts on marine mammals, seafloor habitats, and seabirds.                                                         |
| Monitoring the Health of Marine Ecosystems in South Korea (Choi et al., 2021)        | The CIA was used in a study of the Gyeonggi Bay area, South Korea, to assess the impact of human activities such as fisheries and marine construction. The CIA's results help ecosystem-based planning aimed at reducing the high cumulative impact on local marine ecosystems.                                           |
| River Water Quality Management in Romania (Moldoveanu et al., 2023)                  | The CIA was applied to assess the cumulative impact on the river system of post-construction projects, especially in relation to water flows and hydropower plant activities. This implementation helps determine the level of impact on the entire river ecosystem and guides sustainable water infrastructure planning. |

Source: author search, 2024

The CIA has an important role in detecting the cumulative impact of various projects and human activities on ecosystems. The CIA provides a holistic view of the long-term and indirect impacts, as seen in the study of ecosystem-based ocean management in Sweden as well as coral reef management in Moorea. This shows that the CIA is effective in identifying environmental pressures that may not be detected in the assessment of individual projects. In addition, table 8.1 shows that CIA can be applied in sectors such as energy, fisheries, marine area management, and water quality, both on a local and national or regional scale, such as in marine spatial planning in the European Union and the energy transition in Australia. This confirms that the CIA has high flexibility to adapt to the specific needs of a sector or region to support sustainable planning. However, there are challenges in the implementation of the CIA, namely the need for comprehensive data and cross-sector cooperation. For the CIA's results to be accurate, detailed data and active involvement from various stakeholders are needed. The studies listed in the table show that these challenges

are often obstacles that must be overcome, especially in major projects such as ocean planning, offshore energy, and river water quality management. Nonetheless, the CIA's benefits in supporting evidence-based decision-making are significant. By considering the cumulative impact, the CIA helps policymakers make wiser decisions regarding ecosystem sustainability, as demonstrated in the case of the energy transition in Australia where the CIA was used to understand the cumulative impact of offshore energy activities. Overall, table 8.1. shows that the CIA is an effective tool to support sustainable ecosystem management. Through the identification of critical pressure points on ecosystems, the CIA helps policymakers understand how various human activities can impact ecosystems in the future, allowing for more preventive and environmentally sustainability-oriented planning. These results confirm that while the CIA demands a significant investment of time, data, and collaboration, this approach provides a strong scientific foundation for responsible and sustainable environmental policy.

Referring to chapters 3 and 4, the CIA approach can be applied in the analysis of regional needs for BUMDs in Wajo Regency through mapping the potential and impact of various activities that will be provided by BUMDs, such as in environmental planning and policy. Cumulative Impact Analysis in Marine Area Planning–In French Polynesia, the CIA applied coral reefs to identify impacts from closely related land and marine activities. This approach shows that a focus on the interaction of different sectors can uncover sources of cumulative impacts that are not seen if only one project is analyzed. In the context of BUMD, this approach can be used to assess how different types of services and projects can have a cumulative impact on the community and the surrounding environment (Loiseau et al., 2021). Evaluation of Methodologies for Regional Policy–In the context of the United States, studies of cumulative impacts in environmental policy show that a comprehensive assessment of existing and future impacts helps shape policies that are responsive to social and environmental change. The CIA at this policy level is in line with the BUMD's goal of identifying and managing long-term public service impacts, which also needs to include a collaborative approach and cross-sector data (Mccold & Saulsbury, 1996).

CIA in the local needs for Regionally-Owned Enterprises (namely BUMDs) can provide a deep understanding of the cumulative impacts of planned projects, ensuring that interrelated social, economic, and environmental impacts can be identified and managed more effectively. In the context of assessing the needs of BUMD, the CIA approach can play an important role in identifying the potential of business sectors that take into account aspects of sustainability, public interest, and the use of local resources. Based on CIA studies in various regions, comprehensive data integration from various sectors is needed so that decisions related to economic, social, and environmental impacts can be made holistically and support the sustainability of local economies. For example, in a CIA assessment conducted in Jilin Province, China,

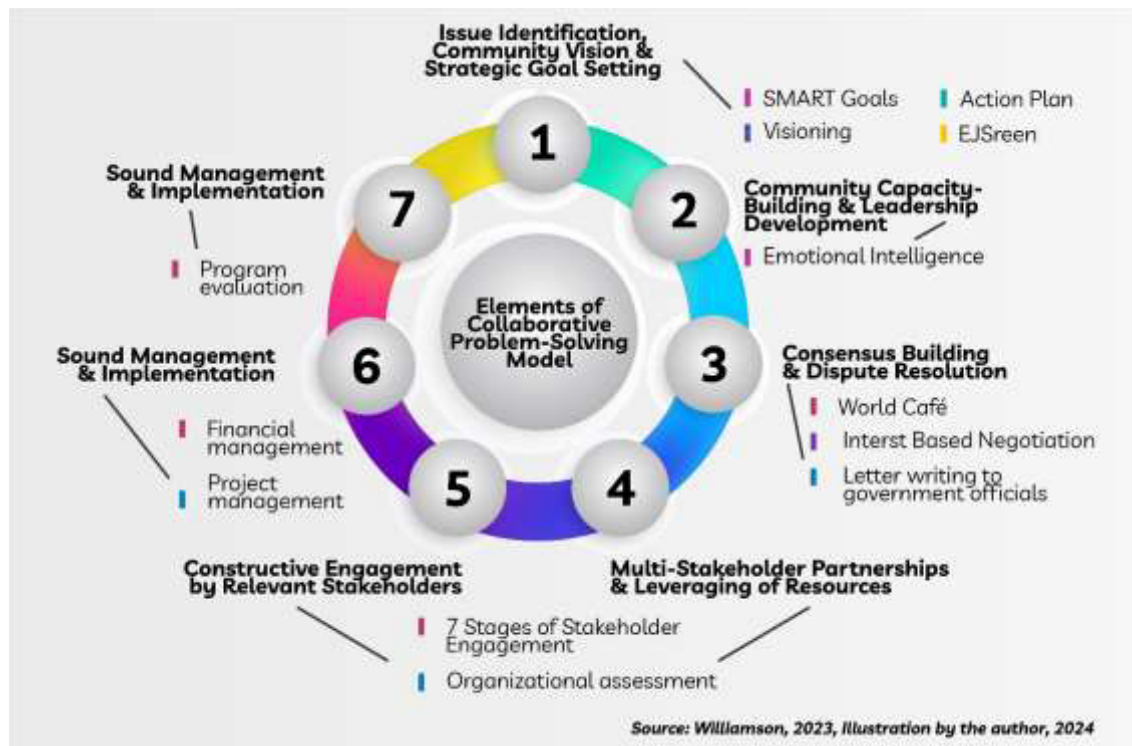
this approach was proven to be able to link the economic value of forest ecosystem services to environmental protection efforts, through comprehensive data analysis and cumulative evaluation of the impact of ecosystem services. In another study, the CIA's application of coral reefs in Moorea, French Polynesia, showed that a focus on ecosystem-based management aids in mapping the cumulative impacts of various human activities and provides important insights for sustainable marine spatial planning (Loiseau et al., 2021).

The CIA's approach is also reinforced by a scenario-based method in Sweden that allows for the projection of environmental impacts of various planning alternatives on marine space management, thus highlighting the importance of considering the collective pressures of various projects on a large area scale (Hammar et al., 2020). In the context of BUMD, this means that strategic decisions must take into account long-term impacts and are interdisciplinary, as data from various sectors, such as environmental, social, and economic, can help regions to make policies that support the sustainable management of local resources. Through the implementation of the CIA, local governments can not only evaluate the cumulative impact of local business initiatives, but also integrate sustainability aspects that support the improvement of Local Original Income (PAD) and the well-being of local communities, with a strong foundation in cross-sector collaboration and the use of accurate data for long-term impact assessment.

### **8.3. Environmental justice theory**

The theory of environmental justice emerged in response to the inequality of environmental impacts experienced by vulnerable groups. This awareness developed from social movements in the United States in the 1980s, mainly through the protests of African-American communities facing pollution from toxic waste dumps and hazardous facilities in their neighborhoods (Mitchell, 2011). Moving from here, the concept of environmental justice extends to various aspects of social, economic, and health inequalities, involving activists, researchers, and public policy to prioritize the equitable distribution of environmental risks and resources (Temper, 2019). Descriptively, environmental justice refers to the fair distribution of environmental benefits and burdens as well as inclusion in environmental decision-making. This theory looks at distributive justice (sharing of risks and benefits), procedural justice (participation in decisions), and recognition of historically marginalized communities (de Kleyne & Ryan, 2018). Environmental justice models often utilize risk analysis approaches that focus on the spread of pollution and access to green spaces. One of the key models is the use of GIS to map the distribution of environmental risks in spatially vulnerable areas, as applied to environmental justice studies in four major economic zones in China (He et al., 2019). The implementation of this theory is also seen in the Collaborative Problem-Solving Model approach from the U.S.

Environmental Protection Agency (EPA) which prioritizes collaboration between stakeholders to address environmental justice issues directly in the community (Williamson et al., 2023). The pioneers of this theory include a wide range of experts and activists, with significant contributions from Dr. Robert Bullard, who is often referred to as the Father of Environmental Justice for his research documenting the unequal impact of the environment on minority groups. Bullard's thinking encouraged the widespread acceptance of this theory as a cornerstone in environmental studies and public policy.



Gambar 8.2. Collaborative Problem-Solving Model

Figure 8.2. featuring the Collaborative Problem-Solving Model developed by the United States EPA. The model is designed to support communities in addressing environmental and social issues collaboratively, by involving stakeholders from various sectors. The model consists of seven main elements that include structured steps in the problem-solving process, with the goal of achieving sustainable and inclusive outcomes. The first stage is Issue Identification, Community Vision, and Strategic Goal Setting, where the community identifies the main issues that it wants to solve, forms a common vision, and sets strategic goals using approaches such as SMART Goals, Visioning, and Action Plan. This process helps ensure all stakeholders have the same understanding of the goals to be achieved. The next stage, Community Capacity Building and Leadership, focuses on building community capacity through the development of emotional intelligence and leadership skills, which are essential for managing conflict and supporting effective collaboration. Research shows that

strong leadership capacity at the community level helps to increase resilience in the face of complex challenges. Consensus Building and Dispute Resolution is the third element, which uses techniques such as World Café and Interest-Based Negotiation to bring together various interests and build consensus between stakeholders. This consensus-based approach has been proven to reduce conflicts and improve the quality of decision-making in the context of environmental and social collaboration. In the fourth stage, Cross-Stakeholder Partnerships and Resource Mobilization, communities collaborate with various parties to mobilize the resources needed to achieve goals. This cross-stakeholder collaboration strengthens support in the implementation of community-driven programs, especially in environmental projects that require a lot of resources and multi-sector involvement. The next stage is Constructive Engagement with Relevant Stakeholders, which involves a seven Stages of Stakeholder Engagement approach to ensure all stakeholders are actively involved in each stage of the project. This active participation of stakeholders is important in improving the successful implementation of programs that focus on complex environmental issues. Financial and project management in the sixth stage emphasizes the importance of effective financial and project management so that resources are used optimally and transparently. Good management ensures the smooth implementation of the program and increases accountability in community projects. Finally, a Program Evaluation and Sustainable Implementation is conducted to assess the effectiveness and impact of the interventions carried out. This continuous evaluation allows for the adaptation of strategies based on the results achieved, so that the program can continue sustainably and have a long-term positive impact. The EPA's Collaborative Problem-Solving Model provides a systematic and comprehensive framework for communities to address complex environmental and social issues, facilitate cross-sectoral cooperation, and support the achievement of sustainable outcomes.

Table 8.2. summarizes the practices of implementing the Collaborative Problem-Solving Model (CPS) developed by the U.S. EPA. The model is designed to support communities in identifying and resolving environmental issues through a collaborative approach that involves a wide range of stakeholders, such as governments, non-profit organizations, academics, and the community. CPS focuses on the active participation of the community to ensure that the resulting solutions are relevant, contextual, and sustainable. The CPS developed by EPA shows effectiveness in various aspects of handling environmental problems. First, this model has succeeded in strengthening community involvement in the process of identifying and solving environmental problems. By engaging communities directly, EPA helps them understand and identify specific issues in their communities, such as water quality or air pollution, so that people become more aware of their own environmental conditions and are encouraged to be active in solving these problems (Patton, 2015).

Table 8.2. CPS Model CPS implementation practices

| It | Praktik CPS Model                                                                   | Description.                                                                                                                                                                                                                             |
|----|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Identification of Local Environmental Problems (Patton, 2015)                       | EPA encourages people to recognize specific environmental issues in their communities, such as water quality or air pollution. This increases local awareness and triggers contextual solutions.                                         |
| 2  | Continuous Learning and Adaptation (Franco-Trigo et al., 2020)                      | The community and EPA reflect and adjust the approach taken, by adjusting strategies based on the results of evaluation and feedback.                                                                                                    |
| 3  | CPS Model for Environmental Justice (Williamson et al., 2023)                       | An evaluation of the collaborative model of the Environmental Justice Academy by the EPA showed that participants were able to apply a community-based approach in solving environmental health and justice issues in their communities. |
| 4  | STEM Models in Environmental Education (Alkair et al., 2023)(Alkair et al., 2023)   | A collaborative approach in STEM programs for elementary school students improves students' understanding of environmental issues and strengthens their collaborative attitudes.                                                         |
| 5  | Collaborative Learning to Improve Environmental Sensitivity (Zuhriyah et al., 2020) | Using a collaborative learning model with a problem-solving approach, students showed increased sensitivity to environmental issues compared to conventional learning methods.                                                           |
| 6  | Collaboration and Independent Learning Skills (Mulyani, 2022)                       | The creative problem-solving model improves students' collaboration and independent learning skills in understanding environmental change issues.                                                                                        |
| 7  | CPS in Engineering Design Tasks (Herro et al., 2021)                                | In engineering students, the CPS model helps build trust in multidisciplinary teams and leverage shared expertise to complete design tasks.                                                                                              |

Source: author search, 2024

This step is particularly effective because the resulting solution becomes more relevant to the local context and needs, compared to the often less relevant top-down approach. Second, cross-sector partnerships initiated through the CPS model have a significant impact on the sustainability of environmental solutions. By building a network between communities, nonprofits, governments, and educational institutions, EPA is able to create stronger and more comprehensive structural support for addressing environmental challenges. In the context of education, the CPS model has proven to be effective in building awareness and collaborative skills among students. The implementation of CPS in environmental and STEM education shows an increase in students' understanding of environmental issues as well as strengthening their ability to work collaboratively in solving problems (Alkair et al., 2023; Zuhriyah et al., 2020). This shows that the CPS model has great potential in creating a generation that cares more about the environment and is ready to contribute to environmental conservation in the future. Even in the context of engineering education, CPS helps students develop confidence in working in multidisciplinary teams, where they can combine their respective expertise to achieve a common goal (Herro et al., 2021). Overall, the EPA's application of the CPS Model shows that this approach is not only effective in addressing environmental issues but also in building the capacity of communities and individuals to collaborate in the long-term. This model proves that solving environmental problems requires a holistic

approach that involves various stakeholders and considers sustainable adaptation. CPS, with all its flexibility, presents an innovative and comprehensive way of supporting environmental justice and sustainability.

Chapter 3 of this book is closely related to the results of the implementation of the CPS model by EPA in several aspects, especially in terms of collaborative approaches to achieve development goals and sustainable resource management. In this feasibility study, the analysis of regional needs underscores the urgency of establishing an Energy BUMD in Riau Islands Province for the management of a 10% Participating Interest (PI) in oil and gas fields, which reflects an important aspect of CPS, namely building cross-stakeholder partnerships to encourage local economic independence through the utilization of available energy potential. The collaborative approach is seen in the recommendation for the establishment of this BUMD as a strategic step to utilize local resources, which is in line with CPS's goal of empowering local communities and governments to actively participate in resource management. In addition, this document emphasizes the importance of analyzing public needs, evaluating economic impacts, and contributing to community well-being, reflecting the CPS principles in ensuring that the implemented solutions are relevant, adaptive, and have a positive impact on the wider community. Overall, the approach outlined in this document is in line with the principles of CPS, where partnerships between local governments, SKK Migas, and local oil and gas contractors lead to comprehensive and inclusive solutions for natural resource management, as well as support the improvement of Regional Original Revenue (PAD) and community welfare through active participation and sustainable economic benefits for the region.

#### **8.4. Systemic risk analysis theory**

Systemic risk analysis theory is a framework that seeks to understand the potential risks in a system as a whole to prevent or manage impacts that may arise on other elements of the system. This analysis is widely applied in the financial and banking industries to assess the impact of interdependence in interrelated financial institutions, as well as in other sectors that have a high level of interdependence. The implementation of this theory generally involves the use of mathematical models and simulations that consider various scenarios to anticipate events that may exacerbate systemic conditions, such as the use of the Monte Carlo method and other scenario analyses (Saputra et al., 2021). This theory developed from the experience of the global financial crisis in 2008, which showed the importance of understanding collective risk that is invisible if it focuses only on individuals or a single component in the system. In this regard, organizations such as central banks and financial institutions play an important role in the application of this analysis to maintain financial stability and mitigate the impact of potential systemic crises. Regulatory bodies such as the Basel Committee and other organizations have promoted the



application of systemic risk analysis as part of an integrated risk management policy in the global financial system since the early 2010s (Murtadho & Wahid, 2016). In its implementation, obstacles such as differences in regulatory standards between countries and limited data are often the main challenges. In addition, the technological sophistication required for risk modeling requires constant adjustments, especially in terms of infrastructure and human resource readiness (Saputra et al., 2021). The theory and practice of systemic risk analysis is recognized as an important foundation for minimizing potential losses due to interdependence in complex systems, especially in industries that have the potential to have a wide impact on the global economy.

In the application of systemic risk analysis theory, there are several important parameters used to measure and manage these risks, including:

1. Interconnectedness coefficient or inter-system correlation, this parameter is used to measure how interconnected entities are within a system and how the impact of one entity can spread to other entities, which is often monitored using complex network methods and correlation analysis on stock index data or other financial parameters. The study found that a high degree of correlation increases the potential systemic risk when external shocks occur (Chen et al., 2020).
2. Measurement of Systemic Expected Shortfall (SES) risk, SES is a parameter that measures the vulnerability of a system to potential collective capital shortfalls, which relies on the leverage of each institution and their expected losses in the worst-case scenario. This parameter is particularly useful for risk assessment in financial crises, such as the 2008 crisis, where the SES helps predict the most vulnerable institutions (Acharya et al., 2010).
3. Conditional distribution using the copula model, this method allows for more accurate risk evaluation through multivariate distributions that consider non-linear relationships between entities. Using copulas, individual risks can be mapped to systemic risks, providing a more integrated picture of interdependencies in highly connected systems (Hochrainer-Stigler et al., 2018).
4. Dynamic model of systemic networks, dynamic network modeling, which evaluates connections between financial entities and changes in their relationships over time, allows for more real-time monitoring and prediction of risks. This model, adapted from the risk credit and social network models, takes into account all institutions in the system as well as the changes in risk posed by each inter-entity connection (Das et al., 2019).

The use of these various parameters in systemic risk analysis provides a more detailed and thorough picture of potential vulnerabilities in the system, which helps in risk mitigation and better decision-making in financial management with its advantages and disadvantages, as presented in table 8.3.

Table 8.3. Advantages and disadvantages

| Aspects                               | Superiority.                                                                                                                                                | Debilitation.                                                                                                         |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Risk Prediction Accuracy              | Early identification of high risk, allowing for faster mitigation (Acharya et al., 2010).                                                                   | Relying on high-quality financial data is sometimes difficult to obtain, especially in cross-country analysis.        |
| A Comprehensive Multivariate Approach | Able to capture non-linear dependencies between entities with copulas, useful in systems with complex interconnectedness (Hochrainer-Stigler et al., 2018). | It requires intensive computing and expert knowledge, as well as infrastructure that small institutions may not have. |
| Real-Time Dynamic Network Monitoring  | Dynamic network modeling allows real-time monitoring of risk in the modern financial system (Das et al., 2019).                                             | The risk of errors in the assumption model can lead to less accurate results and the risk of errors in mitigation.    |

Source: author search, 2024

Public health practices around oil and gas work areas include several important steps in mitigating environmental impacts and protecting the health of workers and the community. One of the key practices is environmental health risk assessment, which includes air and water quality monitoring to detect potential exposure to hazardous substances for workers and nearby residents, such as pollutants and chemical contaminants in oil extraction areas (Suleimanov et al., 2020). In addition, monitoring the health of workers is indispensable, including the implementation of intervention programs that identify environmental risks, such as water quality for adequate consumption, as poor sanitation conditions can lead to infections or chronic diseases among workers (Oliveira et al., 2020). Another prominent practice is the management of workers' mental and physical safety, especially in remote or offshore work environments. The implementation of "mental hygiene" and the development of mental health for workers aims to reduce stress and anxiety that have the potential to interfere with their performance and psychological well-being, which often increases due to high work pressure and isolation at work away from family (Khalid et al., 2022). In addition, in pandemic conditions such as COVID-19, a humane health approach is also applied through training on compliance with health protocols that encourage worker safety in the oil and gas environment (Rohmah & Cahyani, 2022). These practices highlight the importance of collaboration between oil and gas companies, workers, and the community in building a safe and healthy work environment, as well as reducing the negative impact of oil and gas activities on public health around the work area.

### 8.5. Evidence-based assessment theory

The implementation of evidence-based assessment theory in public health in oil and gas work areas focus on analyzing health risks due to exposure of the oil and gas industry to the surrounding community. This theory is applied through systematic assessment and continuous monitoring to identify health risks from pollutants and hazardous working conditions around oil and gas extraction areas (Suleimanov et al., 2020). In the context of public health, an evidence-based approach is needed to

address the health impacts of exposure to environmental pollutants, reduce the risk of chronic disease, and optimize public health interventions. Evidence-based assessments in oil and gas working areas are important because these areas tend to have high levels of pollution and can increase the risk of respiratory diseases, cancer, and other health problems for nearby residents (Bamber et al., 2019). In its implementation, the main actors who play a role include the government, the oil and gas industry, and the public health community who work together to conduct a Health Impact Assessment (HIA) to understand the direct and indirect impacts on public health (Wernham, 2007). This approach has begun to evolve rapidly since the last decade when awareness of the importance of public health and the demand for more responsible industrial practices increased. Evidence-based analysis allows for the identification of exposure pathways, monitoring of health effects, and the formulation of targeted intervention policies, such as emission reduction and improvement of work standards to reduce the negative impact of the industry on the surrounding community (Morgan et al., 2016).

In the context of public health in oil and gas work areas, several key parameters are used to measure risks and impacts on health. These parameters include air quality, especially those related to pollutants such as volatile organic compounds (VOCs) that can trigger respiratory and neurological health problems due to long-term exposure (Holder et al., 2019). In addition, the quality of water around the extraction site is also a concern because contaminated water can cause acute and chronic diseases in the surrounding community (de Oliveira Bredariol, 2020). Psychophysical impacts, including the level of physical and mental fatigue due to exposure to the industrial environment, are also important parameters in the evaluation of public health in oil and gas areas. Studies show that long-term exposure to an unfavorable environment can increase the risk of psychosomatic illness as well as mental problems such as depression and anxiety (Bashbaeva et al., 2020). On the other hand, the evaluation of the humoral immunity of the population, including the level of immunoglobulin in the blood, is an important indicator to see the impact of air pollutants on the immune system of residents around oil and gas facilities (Kryazhev et al., 2022). These parameters help in identifying the health risks of oil and gas operations and formulating the necessary interventions to protect public health in this industrial area. The advantages and disadvantages of the evidence-based assessment (EBA) theory are presented in table 8.5.

The implementation of EBA is widely used in various practices to improve the accuracy and quality of decisions in the clinical, educational, and psychological sectors. For example, in clinical psychology, EBA is used to evaluate mental states by using empirical data to assess the accuracy of diagnosis and determine the appropriate treatment according to the patient's individual characteristics (Bornstein, 2017). In the field of special education, EBA is applied in the preparation of evidence-

based learning evaluation tools that integrate the principles of cognitive theory, item response theory, and assessment methodologies developed to understand student performance more objectively (Talbot et al., 2023). In addition, in the public health sector, the EBA assists in the preparation of health risk assessments to identify the potential effects of environmental factors on the population, especially in areas exposed to pollution or hazardous industrial activities. This evidence-based approach is used to generate data that can guide more appropriate and responsive public health policies (Dunet et al., 2013). With the EBA approach, assessments become more transparent and consistent, resulting in decisions that are data-driven and relevant to the specific needs of a population or individual. A study by (Suleimanov et al., 2020) revealed that oil extraction activities are a major source of pollution affecting the health of surrounding communities, including an increased risk of respiratory distress and chronic health problems. Other studies also highlight the importance of environmental health impact assessments that link air and water contamination data to long-term health effects on surrounding communities (Deziel et al., 2020). Methods such as HIA are used to identify the health impacts of oil and gas activities that include exposure to air pollution during extraction and processing activities, which often increase the risk of asthma, premature birth, and various other diseases among the surrounding population (E. Hill & Ma, 2021). Overall, these practices allow for more accurate health monitoring and evidence-based public health policies to protect communities around oil and gas working areas.

Table 8.4. Advantages and disadvantages of EBA theory

| Superiority.                                                                                                                                                                                                      | Debilitation.                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| High Accuracy in Decision-Making: EBA improves accuracy in clinical and educational decisions by using relevant and valid data (Hunsley & Mash, 2007).                                                            | Requires Large Resources: EBA requires time, specialized training, and large resources for data collection and analysis, which can hinder its use in environments with limited resources (Neumann et al., 2021).               |
| Transparency and Consistency: The EBA supports transparent and consistent evaluation standards, minimizing bias in the evaluation process (Bornstein, 2017).                                                      | Difficulties in Practice: Practitioners can have difficulty implementing strict procedures, especially when they are unfamiliar with evidence-based methods or face rejection from service users (Jensen-Doss & Hawley, 2010). |
| Support for Informed Decisions: EBA assists practitioners in making decisions based on concrete evidence relevant to the needs of individual clients, increasing confidence in evaluation results (McFall, 2005). | Technical Demands and Methodological Complexity: Requires a deep understanding of measurement methods that can be complicated, such as a deeper understanding of psychometrics (Hunsley & Mash, 2007).                         |
| Encourages High Professional Standards: The use of EBAs can improve standards of practice in areas such as education, health, and psychology, by facilitating clinically relevant research (Joshi et al., 2019).  | Resistance to Practice Change: Some practitioners show resistance to EBA adoption due to the perception that this approach is too mechanical or less flexible (Daniel et al., 2019).                                           |

Source: author search, 2024

From the implementation of EBA in oil and gas work areas, several important lessons can be learned related to public health in this area. First, the EBA shows that

oil and gas extraction activities are a major source of pollution that affects public health, such as an increased risk of respiratory diseases, asthma, and other chronic diseases arising from exposure to VOCs and other industrial pollutants ((Suleimanov et al., 2020). Second, the HIA method applied in this context highlights the importance of using air and water contamination data to estimate long-term health impacts, such as the risk of premature birth and cardiovascular disease among residents around oil and gas facilities (Deziel et al., 2020). These results show that continuous monitoring and transparent data can help in formulating responsive and evidence-based public health policies. Third, the implementation of EBA in this sector emphasizes that evidence-based health risk assessments are critical to identifying exposure pathways and key risk factors. This allows for more specific prevention and mitigation measures to reduce the health impacts of industrial exposure on surrounding communities (E. Hill & Ma, 2021). EBA in oil and gas working areas provides an in-depth understanding of the importance of data-backed risk analysis as a basis for safer and adaptive policy-making for public health in environments that are vulnerable to industrial impacts.

### **8.6. Public health around oil and gas work areas**

The model and implementation of public health around oil and gas work areas can be explained through several key theoretical approaches, such as cumulative environmental impacts, environmental justice, systemic risk analysis, and evidence-based assessments. Each of these approaches has different implications for health and environmental management around oil and gas exploration areas.

The cumulative environmental impact approach considers the combined effects of various environmental risk factors. A study by (Miller, 2023) shows that the implementation of the CIA is essential to evaluate sustainable impacts on the environment in industrial areas, including oil and gas, and provide a systematic approach to managing impacts in areas with diverse activities such as in the offshore energy sector. Modeling and implementation of cumulative environmental impacts on public health in oil and gas working areas requires a thorough risk assessment that includes the environmental, social, and health aspects of continuous exposure to various pollutants and industrial activities. Several recent studies underscore the approach and application of CIAs and their implications for public health.

The cumulative impact of environmental pollutants in oil and gas work areas increase the risk to public health, especially for communities close to industrial sites. A study by (Johnston & Cushing, 2020) shows that people living near oil and gas industry areas are more susceptible to exposure to harmful chemicals, including heavy metals and PFAS, which can increase the prevalence of respiratory diseases and other health problems due to exposure to these harmful pollutants. The cumulative environmental impact model applied in Australia highlights the

challenges in designing standardized assessment methods, especially in complex marine environments such as offshore oil and gas. Miller's study proposes the development of a more holistic CIA method, which takes into account the influence of simultaneous activities in industrial areas to reduce negative impacts on ecosystems and public health (Miller, 2023). (C. B. Hill et al., 2021) show the importance of applying a systemic risk model to manage and anticipate the potential health impacts of oil and gas development. This model involves layered surveillance that includes the development, production, and use of new technologies for monitoring, such as drones and big data analysis, to strengthen the early detection of health and environmental risks.

A study by (Viliani & Harris, 2020) noted that although environmental impact assessments (EIAs) are often applied in industrial projects, public health components such as HIA are still poorly integrated. A more comprehensive approach is needed in oil and gas project planning to ensure that health risks to surrounding communities are identified from the outset, so that preventive interventions can be implemented to minimize adverse health impacts. The study in British Columbia used the EnviroScreen approach to identify communities most vulnerable to cumulative impacts in resource-rich regions. This tool helps integrate social and health data to identify populations that are more vulnerable to environmental risks, which can be applied in the context of oil and gas to identify high risk groups (Buse et al., 2022). Cumulative environmental impact models applied to public health in oil and gas regions should combine systemic risk assessment, HIA integration, and the development of a comprehensive CIA framework to mitigate the long-term health risks faced by communities around work areas.

The implementation of public health in the context of oil and gas work areas using the CIA model can be defined as an integrative effort to reduce the health risks that local communities may face due to industrial activities. In the feasibility study document of the Riau Islands Province Oil and Gas Energy BUMD, this implementation is closely related to the analysis of regional needs and strategies to improve community welfare in oil and gas exploration and production areas. To ensure that public health is protected, this document proposes the need for regular monitoring of air, water, and soil quality around oil and gas work areas. This monitoring is carried out to detect early the potential cumulative impact of various pollution sources. The corporate social responsibility (CSR) program in this case can be used to finance public health programs, including free health services for communities around oil and gas locations. Through the partnership mechanism, this BUMD is also required to organize a Partnership and Community Development Program (called PKBL) that focuses on improving public health. These programs include health education, increased access to medical facilities, and campaigns for healthy lifestyles to reduce diseases caused by pollution and the oil and gas work

environment. The implementation of this PKBL is aimed at providing direct benefits to the local community, including health assistance for workers and families affected by oil and gas activities. Public welfare and health can also be improved through economic support. The establishment of this BUMD aims to create new jobs for local residents, which ultimately improves living standards and lowers the unemployment rate in the region. This approach strengthens the social and mental health of local communities, with the hope that economic stability can reduce social tensions and poverty-related health risks. With a PI of 10%, the profits generated by BUMD are expected to support health services at the regional level, which includes the development of health infrastructure and the provision of medical services for the community in oil and gas work areas. This will contribute to the sustainability of overall public health by allocating PAD for health. This implementation model places public health as an important aspect in the management of cumulative environmental impacts, by ensuring that every element of oil and gas activities supports the sustainable improvement of the welfare and health of local communities.

The environmental justice theory highlights the unequal risk exposure among low-income or minority communities living near oil and gas industry sites. (Johnston & Cushing, 2020) point out that these communities often face higher exposures to harmful pollutants compared to other groups, which requires more equitable policies in site-based health risk assessment. The implementation of public health based on environmental justice theory in the context of oil and gas areas, as studied in the feasibility study document of the Riau Islands Energy BUMD, involves several important steps to respond to the unequal exposure of risk in communities close to oil and gas activities. BUMDs that participate in the management of 10% PI in oil and gas areas are required to implement the PKBL. This program aims to provide direct support to communities around oil and gas sites through health education, improved health facilities, and more equitable environmental impact mitigation programs, which will reduce the negative impact of pollution exposure on low-income communities living near oil and gas industry areas. The impact of environmental justice is also reflected in efforts to create jobs for local communities, especially in sectors directly related to oil and gas projects. This step is expected to reduce unbalanced economic dependence and improve the welfare of local communities. This program not only reduces social inequality, but also provides more equitable economic access to groups that are vulnerable to the impact of the oil and gas industry. With revenue from a PI of 10%, BUMD is expected to allocate part of the profits to support health infrastructure and public health programs. These funds can be used to build or improve health facilities and provide free health services for the surrounding community, especially those who are more vulnerable to exposure to oil and gas pollutants. This step is in accordance with the principle of environmental

justice which encourages equal access to health services for all community groups. The implementation of environmental justice in public health also involves education and increasing public awareness of the health impacts of exposure to the oil and gas industry. PKBL, as part of BUMD's obligations, includes educational activities related to health risks and mitigation measures that communities can take to protect themselves. This ensures that information regarding health risks is not only known by elite groups but also reaches the general public, especially those who live close to oil and gas locations. This implementation ensures that communities around oil and gas areas are not only protected from exposure to environmental risks, but also have access to better economic, educational, and healthcare opportunities.

Systemic risk analysis emphasizes the importance of risk management that includes social and environmental elements in an integrated manner. The study of (C. B. Hill et al., 2021) emphasizes a three-tier model that combines digital technologies such as big data and artificial intelligence to improve risk prediction and health management in oil and gas working areas. The implementation of public health based on systemic risk analysis around oil and gas work areas, as described in the Riau Islands Energy BUMD document, includes the integration of digital elements and integrated monitoring to support risk prediction and mitigation. The three-tier approach outlined by (C. B. Hill et al., 2021) provides the basis for using big data technology and artificial intelligence, which allows for real-time analysis of environmental data as well as early detection of pollutants that have the potential to harm public health around the oil and gas industry area. With this approach, BUMDs can leverage sensor-based monitoring technology to identify changes in air, water, and soil quality, enabling rapid mitigation actions against public health threats. As part of CSR, BUMD also has a role in implementing the PKBL, which includes the provision of community-based health services, sustainable environmental monitoring, and the improvement of health facilities for the surrounding community. This implementation not only emphasizes environmental management but also includes direct health support for communities that are vulnerable to the negative impacts of oil and gas activities. The use of big data and artificial intelligence also allows for the development of evidence-based policies to identify potential patterns and risks in the long-term. In this context, models designed to detect environmental changes can provide relevant data for local governments to formulate more responsive and adaptive health strategies. Thus, this implementation supports integrated and holistic health risk management, focusing on prevention and early detection to protect public health in a sustainable manner.

Finally, an evidence-based approach prioritizes the use of accurate scientific data to understand and manage environmental health risks. A study by (Orisakwe, 2021) in the Niger Delta, Nigeria, supports the use of Environmental Medicine Research to produce relevant data in assessing the health impacts of oil and gas



exploration and designing interventions that can improve the environmental and social health of surrounding communities. The implementation of the public health model around the oil and gas working area requires a synergy of approaches that consider cumulative impacts, environmental justice, systemic risk analysis, and evidence-based evaluation to produce sustainable and fair policies for all parties.

### **8.7. Mitigation of health impacts due to oil and gas operations**

Mitigation of health impacts due to oil and gas operations can be optimized with the approach of cumulative environmental impact theory, environmental justice theory, and systemic risk analysis. In the perspective of cumulative environmental impact theory, public health risks from exposure to pollutants such as PM10 in mining activities have been proven to be significant on respiratory distress and the quality of life of surrounding communities. Research in Padang shows that PM10 concentrations that exceed the safe air quality threshold, which can result in serious health problems such as respiratory diseases in the surrounding community, demonstrating the need for strict air quality control in oil and gas operations (Nur et al., 2021). Environmental justice theory emphasizes that the environmental and health impacts of oil and gas activities are often felt by communities with limited access to health services or adequate information about risks. A study of dengue fever homes in endemic areas shows that poor environmental sanitation conditions, such as open-water shelters, are the main triggers for the spread of the disease. This shows that equality in access to information and environmental management is key in mitigating health impacts around oil and gas operations (Yulidar et al., 2021). The systemic risk analysis approach provides a framework for identifying, assessing, and managing health risks due to exposure to chemicals and pollutants in oil and gas activities. This strategy helps in designing risk management systems that can take into account the potential cumulative hazards of various sources, including uncertain whether factors and uncertainties in fish catches affected by oil operations at sea. By making optimal use of weather and environmental information, the health risks faced by fishing communities in the region can be reduced (Yulianti et al., 2020). In order to mitigate the health impacts of oil and gas operations, a multidisciplinary approach that considers systemic risk analysis, environmental justice, and cumulative impacts is needed to protect the health of the communities around oil and gas operations.

In the Final Report of the Wajo Regency BUMD Needs Study, it does not directly discuss the mitigation of health impacts due to oil and gas operations based on the theory of cumulative environmental impacts, the theory of environmental justice, or the theory of systemic risk analysis. The main focus is on the formation of BUMD to improve the local economy, especially in the fields of integrated agriculture, markets, and parking, as well as the potential for regional revenue and improvement of public services. However, the document is indirectly relevant if the BUMD to be formed in

Wajo Regency aims to manage oil and gas assets or participate in oil and gas activities through the 10% PI scheme. In this context, these theories can be applied to ensure that the existence of BUMDs in the oil and gas sector not only increases regional income but also considers environmental health and safety aspects for the surrounding community. The use of cumulative environmental impact theory can help BUMDs in assessing the accumulation of pollution from oil and gas activities, while environmental justice theory ensures a fair distribution of benefits and risks in the region. Systemic risk analysis theory, on the other hand, can be used to proactively predict and manage health risks arising from oil and gas operations.

In the context of the establishment of BUMDs that may be involved in the oil and gas sector, several important steps need to be taken to effectively manage health and environmental impacts by considering the cumulative environmental impact theory, environmental justice theory, and systemic risk analysis theory.

1. Comprehensive CIA, before activities begin, it is important to conduct a cumulative impact assessment to identify potential air, water, and soil pollution from oil and gas activities that may occur continuously. This assessment should include an analysis of long-term environmental and health changes to ensure there is no accumulation of risks detrimental to the community around the operating site.
2. Ensuring Justice in the Distribution of Impacts and Benefits, the application of environmental justice theory is very important to ensure that the economic benefits of oil and gas activities, such as increasing Regional Original Revenue (PAD), are not only enjoyed by certain parties. The distribution of economic benefits, such as access to jobs and health services, as well as the sharing of health risks, needs to be managed so as not to burden vulnerable or low-income communities that may be closer to oil and gas operating areas.
3. Implementation of Systemic Risk Analysis for Continuous Monitoring, using a systemic risk analysis approach, BUMD must monitor risk factors on an ongoing basis and coordinate with local governments and local communities. This involves regular monitoring of air, water, and health quality of nearby residents. This systemic approach also includes preparedness to face the risk of unexpected environmental or health disasters due to oil and gas operations.
4. Community Involvement in Decision-Making, actively involving the community in the planning and decision-making process related to oil and gas operations is very important to get social support and understand the needs of the community. This can be in the form of public consultation forums, group discussions, or the distribution of open and transparent information about the risks and benefits of activities.
5. Transparency and Accountability in the Implementation of Operations, transparency in risk reporting and accountability in managing health impacts must be an integral part of BUMD's oil and gas operations. Providing access for

the public to monitor the results of health and environmental impact measurements will help build trust and ensure compliance with health and safety standards.

These measures help ensure that BUMDs not only pursue economic benefits but also protect the health and well-being of the environment and surrounding communities in a fair and sustainable manner.

## **8.8. Conclusion**

In this Chapter 8, the problems discussed are related to the impact of oil and gas exploration and production on public health and the surrounding environment. The main focus is on exposure to air pollution, declining water quality, and health risks faced by communities living around oil and gas operations. This chapter also includes theories used to understand and mitigate these impacts, such as cumulative environmental impact theory, environmental justice, and systemic risk analysis. This chapter concludes that oil and gas exploration and production carry significant health and environmental risks to surrounding communities, especially through air and water pollution. Mitigation approaches that include strict regulation, the use of clean technologies, and environmental monitoring are needed to mitigate these risks. To minimize health and environmental impacts, this chapter suggests the implementation of strict regulations in waste management and oil and gas emissions, the application of technologies that can reduce pollution, and collaboration between governments, industry, and local communities for regular monitoring of environmental quality. The novelty in this chapter lies in the holistic approach applied through cumulative environmental impact theory and systemic risk analysis. This includes a thorough health impact evaluation that considers various risk factors simultaneously, as well as the application of environmental justice theory that highlights the injustices experienced by vulnerable communities near oil and gas operating areas. This chapter recommends enhancing cross-sector collaboration to develop more effective monitoring methods and to integrate public health as an integral part of oil and gas project planning. Further studies to develop pollution monitoring technologies and evidence-based approaches in public health are also recommended so that they can be widely and effectively applied.

## Reference

- Acharya, V. V., Pedersen, L. H., Philippon, T., & Richardson, M. P. (2010). Measuring Systemic Risk. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.1573171>
- Alkair, S., Ali, R., Abouhashem, A., Aledamat, R., Bhadra, J., Ahmad, Z., Sellami, A., & Al-Thani, N. J. (2023). A STEM model for engaging students in environmental sustainability programs through a problem-solving approach. *Applied Environmental Education and Communication*, 22(1). <https://doi.org/10.1080/1533015X.2023.2179556>
- Antwi, E. K., Boakye-Danquah, J., Owusu-Banahene, W., Dabros, A., Eddy, I. M. S., Silver, D. A., Abolina, E., Eddy, B., & Winder, R. S. (2023). Risk assessment framework for cumulative effects (RAFCE). *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.1055159>
- Apergis, N., Mustafa, G., & Dastidar, S. G. (2021). An analysis of the impact of unconventional oil and gas activities on public health: New evidence across Oklahoma counties. *Energy Economics*, 97. <https://doi.org/10.1016/j.eneco.2021.105223>
- Bamber, A. M., Hasanali, S. H., Nair, A. S., Watkins, S. M., Vigil, D. I., Van Dyke, M., McMullin, T. S., & Richardson, K. (2019). A systematic review of the epidemiologic literature assessing health outcomes in populations living near oil and natural gas operations: Study quality and future recommendations. In *International Journal of Environmental Research and Public Health* (Vol. 16, Issue 12). <https://doi.org/10.3390/ijerph16122123>
- Bashbaeva, M., Zinalieva, A., Umarova, G., Baspakova, A., & Duisenova, A. (2020). Psychophysical aspects of public health in the oil and gas region. *Open Access Macedonian Journal of Medical Sciences*, 8. <https://doi.org/10.3889/oamjms.2020.4542>
- Bonetti, P., Leuz, C., & Michelon, G. (2022). Internalizing Externalities: Disclosure Regulation for Hydraulic Fracturing, Drilling Activity and Water Quality. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4171246>
- Bornstein, R. F. (2017). Evidence-Based Psychological Assessment. In *Journal of Personality Assessment* (Vol. 99, Issue 4). <https://doi.org/10.1080/00223891.2016.1236343>
- Buse, C. G., Bezzola, A., Brubacher, J., Takaro, T. K., Fredeen, A. L., & Parkes, M. W. (2022). Cumulative Impacts of Diverse Land Uses in British Columbia, Canada: Application of the “EnviroScreen” Method. *International Journal of Environmental Research and Public Health*, 19(18). <https://doi.org/10.3390/ijerph191811171>
- Chen, L., Han, Q., Qiao, Z., & Stanley, H. E. (2020). Correlation analysis and systemic risk measurement of regional, financial and global stock indices. *Physica A: Statistical Mechanics and Its Applications*, 542. <https://doi.org/10.1016/j.physa.2019.122653>
- Choi, H. J., Cho, S. J., Hwang, T., Nam, J., & Hwang, C. S. (2021). Cumulative Impact Assessment for Marine Spatial Planning: A Case Study of the Gyeonggi Bay in South Korea. *Journal of Coastal Research*, 114(sp1). <https://doi.org/10.2112/JCR-SI114-073.1>

- Daniel, M., Rencic, J., Durning, S. J., Holmboe, E., Santen, S. A., Lang, V., Ratcliffe, T., Gordon, D., Heist, B., Lubarsky, S., Estrada, C. A., Ballard, T., Artino, A. R., Sergio Da Silva, A., Cleary, T., Stojan, J., & Gruppen, L. D. (2019). Clinical Reasoning Assessment Methods: A Scoping Review and Practical Guidance. In *Academic Medicine* (Vol. 94, Issue 6). <https://doi.org/10.1097/ACM.0000000000002618>
- Das, S. R., Kim, S., & Ostrov, D. N. (2019). Dynamic Systemic Risk: Networks in Data Science. *Journal of Financial Data Science*, 1(1). <https://doi.org/10.3905/jfds.2019.1.1.141>
- de Kleyn, L., & Ryan, M. (2018). Theories of environmental justice. In *Environmental Justice and Land Use Conflict*. <https://doi.org/10.4324/9781315713335-2>
- de Oliveira Bredariol, T. (2020). Developing indicators for environmental licensing the case of the Brazilian offshore oil and gas sector. *Impact Assessment and Project Appraisal*, 38(5). <https://doi.org/10.1080/14615517.2020.1804305>
- Deziel, N. C., Brokovich, E., Grotto, I., Clark, C. J., Barnett-Itzhaki, Z., Broday, D., & Agay-Shay, K. (2020). Unconventional oil and gas development and health outcomes: A scoping review of the epidemiological research. In *Environmental Research* (Vol. 182). <https://doi.org/10.1016/j.envres.2020.109124>
- Dunet, D. O., Losby, J. L., & Tucker-Brown, A. (2013). Using evaluability assessment to support the development of practice-based evidence in public health. *Journal of Public Health Management and Practice*, 19(5). <https://doi.org/10.1097/PHH.0b013e318280014f>
- Stolz, D. , & Griffin, M. (2022). Environmental Impacts from the Development of Unconventional Oil and Gas Reserves. In *Environmental Impacts from the Development of Unconventional Oil and Gas Reserves*. <https://doi.org/10.1017/9781108774178>
- Franco-Trigo, L., Marqués-Sánchez, P., Tudball, J., Benrimoj, S. I., Martínez-Martínez, F., & Sabater-Hernández, D. (2020). Collaborative health service planning: A stakeholder analysis with social network analysis to develop a community pharmacy service. *Research in Social and Administrative Pharmacy*, 16(2). <https://doi.org/10.1016/j.sapharm.2019.05.008>
- Hammar, L., Molander, S., Pålsson, J., Schmidtbauer Crona, J., Carneiro, G., Johansson, T., Hume, D., Kågesten, G., Mattsson, D., Törnqvist, O., Zillén, L., Mattsson, M., Bergström, U., Perry, D., Caldow, C., & Andersen, J. H. (2020). Cumulative impact assessment for ecosystem-based marine spatial planning. *Science of the Total Environment*, 734. <https://doi.org/10.1016/j.scitotenv.2020.139024>
- He, Q., Wang, R., Ji, H., Wei, G., Wang, J., & Liu, J. (2019). Theoretical model of environmental justice and environmental inequality in China's four major economic zones. *Sustainability (Switzerland)*, 11(21). <https://doi.org/10.3390/su11215923>
- Herro, D., McNeese, N., O'Hara, R., Frady, K., & Switzer, D. (2021). Exploring graduate students' collaborative problem-solving in engineering design tasks. *Journal of Engineering Design*, 32(9). <https://doi.org/10.1080/09544828.2021.1922616>
- Hill, C. B., Yadav, O. P., & Khan, E. (2021). Systemic risk analyses for potential impacts of onshore unconventional oil and gas development on public health and the environment: A

- critical review. In *Science of the Total Environment* (Vol. 786). <https://doi.org/10.1016/j.scitotenv.2021.147512>
- Hill, E., & Ma, L. (2021). The fracking concern with water quality. In *Science* (Vol. 373, Issue 6557). <https://doi.org/10.1126/science.abk3433>
- Hochrainer-Stigler, S., Pflug, G., Dieckmann, U., Rovenskaya, E., Thurner, S., Poledna, S., Boza, G., Linnerooth-Bayer, J., & Brännström, Å. (2018). Integrating Systemic Risk and Risk Analysis Using Copulas. *International Journal of Disaster Risk Science*, 9(4). <https://doi.org/10.1007/s13753-018-0198-1>
- Holder, C., Hader, J., Avanası, R., Hong, T., Carr, E., Mendez, B., Wignall, J., Glen, G., Guelden, B., & Wei, Y. (2019). Evaluating potential human health risks from modeled inhalation exposures to volatile organic compounds emitted from oil and gas operations. *Journal of the Air and Waste Management Association*, 69(12). <https://doi.org/10.1080/10962247.2019.1680459>
- Hunsley, J., & Mash, E. J. (2007). Evidence-based assessment. In *Annual Review of Clinical Psychology* (Vol. 3). <https://doi.org/10.1146/annurev.clinpsy.3.022806.091419>
- Jensen-Doss, A., & Hawley, K. M. (2010). Understanding barriers to evidence-based assessment: Clinician attitudes toward standardized assessment tools. *Journal of Clinical Child and Adolescent Psychology*, 39(6). <https://doi.org/10.1080/15374416.2010.517169>
- Johnston, J., & Cushing, L. (2020). Chemical Exposures, Health, and Environmental Justice in Communities Living on the Fenceline of Industry. In *Current environmental health reports* (Vol. 7, Issue 1). <https://doi.org/10.1007/s40572-020-00263-8>
- Jonsson, P. R., Hammar, L., Wåhlström, I., Pålsson, J., Hume, D., Almroth-Rosell, E., & Mattsson, M. (2021). Combining seascape connectivity with cumulative impact assessment in support of ecosystem-based marine spatial planning. *Journal of Applied Ecology*, 58(3). <https://doi.org/10.1111/1365-2664.13813>
- Joshi, V., Parashar, S., & Sharma, P. (2019). *Evidence Based Assessment – Policy, Principle and Practice Perspective*. <https://doi.org/10.33422/worldcre.2019.08.459>
- Khalid, A., Felfernig, M., Purra, A., Ramirez, F. E., Alshamsi, M., & Dwedari, Z. (2022). Shifting Paradigm of Mental Hygiene; A Novel Approach to Mitigate Workers' Distress in Oil and Gas Industry. *Society of Petroleum Engineers - ADIPEC 2022*. <https://doi.org/10.2118/210788-MS>
- Kirkfeldt, T. S., & Andersen, J. H. (2021). Assessment of collective pressure in marine spatial planning: The current approach of EU Member States. *Ocean and Coastal Management*, 203. <https://doi.org/10.1016/j.ocecoaman.2020.105448>
- Kryazhev, D. A., Karpenko, I. L., Barhatova, L. A., & Boev, V. M. (2022). Assessment of humoral immunity and health risk to the population living in the area of oil production facilities influence. *Sanitarnyj Vrač (Sanitary Doctor)*, 7, 500–509. <https://doi.org/10.33920/med-08-2207-07>

- Loiseau, C., Thiault, L., Devillers, R., & Claudet, J. (2021). Cumulative impact assessments highlight the benefits of integrating land-based management with marine spatial planning. *Science of the Total Environment*, 787. <https://doi.org/10.1016/j.scitotenv.2021.147339>
- Martin, C. W., McDonald, A. M., Valentine, J. F., & Roberts, B. J. (2023). Towards relevant ecological experiments and assessments of coastal oil spill effects: Insights from the 2010 Deepwater Horizon oil spill. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.1092097>
- Mccold, L. N., & Saulsbury, J. W. (1996). Including past and present impacts in cumulative impact assessments. In *Environmental Management* (Vol. 20, Issue 5). <https://doi.org/10.1007/BF01204147>
- McFall, R. M. (2005). Theory and utility - Key themes in evidence-based assessment: Comment on the special section. In *Psychological Assessment* (Vol. 17, Issue 3). <https://doi.org/10.1037/1040-3590.17.3.312>
- Miller, A. (2023). Cumulative impact assessments – its relevance for Australia's energy transition. *The APPEA Journal*, 63(2). <https://doi.org/10.1071/aj22072>
- Mitchell, G. (2011). Environmental Justice: An Overview. In *Encyclopedia of Environmental Health, Volume 1-5* (Vol. 2). <https://doi.org/10.1016/B978-0-444-52272-6.00704-2>
- Moldoveanu, M., Stănescu, S. V., & Gălie, A. C. (2023). Post-Construction, Hydromorphological Cumulative Impact Assessment: An Approach at the Waterbody Level Integrating Different Spatial Scales. *Water (Switzerland)*, 15(3). <https://doi.org/10.3390/w15030382>
- Morgan, R. L., Thayer, K. A., Bero, L., Bruce, N., Falck-Ytter, Y., Gherzi, D., Guyatt, G., Hooijmans, C., Langendam, M., Mandrioli, D., Mustafa, R. A., Rehfuss, E. A., Rooney, A. A., Shea, B., Silbergeld, E. K., Sutton, P., Wolfe, M. S., Woodruff, T. J., Verbeek, J. H., ... Schünemann, H. J. (2016). GRADE: Assessing the quality of evidence in environmental and occupational health. *Environment International*, 92–93. <https://doi.org/10.1016/j.envint.2016.01.004>
- Mulyani, A. (2022). Keterampilan Kolaborasi Dan Self-Regulated Learning Peserta Didik: Sebuah Implementasi Model Creative Problem Solving. *Jurnal Bioterdidik: Wahana Ekspresi Ilmiah*, 10(3). <https://doi.org/10.23960/jbt.v10.i3.25795>
- Murtadho, M. A., & Wahid, D. F. (2016). Permasalahan implementasi sistem informasi di perguruan tinggi swasta. *Register: Jurnal Ilmiah Teknologi Sistem Informasi*, 2(1). <https://doi.org/10.26594/register.v2i1.441>
- Neumann, M., Niessen, A. S. M., & Meijer, R. R. (2021). Implementing evidence-based assessment and selection in organizations: A review and an agenda for future research. *Organizational Psychology Review*, 11(3). <https://doi.org/10.1177/2041386620983419>
- Nur, E., Seno, B. A., & Hidayanti, R. (2021). Risiko Gangguan Kesehatan Masyarakat Akibat Paparan PM10 di Kota Padang. *Jurnal Kesehatan Lingkungan Indonesia*, 20(2). <https://doi.org/10.14710/jkli.20.2.97-103>

- Oliveira, G. M., Vidal, D. G., Viterbo, L. M. F., Costa, A. S., & Ferraz, M. P. (2020). Health Monitoring and Intervention Plan on Oil Industry Workers: Results from a Case-Study. In *Studies in Systems, Decision and Control* (Vol. 277). [https://doi.org/10.1007/978-3-030-41486-3\\_29](https://doi.org/10.1007/978-3-030-41486-3_29)
- Orisakwe, O. E. (2021). Crude oil and public health issues in Niger Delta, Nigeria: Much ado about the inevitable. In *Environmental Research* (Vol. 194). <https://doi.org/10.1016/j.envres.2021.110725>
- Patton, M. Q. (2015). The Sociological Roots of Utilization-Focused Evaluation. *American Sociologist*, 46(4). <https://doi.org/10.1007/s12108-015-9275-8>
- Piet, G. J., Tamis, J. E., Volwater, J., de Vries, P., van der Wal, J. T., & Jongbloed, R. H. (2021). A roadmap towards quantitative cumulative impact assessments: Every step of the way. *Science of the Total Environment*, 784. <https://doi.org/10.1016/j.scitotenv.2021.146847>
- Raimi, O. M., Sawyerr, O. H., Ezekwe, C. I., & Salako, G. (2022). Many oil wells, one evil: comprehensive assessment of toxic metals concentration, seasonal variation and human health risk in drinking water quality in areas surrounding crude oil exploration facilities in rivers state, Nigeria. *International Journal of Hydrology*, 6(1). <https://doi.org/10.15406/ijh.2022.06.00299>
- Rohmah, I. Y. A., & Cahyani, D. D. (2022). HUMAN APPROACH IN THE IMPLEMENTING HEALTH PROTOCOLS FOR WORKERS SAFETY IN THE ENGINEERING OF OIL AND GAS INDUSTRY DURING THE PANDEMIC COVID 19. *Journal of Social Political Sciences*, 3(1). <https://doi.org/10.52166/jsps.v3i1.94>
- Saputra, U. R., Suwono, I., & Sholikah, M. (2021). IMPLEMENTASI TEORI SERVQUAL PADA LAYANAN AKADEMIK SATU PINTU. *Efisiensi: Kajian Ilmu Administrasi*, 18(1). <https://doi.org/10.21831/efisiensi.v18i1.32580>
- Scanlon, B. R., Ikonnikova, S., Yang, Q., & Reedy, R. C. (2020). Will Water Issues Constrain Oil and Gas Production in the United States? *Environmental Science and Technology*, 54(6). <https://doi.org/10.1021/acs.est.9b06390>
- Stockbridge, J., Jones, A. R., Gaylard, S. G., Nelson, M. J., & Gillanders, B. M. (2021). Evaluation of a popular spatial cumulative impact assessment method for marine systems: A seagrass case study. *Science of the Total Environment*, 780. <https://doi.org/10.1016/j.scitotenv.2021.146401>
- Suleimanov, R. A., Bakirov, A. B., Gimranova, G. G., & Valeev, T. K. (2020). Hygienic assessment of health risks of the population living in the areas of intensive oil extraction. *Revista Amazonia Investiga*, 9(26). <https://doi.org/10.34069/ai/2020.26.02.11>
- Talbott, E., De Los Reyes, A., Kearns, D. M., Mancilla-Martinez, J., & Wang, M. (2023). Evidence-Based Assessment in Special Education Research: Advancing the Use of Evidence in Assessment Tools and Empirical Processes. *Exceptional Children*, 89(4). <https://doi.org/10.1177/00144029231171092>
- Temper, L. (2019). Environmental Justice: Approaches, Dimensions, and Movements. In *Ecology*. <https://doi.org/10.1093/obo/9780199830060-0209>



- Viliani, F., & Harris, P. (2020). Assessment of health impacts on local communities is fundamental for sustainability. *Society of Petroleum Engineers - SPE International Conference and Exhibition on Health, Safety, Environment, and Sustainability 2020, HSE and Sustainability 2020*. <https://doi.org/10.2118/199487-ms>
- Watterson, A., & Dinan, W. (2020). Lagging and flagging: Air pollution, shale gas exploration and the interaction of policy, science, ethics and environmental justice in England. In *International Journal of Environmental Research and Public Health* (Vol. 17, Issue 12). <https://doi.org/10.3390/ijerph17124320>
- Wernham, A. (2007). Inupiat health and proposed Alaskan oil development: Results of the first integrated health impact assessment/environmental impact statement for proposed oil development on Alaska's north slope (EcoHealth DOI: 10.1007/S10393-007-0132-2). In *EcoHealth* (Vol. 4, Issue 4). <https://doi.org/10.1007/s10393-007-0143-z>
- Williamson, D. H. Z., Good, S., Wilson, D., Jelks, N. O., Johnson, D. A., Komro, K. A., & Kegler, M. C. (2023). Using the Collaborative Problem-Solving Model: Findings from an Evaluation of U.S. EPA's Environmental Justice Academy. *Sustainability*, 15(20). <https://doi.org/10.3390/su152014999>
- Yulianti, F., Sukiyono, K., & Utama, S. P. (2020). MANAJEMEN RISIKO USAHA PENANGKAPAN IKAN LAUT DENGAN ALAT TANGKAP GILLNET DI PULAU BAAI, KOTA BENGKULU. *Buletin Ilmiah Marina Sosial Ekonomi Kelautan Dan Perikanan*, 6(2). <https://doi.org/10.15578/marina.v6i2.8268>
- Yulidar, Y., Maksuk, M., & Priyadi, P. (2021). Kondisi Sanitasi Lingkungan Rumah Penderita Demam Berdarah Dengue (DBD) di Wilayah Kerja Puskesmas. *Jurnal Sanitasi Lingkungan*, 1(1). <https://doi.org/10.36086/salink.v1i1.1105>
- Zuhriyah, A., . I. M. A., & . Y. (2020). Collaborative Learning Model With Problem Solving Approach To Improving Student Environment Sensitivity. *KnE Social Sciences*. <https://doi.org/10.18502/kss.v4i14.7859>



# Health Management Strategies in the Operations of Oil and Gas Regionally-Owned Enterprises

Andi Tenri Awaru, Hasniati

A strategy based on five pillars is able to support the safety, efficiency, and operational sustainability of the Regionally Owned Enterprises (BUMD) oil and gas sector. Local adjustments and technology adoption are key to its successful implementation.

The Occupational Health and Safety (OHS) management strategy in the oil and gas sector shown in the infographic has five main pillars that are supported by various theories and modern scientific approaches. The first pillar, Health and Safety Operational Management, includes the implementation of international standards such as ISO 45001. This standard aims to reduce the risk of accidents and improve safety by implementing a systematic and structured approach. In its implementation, ISO 45001 involves the participation of the entire organization, among other things, top management, to ensure the commitment and integration of OSH practices in all operational processes (SGS, 2021). Risk management in remote or dangerous locations, as the second pillar, uses a Risk-Based Management Approach (RBM) that allows companies to proactively identify and mitigate risks. This approach is especially important given that the oil and gas sector often operates in areas with high potential hazards, such as offshore or remote areas, which requires in-depth risk analysis as well as planned mitigation measures (Doronina & Safonov, 2016).

The third pillar focuses on the promotion and maintenance of worker health through the concept of Total Worker Health (TWH). The Software not only pays attention to the physical health aspect, but also the mental well-being of workers. Interventions such as routine health checkups, counseling programs, and other health promotion activities have proven effective in increasing productivity and reducing worker absenteeism. This pillar emphasizes the importance of holistic well-being for the workforce as part of endeavors to prevent occupational diseases (Balkat & Khaleel, 2021). The fourth pillar, namely waste management and environmental sustainability, uses Environmental Management Systems (EMS) such as ISO 14001. This system is designed to help companies minimize negative impacts on the environment by managing waste safely and complying with strict environmental regulations (Alshaheen, 2021).

The fifth pillar includes risk-based infrastructure maintenance, which aims to improve efficiency through a proactive approach to equipment maintenance. This data-driven maintenance system allows for early identification of potential failures before they occur, thereby minimizing downtime and improving overall operational efficiency ((Doronina & Safonov, 2016). This strategy is reinforced by the theory of High Reliability Organizations (HRO) which emphasizes operational resilience in complex environments as well as the use of Incident Command System (ICS) to ensure effective coordination during emergencies.

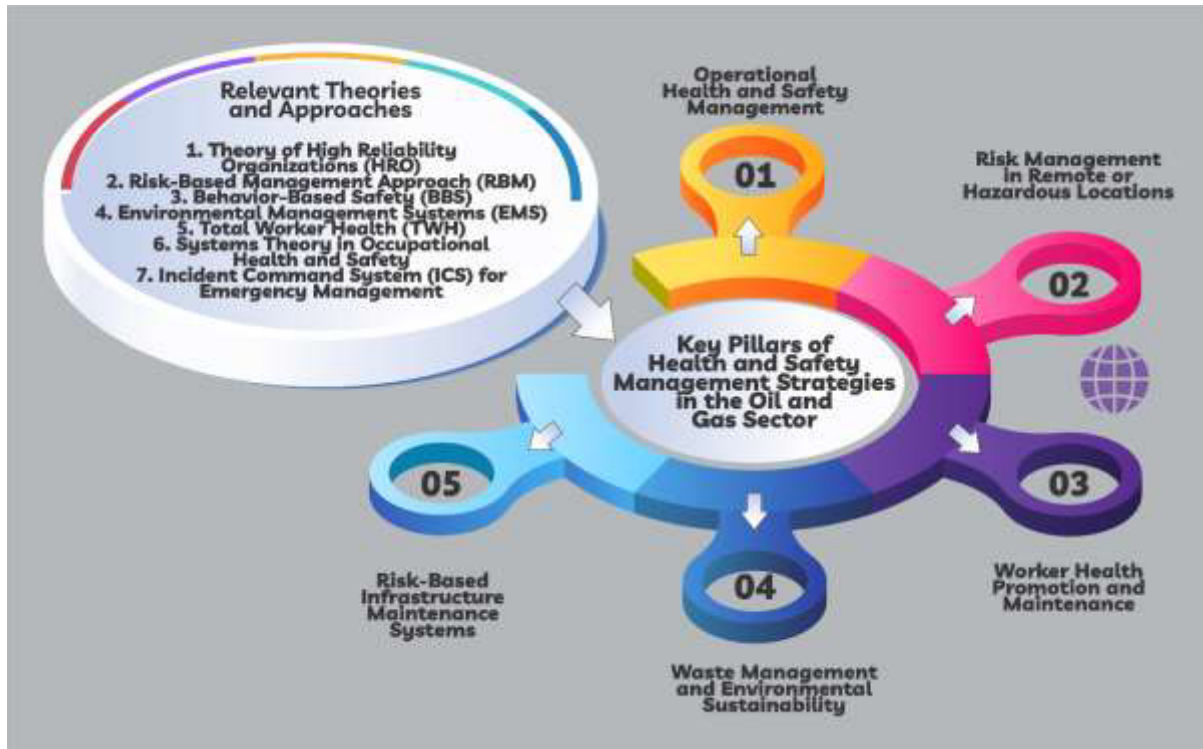


Figure 9.1. Key pillars of health and safety management (OSH) strategies in the oil and gas sector

This integrated approach illustrates the oil and gas sector's endeavors to promote safety and sustainability amid high operational challenges. With effective implementation, a comprehensive OSH strategy can minimize risks, protect workers, and maximize organizational performance.

### 9.1. Health and Safety Operational Management

The first pillar focuses on the implementation of a health and safety management system that operates across the organization. This includes the implementation of international standards such as ISO 45001, which helps to reduce the risk of occupational accidents in a systematic and structured manner. Effective operational management can prevent incidents and promote a safe working environment, especially in complex operations in the oil and gas sector. The implementation of OHS operational management by the ISO 45001 standard in the oil and gas industry can be seen in the implementation carried out by BP (British

Petroleum). As a global company, BP uses the ISO 45001 framework to identify hazards, manage risks and improve OHS practices on an ongoing basis. The first step is to systematically identify hazards across operational facilities, among other things, oil refineries and offshore drilling platforms, using analytics Software to map possible incidents based on historical data. Furthermore, BP developed risk control protocols, such as periodic inspections of critical infrastructure and regular training for workers to improve preparedness for potential incidents. The adopted digital-based incident reporting system allows workers to report risks or incidents quickly, with data analyzed to continuously improve the system. In addition, worker involvement in safety forums is used to discuss risk mitigation measures and health programs, such as stress management and mental health promotion. The implementation of ISO 45001 has succeeded in reducing the rate of worker injuries by 25% in three years and improving compliance with international regulations. This Illustration shows how the ISO 45001 standard can be adopted BUMDs in the oil and gas sector to create a safe and sustainable work environment.

The implementation of OHS (K3) operational management by the ISO 45001 standard has been successfully implemented by various oil and gas companies. For Illustration, Shell implemented the Hazard Identification and Risk Assessment (HIRA) method to identify operational risks, complemented by safety training such as emergency evacuation and the use of personal protective equipment (PPE), which has successfully reduced the rate of occupational accidents by 30% in the last five years. ExxonMobil uses the Operational Integrity Management System (OIMS) Software, among other things, a digital-based incident reporting system and participatory safety audits, to improve operational efficiency and reduce the number of occupational injuries. In Indonesia, Pertamina has integrated ISO 45001 with risk monitoring technologies such as smart sensors to detect gas leaks, as well as emergency response training for employees and contractors, thereby increasing compliance with international OSH standards. Meanwhile, TotalEnergies runs a "Safety at Heart" Software that focuses on changing the safety culture through a global campaign, the integration of ISO 45001 with ISO 14001, as well as the use of wearable devices to monitor the vital condition of workers, which has successfully reduced safety incidents by 20% in two years. ConocoPhillips adopted predictive technology to monitor the condition of critical equipment and used digital training through e-learning to increase workers' awareness of OSH protocols. These examples show that the implementation of ISO 45001 can improve health, safety, and operational efficiency, as well as become a model that can be adapted by BUMDs in the oil and gas sector.

To implement health and safety operational management by the ISO 45001 standard in the oil and gas industry, there are several important aspects that must be considered, among other things, preparation, challenges, and potential that can be

harnessed. In preparation, companies need to ensure that internal training is done well, especially to improve internal audit skills. Research conducted in the oil sector shows that adequate training can help reduce discrepancies in OSH management system audits, thereby increasing compliance with ISO 45001 standards (Balkat & Khaleel, 2021). In addition, integration with other management systems such as ISO 9001 (quality) and ISO 14001 (environment) can improve operational efficiency and ensure synergy in safety management (Khaerul Fahmi et al., 2021). The development of technologies and the use of new inspection tools, such as diver-less inspections and remote techniques, are also needed to handle the complexity of floating facilities such as FPSOs (Feder, 2021). On the other hand, the main challenges in the implementation of ISO 45001 include resistance to change, especially in companies that previously used the OHSAS 18001 standard. Additionally, the pressure to reduce operational costs often clashes with the need to maintain high safety standards, forcing companies to seek new approaches in asset management and technology investments (Feder, 2021). Evolving regulatory changes are also a challenge, where companies must adapt quickly to ensure compliance and reduce the risk of accidents (Doronina & Safonov, 2016). Despite the significant challenges, there is great potential in the implementation of ISO 45001 in the oil and gas industry. The use of data and automation, such as in remote inspections, can reduce human involvement in high-risk environments and improve operational safety (Feder, 2021). In addition, the implementation of risk-based thinking in the decision-making process can help reduce the likelihood of accidents and increase protection for workers (Khaerul Fahmi et al., 2021). Overall, with careful preparation and proper adaptation, the implementation of ISO 45001 in this sector has great potential to improve operational safety and efficiency. The discussion on the implementation of OHS (K3) operational management based on the ISO 45001 standard in the oil and gas industry is closely related to the topics outlined in the paper, especially related to operational and environmental risk management and management systems. The paper explains the importance of implementing a structured management system, such as an ISO 14001-based EMS, to manage operational risks and significant environmental impacts in the oil and gas sector.

In addition, the integration of ISO 45001 with other management systems such as ISO 14001 (environment) and ISO 9001 (quality) is relevant to the holistic approach mentioned in the text, where operational management must cover all aspects, among other things, environment, safety, and quality. The paper emphasizes the importance of continuous monitoring through key performance indicators (KPIs) to ensure all standards and regulations are met, similar to the evaluation and monitoring elements in ISO 45001. The challenges of ISO 45001 implementation, such as resistance to change and the need to adapt to new regulations, are also reflected in the discussion of the manuscript on the barriers to EMS implementation.

Challenges such as the need for high operational costs and the resistance of corporate culture that does not support sustainability, are similar issues faced in the implementation of OSH management standards in the oil and gas sector. The potential for automation and technology development for remote inspection in the implementation of ISO 45001 is also in line with the operational modernization trends discussed in the text. For illustration, the real-time technology for waste and emissions monitoring mentioned in the manuscript could be parallel to the development of non-destructive inspection tools for floating facilities in the oil and gas sector.

Table 9.1. K3 management performance indicators in the oil and gas sector

| Category    | Performance Indicators                                | Description.                                                                                                              | Source Documents.                | Reference Sources                       |
|-------------|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------------|-----------------------------------------|
| OHS (K3)    | Frequency of Work Accidents (LTIFR)                   | Measure the number of work accidents that cause lost work time per million hours worked.                                  | Indirect, relevant for K3.       | (Oduoza et al, 2023)                    |
|             | Compliance with ISO 45001 Standard                    | Percentage of units or operational locations that have been certified to ISO 45001.                                       | Indirect, relevant for K3.       | (Balkat & Khaleel, 2021)                |
|             | Number of K3 Training Completed                       | The number of training that workers participate in to improve OSH awareness and skills.                                   | Indirect, relevant for training. | (Tverytnykova et al, 2021)              |
| Milieu      | Reduction of Greenhouse Gas Emissions (GHG Emissions) | The number of tons of CO <sub>2</sub> and other gases that have been successfully reduced according to the annual target. |                                  | (Johnstone & Hallberg, 2020)            |
|             | Volume of waste Managed                               | The amount of hazardous or non-hazardous waste that is managed efficiently.                                               |                                  | (Alsulamy et al, 2022)                  |
|             | Specific Energy Consumption                           | Energy usage per unit of output produced, reflecting operational efficiency.                                              |                                  | (Huseynov, 2021)                        |
| Operational | Average Time to Completion of an Audit                | Measure the time efficiency vital to complete a K3 and environmental audit.                                               | Indirect, relevant for audits.   | (Khaerul Fahmi et al, 2021)             |
|             | Achievement of Environmental Planning Targets         | The percentage of environmental targets achieved from the annual plan, such as emission reductions.                       |                                  | (Waly et al, 2021)                      |
|             | Use of Eco-Friendly Technology                        | The number or percentage of processes that use environmentally friendly technology.                                       |                                  | (Jasim Resen & Sadiq AbdulRazzaq, 2022) |

Source : search results, 2024

The implementation of ISO 45001 in the oil and gas sector as described is in line with the principles and approaches outlined in the paper, namely the need for integrated management for health, safety, and the environment that supports operational sustainability and more effective risk management (table 9.1).

The implementation of ISO 45001 and ISO 14001 standards in the oil and gas sector managed by BUMD is a strategic step to improve operational efficiency, occupational safety, and environmental sustainability. This implementation must be adjusted to local characteristics, national regulations, and regional sustainability goals. The implementation stage begins with a plan, which involves analyzing local risks and impacts, drafting safety and environmental policies, and determining performance indicators such as the Lost Time Damage Frequency Rate, reducing greenhouse gas emissions, and the volume of waste managed. At the implementation stage, BUMD needs to provide training to workers, especially in waste management and safety, as well as apply local technology, such as non-destructive inspections for floating oil and gas facilities that are by local geographical conditions. Furthermore, at the check stage, internal audits based on ISO 19011 guidelines are carried out periodically to ensure compliance with standards, accompanied by environmental monitoring that measures water and air quality around operational sites. The results of these audits and monitoring are used for corrective actions at the follow-up stage (Act), where policies and procedures are adjusted to ensure continuous improvement. In addition, BUMDs can empower local communities through environment-based social responsibility (CSR) programs, such as mangrove conservation or recycling training.

This model provides several advantages, such as operational sustainability through energy efficiency and waste management, regional competitiveness through improved reputation, and compliance with national and regional regulations. Research by (Waly et al., 2021) shows that the integration of ISO 45001 and ISO 14001 can reduce bureaucratic costs and improve the efficiency of safety and environmental management. In addition, a study by (Johnstone & Hallberg, 2020) highlights how the implementation of ISO 14001 improves energy efficiency and reduces greenhouse gas emissions, which is relevant for BUMD oil and gas operations. With careful planning and Shareholder involvement, this implementation can effectively support the operational sustainability of BUMDs in the oil and gas sector.

## **9.2. Risk Management in Hazardous or Remote Locations**

Risk management in hazardous environments is a priority in this sector as operations are often carried out in remote areas with high environmental risks. This approach includes the use of a RBM, which allows companies to proactively identify and mitigate risks based on in-depth risk analysis. An Illustration of the

implementation of the RBM can be seen in risk management in the oil and gas sector, such as that carried out by the global energy company, Chevron. Chevron uses RBM to identify, analyze and mitigate risks associated with operational safety, the environment and worker health. One of the implementations is the use of data-driven analytics tools to monitor technical risks on infrastructure such as oil pipelines and production facilities. In addition, Chevron integrates RBM into safety processes by adopting a proactive approach in identifying potential risks through risk simulation and technology-based inspections such as drones. This approach is also used to manage environmental impacts, such as mitigating the risk of oil spills through early detection systems that utilize Internet of Things (IoT) sensors. The implementation of RBM is not only limited to technology, but also includes regular training for workers to ensure they understand and comply with safety protocols. In a case study at an offshore oil facility, the RBM approach successfully reduced incident rates by up to 30% and improved operational efficiency by reducing downtime due to damages. This Illustration shows that RBM enables organizations in high-risk sectors, among other things, BUMDs that manage energy assets, to improve the safety, efficiency, and sustainability of their operations.

Risk management in hazardous or remote locations is an important element in industrial operations, especially in sectors that deal with hazardous materials and extreme environments. The RBM is the main strategy to identify, analyze, and mitigate risks proactively. This method involves using data and analysis tools to understand risks in-depth, allowing for more informed decision-making. Several studies have underlined the benefits of this approach. (Ispas et al., 2023) show that RBM, especially in the management of integrated management systems, enables organizations to better manage risk synergies, as is the action with quality, environmental, and occupational safety management systems. On the other hand, (Yemelin et al., 2021) present a methodology for assessing environmental risks due to emergency conditions in chemical facilities, focusing on the grouping of risk parameters to evaluate their impact on the environment.

This approach is also applied to aspects of process safety, as described by (Qureshi, 2023), which leverages a six-step framework to proactively manage process safety risks in the oil and gas industry. Meanwhile, (Namvar & Bamdad, 2021) explores a network-based approach to evaluate the efficiency of industrial system transitions from normal to emergency and recovery conditions, providing a new perspective for monitoring risk and resilience. In addition, (Budarin, 2023) highlights the application of RBM in the management of health facilities, which helps in the classification and mitigation of risks based on specific work areas. The RBM approach helps organizations not only understand the risks that exist, but also anticipate and prevent potential threats before they occur. By integrating the latest technology and



data, this approach becomes a strong foundation in creating a safer and more efficient work environment (table 9.2.).

Table 9.2. Stages of RBM in the Oil and Gas Sector in Regionally Owned Enterprises

| Stages                       | Description.                                                                                                                                                                           | Related Resources                                  |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| 1. Risk Identification       | Identify key risks that can affect operations, such as environmental, technical, and worker safety hazards. This approach involves collecting historical data and mapping hazards.     | (Ispas et al., 2023; Yemelin et al., 2021)         |
| 2. Risk Assessment           | Determine the level of probability and impact of each risk using analysis tools such as Failure Mode and Effect Analysis (FMEA) or Bayesian Networks.                                  | (Makhutov & Reznikov, 2022; Namvar & Bamdad, 2021) |
| 3. Mitigation Planning       | Develop action plans to mitigate risks through technical, administrative, and organizational measures. The plan includes training, investments in technology, and emergency protocols. | (Budarin, 2023; Qureshi, 2023)                     |
| 4. Implementation            | Implement designed mitigation measures, among other things, active surveillance using technologies such as IoT and drones for remote area monitoring.                                  | (Ispas et al., 2023; Wang et al., 2021)            |
| 5. Monitoring and Evaluation | Use KPIs to assess the effectiveness of mitigation measures and identify areas that need improvement. A data-driven approach is used to update the strategy.                           | (Das et al., 2022; Namvar & Bamdad, 2021)          |

Source : search results, 2024

The implementation of the RBM in the oil and gas sector has proven to be effective, especially in managing risks in dangerous or remote locations. Implementation models such as Enterprise Risk Management (ERM) used in the oil and gas industry show that RBM can improve an organization's resilience to process safety incidents, as explained by (Qureshi, 2023). Key indicators relevant in this implementation include process safety indicators, such as the frequency of incidents and the reliability level of equipment; operational indicators, such as inspection efficiency and equipment damage levels; environmental indicators, such as greenhouse gas emissions and oil spill incidents; as well as social indicators, such as the participation of local communities in risk mitigation. The relevance of RBM to this sector is reinforced by operating conditions in remote locations that often magnify the impact of incidents on the environment and safety, so this approach provides the ability to proactively manage risks.

In the context of BUMD, the implementation of RBM can commence by building strategic partnerships to utilize local resources and infrastructure. Furthermore, specific risks are identified using local data from BUMDs, such as the potential for oil spills in coastal areas. Integrated technology systems, such as IoT and GIS sensors, can be applied to monitor production sites in real-time. Capacity building for the local workforce is also an important step, by providing RBM-based training

that is relevant to region-specific risks. Periodic evaluations using KPIs ensure the effectiveness of the strategies implemented. Examples of concrete implementations involve the use of drones and sensors for oil pipeline inspections as well as the development of corporate social responsibility programs that involve local communities in emergency preparedness. With this approach, the oil and gas sector managed with BUMDs can improve efficiency, operational safety, and sustainability, through integrated and adaptive risk management.

### **9.3. Promotion and Maintenance of Workers' Health**

Worker health is a priority through the TWH approach, which focuses not only on physical health but also psychological well-being. Health promotion programs often involve routine health checkups, counseling, and interventions to reduce work-related stress, which has been shown to increase productivity and reduce absenteeism (Doronina & Safonov, 2016). The implementation of promotion and maintenance of workers' health has been carried out by various global companies with innovative approaches. Chevron, for illustration, runs a holistic wellness Software that includes annual health checkups, counseling for stress management, and workplace fitness facilities. the Corporation also provides educational campaigns about healthy nutrition to support the lifestyle of workers. BP integrates physical health programs with mental health promotion through work-based counseling services and mindfulness training sessions, which have been proven to improve workers' well-being and productivity. In the tech sector, Google offers a complete wellness Software that includes access to a fitness center, healthy meals at the office, and yoga or meditation sessions to reduce work stress. Meanwhile, in the renewable energy sector, Vestas Wind Systems has a regular health check-up Software and ergonomics training for workers on site sites. the Corporation also leverages digital applications to monitor workers' health and provide recommendations based on the analysis of their health data. In the local context, Pertamina, as a State-Owned Enterprise (BUMN), runs a periodic health check-up Software for its employees, as well as provides sports facilities at the workplace as part of a holistic health initiative. These examples show that worker health promotion not only improves physical and mental health, but also supports organizational sustainability through increased productivity and reduced absenteeism.

In the ASEAN region, several large companies have implemented worker health promotion and maintenance programs with a holistic approach to support the physical and mental well-being of their employees. Petronas (Malaysia), as Malaysia's national oil and gas company, has a comprehensive worker health Software. The Software includes periodic health checkups, fitness facilities at the head office and project sites, as well as counseling sessions to deal with work stress. Petronas also conducts wellness campaigns, such as awareness of the risk of chronic

diseases and the importance of healthy lifestyles, involving working families to support a holistic approach. PTT Group (Thailand), PTT Group implements a wellness Software that focuses on the balance between work and personal life. They provide free psychological counseling services for workers, sports facilities at each job site, as well as mental health awareness campaigns. In addition, the Corporation uses digital applications to monitor workers' health, such as tracking stress levels and physical activity levels.

Singapore Airlines (Singapore), this airline has a worker health Software that includes regular health checkups, fitness training programs, and mental well-being promotion. Singapore Airlines also runs a lifestyle-based wellness Software for cabin crew, which includes stress management training and nutrition guidance to support wellness during long flights. PT Bukit Asam Tbk (Indonesia), as a coal mining company, Bukit Asam provides healthcare facilities at remote mine sites, among other things, a full medical clinic and onsite doctor services. They also hold fitness campaigns to encourage workers to participate in sports activities, as well as regular health check-up programs to monitor the risk of occupational diseases. Brunei Shell Petroleum (Brunei), the Corporation has a holistic health Software that includes physical health promotion through sports facilities, periodic health checkups, and health education. They also provide mental counseling services to support workers who experience high work pressure, especially in remote drilling sites. Vietnam Oil and Gas Group (Petro Vietnam), Petro Vietnam has a health Software that includes health education for workers and their families, disease prevention campaigns, and regular health checkups. They also provide occupational health training to raise awareness of ergonomics and the prevention of physical injuries on the job site. These programs show that many companies have adopted holistic worker health promotion strategies, covering physical, mental, and social aspects, to create a healthy and productive work environment. This approach not only supports the welfare of workers but also has a positive impact on the Corporation's overall productivity.

The implementation of TWH in the oil and gas sector is a project in Bahia, Brazil, that uses the Worker's Health Risk Index (WHRI) to identify and manage worker health risks. The project involved 965 workers in the oil and gas industry, with risk assessments covering chemical exposure, noise, ergonomics, lifestyle habits such as physical activity, as well as health conditions such as hypertension and diabetes. Based on the results of the assessment, workers are classified into low risk (74%), medium (21%), and high (5%) risk categories. The interventions implemented include routine health checks, special counseling for high-risk workers, occupational risk management training, and the use of PPE. Periodic monitoring is conducted to evaluate the effectiveness of the Software, among other things, blood pressure checks, oral hygiene, and blood glucose levels of workers. The results show an improvement in overall worker health and a significant reduction in occupational risk

(Viterbo et al., 2021). The TWH approach has been successfully implemented in various organizations to improve the physical health and psychological well-being of workers. One illustration is NASA, which implements the TWH Software through regular health checkups, psychological counseling to overcome work stress, and the provision of sports facilities and fitness programs. As a result, the Software increases worker engagement and productivity. In the oil and gas sector, Chevron Corporation also adopted TWH by integrating annual health checkups, stress management, and work-life balance policies, which significantly reduced health claims and improved worker welfare. Another illustration is Vermont's Worksite Wellness Software, which combines early health screenings, mental health support, and workplace fitness campaigns, with results in reduced stress and improved quality of worker health. In the healthcare sector, Johns Hopkins HealthCare implements TWH through the provision of healthy meals, fitness facilities, and mindfulness sessions, which increase job satisfaction and reduce Contractor turnover. The implementation of programs like this proves that TWH not only supports worker health but also provides long-term benefits for organizations, among other things, high-risk sectors such as oil and gas managed by BUMD.

This approach can be applied by BUMDs with several contextual adaptations, such as considering specific risks in local areas of operation, such as air pollution or other environmental challenges. In addition, involving the surrounding community in health programs, such as nutrition training and community health checks, can also be a strategic step. Success indicators can include a decrease in the prevalence of work-related diseases, increased worker participation in health programs, and a reduction in occupational accident rates. By implementing this strategy, oil and gas sector BUMDs can not only improve the safety and health of their workers, but also create a sustainable positive impact on the surrounding community. The TWH approach is a holistic strategy that not only focuses on occupational safety and physical health, but also improves the psychological well-being of workers through the integration of programs that support health and productivity in the workplace. TWH offers a comprehensive framework that combines protection from occupational health risks with Contractor health promotion, creating a healthier and safer work environment. This approach has been shown to increase productivity, reduce absenteeism, and provide long-term benefits for both workers and organizations.

Research shows that TWH implementation is effective when supported by committed leadership and a good culture of health and safety. A study by (Tenney et al., 2021) shows that consultation and mentoring in the implementation of TWH helps small and medium-sized companies significantly improve the implementation of policies that support worker health. In the agribusiness sector, TWH adaptation allows multinational organizations to implement policies that take into account the specific needs of workers across cultures and geographies. the action illustration from

(Jaramillo et al., 2021) shows the importance of leadership training and organizational assessment to integrate effective TWH policies in improving worker welfare in Latin America. During the COVID-19 pandemic, TWH's approach has also proven relevant. (Dennerlein et al., 2020) developed an integrative framework that supports the psychological and physical needs of essential workers through the active participation of employees in the identification of solutions, creating a work environment that supports mental and physical health. The implementation of TWH provides tangible benefits in improving worker safety, health, and well-being holistically, while encouraging Contractor productivity and engagement. With a strategic and organization-oriented approach, TWH can be a powerful tool for creating a healthy and productive workplace (table 9.3.).

Table 9.3. Parameters for the Implementation of TWH in the Oil and Gas Sector in Regionally Owned Enterprises

| Parameter                 | Explanation.                                                                                                                                     | Scientific References                         |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| Leadership and Commitment | Leadership support is essential to encourage the sustainable implementation of worker health policies and programs.                              | (Tenney et al., 2021)                         |
| Health Risk Assessment    | A thorough assessment of worker health risks such as exposure to chemicals, noise, or ergonomic risks to determine relevant preventive measures. | (Benson et al., 2021; Viterbo et al., 2020)   |
| Worker Participation      | Involvement of workers in the planning and implementation of health programs to ensure the relevance and sustainability of interventions.        | (Hudson et al., 2021; Nobrega et al., 2020)   |
| Policy Integration        | Integrating occupational safety and health promotion in operational policies to support the total welfare of workers.                            | (Guerin et al., 2021; Jaramillo et al., 2021) |
| Training and Education    | Provide regular training to workers on OHS, as well as healthy lifestyle habits.                                                                 | (Fox et al., 2023; Magnavita, 2023)           |
| Monitoring and Evaluation | Measurement of Software success and periodic monitoring of worker health for continuous improvement.                                             | (Tenney et al., 2021; Viterbo et al., 2021)   |

Source : search results, 2024

The implementation of the TWH parameter in the oil and gas sector, especially for BUMD, requires adaptations that take into account the specific context of the work environment and operational challenges. The context of the oil and gas industry is fraught with risks, such as exposure to hazardous chemicals, physical hazards, and demanding work, requiring the integration of occupational safety policies with sustainable health promotion. A holistic approach like TWH requires strong leadership, active worker participation, relevant training, as well as regular evaluations to ensure the effectiveness of the Software. A study by Benson et al. (2021) highlights the

importance of identifying risks such as ergonomic, physical, and chemical hazards, which are often faced by oil and gas workers, to mitigate long-term health effects such as musculoskeletal disorders and respiratory diseases (Benson et al., 2021). Furthermore, contextual adaptation requires worker involvement in designing and implementing interventions to improve Software relevance and sustainability, as revealed by Nobrega et al. (2020), which shows that worker engagement helps identify implementation barriers and ensure alignment with organizational needs (Nobrega et al., 2020). On the other hand, regular training related to occupational safety and health also plays an important role, as suggested by Fox et al. (2023), who found that worker education can reduce high-risk behaviors in the workplace (Fox et al., 2023).

Regular monitoring and evaluation are important elements to measure the success of the Software and make continuous improvements. Viterbo et al. (2021) created the WHRI to assess worker health risks in the oil industry, showing that monitoring can help establish clearer prevention policies (Viterbo et al., 2021). This implementation also needs to be adjusted to the local dynamics of BUMD, among other things, organizational culture and regional policies, to maximize the sustainability of the Software in this critical energy sector.

The TWH implementation model has been applied in various high-risk industries, such as agribusiness and manufacturing, as well as in the oil and gas sector at the international level. One illustration is a Software implemented in the oil industry in Bahia, Brazil, through the development of the WHRI. This model uses a thorough assessment of worker health risks based on parameters such as chemical exposure, noise, ergonomics, and personal health factors (such as diabetes or hypertension) to design relevant interventions (Viterbo et al., 2021). Argument: This model is relevant to be adopted by BUMDs engaged in the oil and gas sector because BUMDs are often located in areas with high environmental risks and unique operational needs. By integrating the TWH Software, BUMDs can create a healthier and safer work environment, while increasing productivity and reducing long-term operational costs. In addition, this approach is in line with BUMD's social responsibility to engage local workers and create benefits for the community. Vital Indicators:

1. Leadership and Commitment Indicators: The percentage of managers involved in TWH Software training and implementation.
2. Health and Safety Indicators: Occupational accident rates, hazardous material exposure, and prevalence of occupational diseases.
3. Worker Participation Indicator: The number of workers involved in the planning and evaluation of health programs.
4. Software Effectiveness Indicators: Decrease in health-related absenteeism, increase in job satisfaction, and results of worker health surveys.

Forms of Implementation for the Oil and Gas Sector:

1. Initial Assessment: Use tools like WHRI to identify worker health risks based on occupation and work location.
2. Integrated Policy Development: Combining occupational safety with health promotion through operational policies specific to the oil and gas sector.
3. Worker Participation: Forming a joint work team that involves workers in the design of intervention programs such as stress management, ergonomics, and safety training.
4. Training and Education: Provide regular training to raise awareness about work risks and healthy living habits.
5. Monitoring and Evaluation: Conduct periodic surveys to measure the effectiveness of the Software and adjust strategies if needed (Benson et al., 2021).

With this model, the oil and gas sector under BUMD can maximize the sustainability of its operations while fulfilling its social responsibility to workers and local communities. This strategy not only reduces health and safety risks but also improves overall operational efficiency.

#### 9.4. Waste Management and Environmental Sustainability

Waste management in the oil and gas sector is a crucial aspect, especially in the face of increasingly stringent environmental regulations. EMS approaches such as ISO 14001 are used to ensure that hazardous waste is managed safely and that environmental impacts are minimized. Waste management in the oil and gas sector is an important aspect in meeting increasingly stringent environmental regulations, especially in the ASEAN region which faces pressure to maintain environmental sustainability. Approaches such as ISO 14001-based EMS have been widely used to ensure safe management of hazardous waste and minimize the impact on the environment. ISO 14001 helps companies develop a systematic framework for the identification, management, and monitoring of waste through sustainable processes, among other things, emission reduction, waste recycling, and pollution prevention. For Illustration, several oil and gas companies in Thailand and Indonesia have implemented EMS to improve efficiency in the management of liquid and solid waste, among other things, drilling sludge treatment using environmentally friendly technologies. In addition, cooperation with third parties for the recycling of hazardous waste, such as used oil and chemical waste, has become a common practice to reduce the risk of soil and water pollution. With the implementation of EMS, companies are not only able to meet legal requirements, but also improve the Corporation's image in the eyes of the public and investors, while contributing to environmental sustainability in this vulnerable region.

The implementation of ISO 14001 parameters in the oil and gas sector managed by BUMD requires contextual adaptation to support the sustainability of the Software. For Illustration, planning strategies and policies must be adapted to local conditions. For Illustration, BUMDs in coastal areas can integrate flood and oil

spill risk analysis into their operational procedures to minimize environmental impacts through relevant mitigation measures (Muzanni et al., 2022). Management must also demonstrate a strong commitment by providing training for workers, allocating budgets for IoT-based monitoring technologies, such as automated sensors to detect waste leaks, thus ensuring effective environmental management (Saboo, 2023). The involvement of local stakeholders is also very important. For illustration, BUMDs can Joint Venture with local communities to rehabilitate mangrove areas around their facilities, which not only reduces environmental impact, but also strengthens relationships with local communities (Margaret et al., 2024). In addition, cloud-based infrastructure and technology can be used to monitor emissions in real-time, providing data to management for better decision-making in managing environmental risks (Saboo, 2023). Internal audits conducted regularly also help identify weaknesses in waste management systems, such as those in liquid waste treatment facilities, where improvements are made immediately after the audit (Alsulamy et al., 2021).

Good sustainability practices can support the achievement of a company's environmental goals and minimize the risk of contamination waste management in the oil and gas sector by implementing systems such as ISO 14001-based EMS makes a significant contribution to environmental sustainability. This system helps companies improve their public image, comply with environmental regulations, and optimize energy efficiency, which simultaneously reduces environmental impact and improves the Corporation's reputation (Hidayati & SODIKIN, 2023). In addition, the implementation of EMS also provides economic benefits through reduced operational costs, such as efficiency in water and energy use, while increasing market competitiveness by strengthening customer trust and Shareholder loyalty (Silva et al., 2020). However, the high costs associated with EMS implementation and certification are often a bottleneck, especially for small and medium-sized companies. Other challenges include a lack of technical knowledge, training, and resources, which makes it difficult for many organizations to meet the requirements of ISO 14001 (Alnavis et al., 2021).

Another obstacle to the implementation of EMS is the misalignment with business strategy, where some companies feel that the benefits of EMS are less visible in the short term. In addition, changes in operational procedures and organizational culture to meet the ISO 14001 standard require a great commitment from all levels of management (Bailey et al., 2020; Mahzun et al., 2020). However, great potential remains, especially with the adoption of technologies such as cloud-based monitoring systems that can accelerate the collection of real-time environmental data and make data-driven decision-making easier. This not only improves efficiency, but also accelerates the Corporation's transition to sustainability (Saboo, 2023; Ushakov et al., 2021). The implementation of EMS also advises increased



environmental awareness within the organization, advises proactive investment in environmentally friendly practices, and contributes to the overall achievement of sustainable development goals (Matuszak-Flejszman & Paliwoda, 2022; Ociepa-Kubicka et al., 2021). An ISO 14001-based EMS is an effective tool for integrating sustainability in business operations, despite the challenges of costs and internal changes. Government support to reduce implementation barriers, along with the adoption of innovative technologies, can help companies overcome those barriers and maximize their sustainability potential. Collaborative endeavors between governments, industry, and communities will enable more efficient waste management and create a more sustainable future (table 9.4.).

Table 9.4. Parameters for the Implementation of ISO 14001 in the Oil and Gas Sector in Regionally Owned Enterprises

| Parameter                      | Description.                                                                                                                                                     | Source                                                 |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Planning and Policy Strategy   | Formulation of strategies that involve identifying relevant environmental aspects, evaluating risks, and integrating sustainability goals into policies.         | (Muzanni et al, 2022)                                  |
| Management Commitment          | Support from top management for system implementation, among other things, provision of resources, training, and periodic evaluation of Software sustainability. | (Johnstone, 2022; Matuszak-Flejszman & Paliwoda, 2022) |
| Shareholder Engagement         | Consultation with local governments, communities, and workers to ensure compliance and support the sustainable implementation of EMS.                            | (Margaret et al, 2024; Sousa Lira et al, 2021)         |
| Infrastructure and Technology  | Implementation of data-driven environmental monitoring technology to manage waste, monitor emissions, and support resource efficiency.                           | (Kojra et al, 2020; Saboo, 2023)                       |
| Internal Assessment and Audit  | Conduct regular evaluations of the effectiveness of the EMS through internal audits and environmental performance evaluations based on specific indicators.      | (Alsulamy et al, 2022)                                 |
| Risk Management and Compliance | Identify significant environmental risks and implement mitigation measures to comply with local regulations as well as national and international standards.     | (Jasim Resen & Sadiq AbdulRazzaq, 2022)                |
| Continuous Improvement         | Create a long-term plan for continuous improvement of energy efficiency, resource use, and waste reduction.                                                      | (Muzanni et al, 2022)                                  |

Source : search results, 2024

The implementation of ISO 14001 parameters in the oil and gas sector managed by BUMD requires contextual adaptation to ensure the sustainability of the Software. This adaptation includes adapting planning strategies and policies to local needs, such as ensuring that environmental and social aspects in the local context are integrated into the Corporation's operational goals. For Illustration, the involvement of local stakeholders, among other things, local governments, local communities, and workers, is essential to support Software sustainability while minimizing conflicts of interest (Margaret et al., 2024). Additionally, management commitments must be

adapted to include investments in technology-based infrastructure, such as digital waste monitoring systems, that can improve waste management efficiency and reporting transparency (Saboo, 2023).

It is also important to align internal audits and evaluations to align with specific operational needs at the local level. Audits that include measuring regional sustainability indicators, such as impacts on local ecosystems and compliance with local regulations, can ensure the effectiveness of EMS (Alsulamy et al., 2022). The successful implementation of ISO 14001 parameters in the context of BUMDs will largely depend on the adaptation of parameters to local needs and investment in innovative technologies as well as collaboration with local stakeholders.

#### 9.5. Risk-Based Infrastructure Maintenance System

This pillar integrates a maintenance system that prioritizes prevention through Risk-Based Infrastructure Maintenance Systems. The system uses data analytics and equipment condition monitoring to identify problems before failures occur, thereby reducing downtime and improving operational efficiency. A vivid illustration is the use of this system at an offshore oil production facility in Norway, where IoT sensors and data analytics are used to monitor the critical condition of equipment such as pipes, pumps, and valves in real-time. The system analyzes historical data and current conditions to predict possible failures, allowing maintenance teams to take preventive action before damage occurs. In practice, technologies such as machine learning are used to prioritize risks based on their impact on operations and the environment, thereby maximizing the allocation of maintenance resources. Another illustration is an implementation at an LNG facility in Qatar, where this risk-based approach successfully reduced downtime by up to 20% and increased the lifespan of key equipment by detecting signs of early wear. With the integration of advanced analytics technology and condition monitoring, companies can not only improve operational efficiency but also ensure compliance with strict safety and environmental standards.

Oil Drilling Facility in the Gulf of Mexico, an oil drilling platform in the Gulf of Mexico uses a risk-based monitoring system to manage critical infrastructure such as wellheads, drilling platforms, and subsea pipeline systems. Using Digital Twin technology, real-time conditions of underwater structures are monitored to detect corrosion, overpressure, or other mechanical damage. The system enables failure prediction with data-driven simulations, minimizing the risk of oil leaks and costly downtime. Gas Pipeline Network in Australia, a gas pipeline operator in Australia implements RBM for natural gas distribution infrastructure. Through the use of Pipeline Integrity Management Systems (PIMS) integrated with data from internal inspections using pigging tools, operators can detect areas with potential damage such as cracks or settling. This approach helps to prioritize repairs on pipe segments that have the highest risk of leaks or explosions, thereby improving operational

efficiency and compliance with safety standards. Oil mills in India, oil mills in Gujarat, India, use risk-based monitoring for refinery equipment such as boilers, heat exchangers, and storage tanks. The system integrates predictive analytics and Condition Monitoring Systems to detect issues such as decreased thermal efficiency or material wear. This approach allows maintenance teams to proactively schedule repairs, reducing the risk of unplanned shutdowns. The LNG industry in the United States, an LNG production facility in Louisiana, USA, uses a RBM system to manage cryogenic equipment such as compressors and LNG storage tanks. Real-time monitoring of temperature, pressure, and vibration is carried out using the IoT, so early signs of failure can be identified and corrective action can be taken before significant disruption occurs. The result is increased operational reliability and a reduction in maintenance costs by up to 15%. Integrated Energy System In the United Arab Emirates (UAE), the UAE implements a risk-based system on power plants and energy distribution infrastructure related to oil and gas facilities. Using artificial intelligence (AI) Predictive Maintenance Tools, the system processes sensor data from turbines, generators, and transformers to predict failures caused by overheating or opponent wear. This reduces the frequency of downtime and improves the efficiency of energy distribution.

Risk-Based Infrastructure Maintenance Systems are a proactive approach that prioritizes prevention through data analytics and equipment condition monitoring to detect potential problems before they fail. The system provides a range of significant benefits, such as improved operational efficiency and reduced costs through predictive maintenance. For Illustration, the implementation of this system has been shown to increase reliability by up to 98% and significantly reduce operational downtime (Abuelenin, 2020). In addition, optimizing maintenance schedules can extend the life of assets and reduce the risk of failure, as seen in a study on the use of genetic algorithms and Monte Carlo analysis for multi-asset management (Petchrompo et al., 2020). The system also makes a major contribution to safety with risk-based prioritization that helps reduce the potential for critical failures in infrastructure systems such as roads and railways (Sasidharan et al., 2022).

However, the implementation of this system faces various challenges. One of the main obstacles is the lack of accurate data for risk analysis, which can be overcome by leveraging machine learning technology to improve risk prediction (Karimzadeh et al., 2022). The complexity of data management of interrelated assets also requires sophisticated algorithms that thoroughly consider the interactions between assets (Petchrompo et al., 2020). In addition, an unsupportive organizational culture and budget constraints are often major obstacles. Successful implementation requires endeavors to get support from the team as well as aligning company policies with risk-based strategies (Abuelenin, 2020). On the other hand, these systems have great potential to improve sustainability by reducing resource consumption and

environmental impact through more efficient planning (Karimzadeh et al., 2022; Sasidharan et al., 2022). The use of new technologies such as the IoT and AI enables the implementation of condition-based maintenance that provides real-time insights into the status of assets and maintenance needs (Ingemarsdotter et al., 2021). Thus, the implementation of Risk-Based Infrastructure Maintenance Systems can bring significant changes in infrastructure management by improving efficiency, safety, and sustainability, although it requires extra effort to address technical and organizational challenges (table 9.5).

Table 9.5. Parameters for the Implementation of RBM in the Oil and Gas Sector

| Parameter                           | Description.                                                                                                                                         | Source                                                                  |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Risk Management                     | Risk assessment is based on the probability of failure (PoF) and the consequences of failure (CoF) to determine maintenance priorities.              | (Attia & Sinha, 2022; Soedarsono et al., 2023)                          |
| Asset Integrity                     | Monitoring the mechanical integrity of assets through Risk-Based Inspection (RBI) to reduce downtime and increase efficiency.                        | (Abuelenin, 2020; Barkhordari et al., 2020)                             |
| Predictive Modeling                 | The use of AI algorithms for equipment failure prediction and maintenance interval planning based on historical data.                                | (Aditiyawarman et al., 2023; Nzubechukwu Chukwudum Ohalet et al., 2023) |
| Local Government Policies           | Supporting regulations such as RBI standards that refer to international best practices to ensure operational safety and efficiency.                 | (Priyanta et al., 2021)                                                 |
| Operational Sustainability          | Implementation of CBM (Condition-Based Maintenance) for real-time condition data collection to optimize resources and minimize environmental impact. | (Barimah et al., 2021; Johnson et al., 2022)                            |
| Use of New Technologies             | Integration of IoT and cloud-based platforms for data analytics and RBM planning throughout the project lifecycle.                                   | (Hamedifar & Wilczynski, 2021; Shankar et al., 2022)                    |
| Training and Team Engagement        | Upskilling the local workforce through RBM implementation-based training to increase system acceptance and effectiveness.                            | (Abuelenin, 2020)                                                       |
| Economic and Performance Evaluation | Cost-benefit analysis and comparison of economic models to determine the added value of the RBM strategy on the productivity of BUMD.                | (Nithin et al., 2021; Tasmin et al., 2020)                              |

Source : search results, 2024

The implementation of RBM parameters in the region-owned oil and gas sector requires adaptation adapted to the local context to support the sustainability of the Software. Risk management, as the main cornerstone of RBM, requires adjustments to the measurement of the PoF and the CoF that are relevant to the local operational environment, such as the location of facilities, geographical conditions, and supporting infrastructure (Attia & Sinha, 2022). Asset integrity can be improved through RBI, which needs to take into account local government regulations and

applicable international standards to ensure operational consistency and safety, as applied in a study in Indonesia (Priyanta et al., 2021).

Predictive modeling using AI is essential for predicting equipment failures and planning optimal maintenance based on local operational data. This requires the development of systems that can integrate historical data with predictive analytics for data-driven decision-making (Nzubechukwu Chukwudum Ohalet et al., 2023). Operational sustainability can be achieved by adopting CBM, which uses real-time data to minimize resource consumption and environmental impact, while ensuring efficiency through monitoring the condition of equipment (Johnson et al., 2022). Local government policies should support through regulations that allow for flexibility in RBM implementation, while ensuring that international best practices are adopted without neglecting local conditions. For illustration, in Indonesia's oil and gas sector, regulations such as the Minister of Energy and Mineral Resources Regulation No.18/2018 encourage the adoption of risk-based methods for equipment maintenance (Priyanta et al., 2021). The use of new technologies, such as IoT and cloud-based analytics, is also necessary to manage big data in support of risk-based planning, as described in an implementation study in the offshore oil and gas sector (Hamedifar & Wilczynski, 2021). Finally, training for local workers is a key factor in upskilling and acceptance of the new system, as emphasized in the implementation of Streamlined Reliability Centered Maintenance (SRCM) at ADNOC LNG (Abuelenin, 2020). By adapting these parameters to local contexts, Regional-Owned Enterprises in the oil and gas sector can improve efficiency, sustainability, and operational safety, while ensuring that the RBM programs implemented are relevant and have a positive impact on their regions.

The implementation of RBM has yielded tangible results in various oil and gas sectors, among other things, regionally owned companies. For illustration, ADNOC LNG in the UAE uses a SRCM approach to prioritize RBIs and criticality analysis. This approach has succeeded in increasing asset reliability by up to 98%, lowering maintenance costs, and optimizing labor through a system that includes static and rotating equipment (Abuelenin, 2020). In Indonesia, RBI is applied to a 28-year-old subsea gas pipeline, using the API 581 standard to determine the optimal inspection interval. This study shows a significant reduction in inspection costs, without sacrificing operational safety, through the adjustment of maintenance intervals of up to 20 years for some pipe segments (Soedarsono et al., 2023). At the global level, Total Energies leverages IoT and AI technology to support the digitalization of RBM. Equipment condition data is collected in real-time using smart sensors, which are then analyzed to predict the failure of critical equipment such as pumps and compressors, so downtime and maintenance costs can be minimized (Hamedifar & Wilczynski, 2021). In Indonesia, Pertamina RU IV Cilacap adopts CBM to manage heat exchangers that often experience efficiency problems. By using FMEA to analyze

failures and establish risk-based inspection schedules, the project was able to reduce downtime by up to 30% and increase the plant's production capacity. These examples show that with the adaptation of appropriate technologies, methods, and regulations, RBM can improve operational efficiency, safety, and sustainability. This provides a great opportunity for regional-owned oil and gas companies to implement a similar approach, to support more optimal and sustainable performance.

Public health strategies in the oil and gas sector, as outlined in the document, can be implemented by BUMDs in the Riau Islands and Wajo Regency through a five-pillar approach. First, the implementation of ISO 45001-based OHS (K3) operational management can help reduce occupational accidents through a systematic approach. This requires intensive training for local workers as well as integration with ISO 14001 to ensure the management of environmental risks at production sites. Second, risk management based on remote or hazardous locations using the RBM approach allows for proactive risk identification and mitigation. In the context of the coastal areas of the Riau Islands and Wajo Regency, RBM can be used to overcome risks such as oil spills with technology such as IoT and drones for remote inspection.

Third, the promotion and maintenance of worker health through the TWH approach can be applied to improve the welfare of the workforce holistically, among other things, physical and mental health. BUMDs can adopt programs such as routine health checks and counseling, as successfully implemented in an oil industry project in Bahia, Brazil, that increases productivity and reduces worker absenteeism. Fourth, waste management and environmental sustainability based on ISO 14001 are important to ensure that waste is managed sustainably. In the Riau Islands and Wajo Regency, this could include monitoring liquid waste, carbon emissions, and environmental rehabilitation, such as mangrove areas, to mitigate environmental impacts. Fifth, a risk-based infrastructure maintenance system provides a great opportunity to reduce operational downtime and improve efficiency. With the use of AI algorithms, equipment failure predictions can be made more accurately, ensuring efficiency at refinery facilities or oil terminals.

In its implementation, this strategy must be adjusted to national and local regulations, such as the Minister of Energy and Mineral Resources Regulation No. 18/2018, to ensure conformity with local operational conditions. In addition, the involvement of local communities through corporate social responsibility (CSR) programs that focus on health and workforce training can strengthen the sustainability of the Software. The use of technologies such as IoT and cloud-based systems is also key to relevant real-time monitoring in coastal areas. With this holistic and adaptive approach, BUMDs in the oil and gas sector can significantly improve safety, efficiency, and operational sustainability.

#### **9.4. Conclusion**

A five-pillar public health strategy—K3 operational management, location-based risk management, worker health promotion, sustainable waste management, and risk-based infrastructure maintenance—is highly relevant for BUMDs to implement in the oil and gas sector in the Riau Islands and Wajo Regency. The strategy integrates a proactive approach to risk management, worker health monitoring, and environmental sustainability by leveraging technology and community participation. In its implementation, regular training based on ISO 45001 can improve compliance and occupational safety, while the use of IoT technology and drones can help remote area inspections to keep an eye out for potential environmental hazards, such as oil spills. Promoting worker health through the TWH Software which includes routine health checkups, stress management training, and counseling can improve workers' physical and mental well-being. Sustainable waste management is also a priority, with the implementation of EMS based on ISO 14001 to minimize hazardous waste, involve local communities in environmental conservation, and utilize real-time emission monitoring technology. Additionally, risk-based infrastructure maintenance that leverages AI and predictive algorithms can manage equipment more efficiently, reduce downtime, and ensure operational reliability.

The implementation of this strategy will provide significant benefits, such as increasing operational efficiency through IoT-based technology and cloud analytics, improving worker welfare holistically which is proven to increase productivity and reduce absenteeism, as well as strengthening corporate social relations through environment-based CSR programs that involve local community participation. Local regulatory support, such as RBI standards, is a key driver of the success of this strategy. Possible steps forward include increasing investment in technologies such as IoT, drones, and AI to strengthen predictive capabilities and environmental surveillance, building multistakeholder cooperation between BUMDs, local governments, and communities to create integrated strategies, and raising awareness through regular campaigns involving workers and local communities. Continuous evaluation based on KPIs and adaptation to local needs in the Riau Islands and Wajo Regency region is also an important part of ensuring the relevance of this strategy. With this approach, BUMDs in the oil and gas sector can create safer, more efficient, and sustainable operations, while making a positive contribution to the community and the surrounding environment.

## Reference

- Abuelenin, M. H. (2020). Risk based maintenance management system achieving operational excellence. *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference 2020, ADIP 2020*. <https://doi.org/10.2118/203143-ms>
- Aditiyawarman, T., Kaban, A. P. S., & Soedarsono, J. W. (2023). A Recent Review of Risk-Based Inspection Development to Support Service Excellence in the Oil and Gas Industry: An Artificial Intelligence Perspective. *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part B: Mechanical Engineering*, 9(1). <https://doi.org/10.1115/1.4054558>
- Alnavis, N. B., Martono, D. N., & Hamzah, U. S. (2021). RECOMMENDATIONS FOR IMPROVING THE ISO 14001 CERTIFICATION BASED ON THE COMPANY'S PERCEPTION ANALYSIS OF THE CERTIFICATION OBSTACLES AND BENEFITS. *Jurnal Kesehatan Lingkungan*, 13(3). <https://doi.org/10.20473/jkl.v13i3.2021.132-141>
- Alshaheen, S. abdu L. F. (2021). Evaluate the Application of the Occupational Health and Safety Management System Based on International Standard (ISO 45001: 2018) :A Case Study in the Iraqi Ministry of Education. *Journal of Techniques*, 3(3). <https://doi.org/10.51173/jt.v3i3.337>
- Alsulamy, S., Dawood, S., Rafik, M., & Mansour, M. (2022). Industrial Sectors' Perceptions about the Benefits of Implementing ISO 14001 Standard: MANOVA and Discriminant Analysis Approach. *Sustainability (Switzerland)*, 14(9). <https://doi.org/10.3390/su14095025>
- Alsulamy, S., Falqi, I., Mansour, M., Dawood, S., & Alshehri, A. (2021). IMPLEMENTING ISO 14001 and ENVIRONMENTAL PERFORMANCE EVALUATION: A LOGISTIC REGRESSION MODEL. *Transactions of Famena*, 45(3). <https://doi.org/10.21278/TOF.453018320>
- Attia, M., & Sinha, J. (2022). Reliability of quantitative risk models: a case study from offshore gas production platform. *Maintenance, Reliability and Condition Monitoring*, 2(1). <https://doi.org/10.21595/marc.2022.22292>
- Bailey, M., Booth, C. A., Horry, R., Vidalakis, C., Mahamadu, A. M., & Awuah, K. G. B. (2020). Opinions of small and medium UK construction companies on environmental management systems. *Proceedings of Institution of Civil Engineers: Management, Procurement and Law*, 174(1). <https://doi.org/10.1680/jmapl.19.00033>
- Balkat, F. S., & Khaleel, A. S. (2021). THE INTERNAL AUDIT OF THE HEALTH AND SAFETY MANAGEMENT SYSTEM (ISO 45001: 2018) IN THE DEPARTMENT OF STUDIES, PLANNING AND FOLLOWUP - IRAQI MINISTRY OF OIL. *International Journal of Business Management and Economic Review*, 04(05). <https://doi.org/10.35409/ijbmer.2021.3317>



- Barimah, A., Niculita, O., McGlinchey, D., & Alkali, B. (2021). Optimal Service Points (OSP) for PHM Enabled Condition Based Maintenance for Oil and Gas Applications. *PHM Society European Conference*, 6(1). <https://doi.org/10.36001/phme.2021.v6i1.2850>
- Barkhordari, A., Mahmoudian, Y., Yousefi, F., Zarei, P., & Moradi, B. (2020). Risk and Asset Integrated Management with Risk-Based Inspection Technique in Oil, Gas, and Petrochemical Industries. *Occupational Hygiene and Health Promotion*. <https://doi.org/10.18502/ohhp.v4i3.4656>
- Benson, C., Dimopoulos, C., Argyropoulos, C. D., Varianou Mikellidou, C., & Boustras, G. (2021). Assessing the common occupational health hazards and their health risks among oil and gas workers. *Safety Science*, 140. <https://doi.org/10.1016/j.ssci.2021.105284>
- Budarin, S. S. (2023). Applying a Risk-Based Approach to Health Facility Management. *City Healthcare*, 4(2). <https://doi.org/10.47619/2713-2617.zm.2023.v.4i2;112-119>
- Das, M., Vogt-Ardatjew, R., Van Den Berg, B., & Leferink, F. (2022). Risk Management Plan For the Hospital Environment. *IEEE International Symposium on Electromagnetic Compatibility*, 2022-September. <https://doi.org/10.1109/EMCEurope51680.2022.9901309>
- Dennerlein, J. T., Burke, L., Sabbath, E. L., Williams, J. A. R., Peters, S. E., Wallace, L., Karapanos, M., & Sorensen, G. (2020). An Integrative Total Worker Health Framework for Keeping Workers Safe and Healthy During the COVID-19 Pandemic. *Human Factors*, 62(5). <https://doi.org/10.1177/0018720820932699>
- Doronina, O. D., & Safonov, A. L. (2016). [[New International Standard ISO 45001:2016 <<Occupational health and safety management systems - Requirements>>]. *Meditcina Truda i Promyshlenniaia Ekologiya*, 10, 40–44.
- Feder, J. (2021). JIP Drives New Ways of Managing Integrity of Floating Oil and Gas Assets. *Journal of Petroleum Technology*, 73(04). <https://doi.org/10.2118/0421-0037-jpt>
- Fox, J. L., Gurney, T., Kondalsamy-Chennakesavan, S., Pols, T. A. H., Tuffaha, H., Pak, A., & McGrail, M. (2023). A Narrative Review of Health Status and Healthcare Delivery in the Oil and Gas Industry: Impacts on Employees, Employers, and Local Communities. In *Healthcare (Switzerland)* (Vol. 11, Issue 21). <https://doi.org/10.3390/healthcare11212888>
- Guerin, R. J., Harden, S. M., Rabin, B. A., Rohlman, D. S., Cunningham, T. R., Tepoel, M. R., Parish, M., & Glasgow, R. E. (2021). Dissemination and implementation science approaches for occupational safety and health research: Implications for advancing total worker health. In *International Journal of Environmental Research and Public Health* (Vol. 18, Issue 21). <https://doi.org/10.3390/ijerph182111050>

- Hamedifar, H., & Wilczynski, H. (2021). Planning for Unknown in The New Age of Digital: A Paradigm for Offshore Oil and Gas Risk Assessment and Management. *Proceedings of the Annual Offshore Technology Conference*. <https://doi.org/10.4043/31057-MS>
- Hidayati, R. N., & SODIKIN, S. (2023). Benefit analysis of the implementation of Environmental Management System (EMS) ISO 14001:2015 in a tyres industry. *Indonesian Journal of Applied Environmental Studies*, 4(2). <https://doi.org/10.33751/injast.v4i2.8897>
- Hudson, H. L., Schill, A. L., & Richards, R. (2021). An exploratory, qualitative study of how organizations implement the hierarchy of controls applied to total worker health®. *International Journal of Environmental Research and Public Health*, 18(19). <https://doi.org/10.3390/ijerph181910032>
- Huseynov, A. (2021). Environmental and economic indicators of sustainable development of enterprises of oil and gas complexes. *SHS Web of Conferences*, 92. <https://doi.org/10.1051/shsconf/20219208009>
- Ingemarsdotter, E., Kambanou, M. L., Jamsin, E., Sakao, T., & Balkenende, R. (2021). Challenges and solutions in condition-based maintenance implementation - A multiple case study. *Journal of Cleaner Production*, 296. <https://doi.org/10.1016/j.jclepro.2021.126420>
- Ispas, L., Mironeasa, C., & Silvestri, A. (2023). Risk-Based Approach in the Implementation of Integrated Management Systems: A Systematic Literature Review. In *Sustainability (Switzerland)* (Vol. 15, Issue 13). <https://doi.org/10.3390/su151310251>
- Jaramillo, D., Krisher, L., Schwatka, N. V., Tenney, L., Fisher, G. G., Clancy, R. L., Shore, E., Asensio, C., Tetreau, S., Castrillo, M. E., Amenabar, I., Cruz, A., Piloni, D., Zamora, M. E., Butler-Dawson, J., Dally, M., & Newman, L. S. (2021). International total worker health: Applicability to agribusiness in latin america. *International Journal of Environmental Research and Public Health*, 18(5). <https://doi.org/10.3390/ijerph18052252>
- Jasim Resen, E., & Sadiq AbdulRazzaq, M. (2022). An Evaluation of Environmental Performance According to The International Standard (ISO14001: 2015) in a Field East of Baghdad / A Case Study in the Midline Oil Company. *Journal of Economics and Administrative Sciences*, 28(134). <https://doi.org/10.33095/jeas.v28i134.2420>
- Johnson, Engr. N., Hilary, I. W., E. O. E., & Obinna, I. R. (2022). Design Based Condition Maintenance in Oil and Gas Sector, Compendium of the Techniques and Procedure. *International Journal for Research in Applied Science and Engineering Technology*, 10(3). <https://doi.org/10.22214/ijraset.2022.41030>
- Johnstone, L. (2022). The means to substantive performance improvements – environmental management control systems in ISO 14001– certified SMEs.

- Sustainability Accounting, Management and Policy Journal*, 13(5).  
<https://doi.org/10.1108/SAMPJ-11-2021-0456>
- Johnstone, L., & Hallberg, P. (2020). ISO 14001 adoption and environmental performance in small to medium sized enterprises. *Journal of Environmental Management*, 266. <https://doi.org/10.1016/j.jenvman.2020.110592>
- Karimzadeh, A., Shoghli, O., Sabeti, S., & Tabkhi, H. (2022). Multi-Asset Defect Hotspot Prediction for Highway Maintenance Management: A Risk-Based Machine Learning Approach. *Sustainability (Switzerland)*, 14(9).  
<https://doi.org/10.3390/su14094979>
- Khaerul Fahmi, Ali Mustofa, Imbuh Rochmad, Eva Sulastri, Indah Sri Wahyuni, & Irwansyah. (2021). Effect Of ISO 9001:2015, ISO 14001:2015 AND ISO 45001:2018 On Operational Performance Of Automotive Industries. *JIEMAR (Journal of Industrial Engineering & Management Research)* , 2(1).
- Kojra, F. R., Sukanta, S., & Kusnadi, K. (2020). ANALYSIS OF THE APPLICATION OF THE ENVIRONMENTAL MANAGEMENT SYSTEM BASED ON STANDARDS IN THE INTERNATIONAL REQUIREMENTS OF ISO 14001. *Journal of Community Based Environmental Engineering and Management*.  
<https://doi.org/10.23969/jcbeem.v4i2.2948>
- Magnavita, N. (2023). Workplace Health Promotion Embedded in Medical Surveillance: The Italian Way to Total Worker Health Program. *International Journal of Environmental Research and Public Health*, 20(4).  
<https://doi.org/10.3390/ijerph20043659>
- Mahzun, R., Thamrin, Bahrudin, & Nofrizal. (2020). Effect of ecological, economic and social factors on the implementation of ISO 14001 environmental management system in heavy industries in Indonesia. *International Journal of Energy Economics and Policy*, 10(6). <https://doi.org/10.32479/ijeep.8984>
- Makhutov, N. A., & Reznikov, D. O. (2022). Prior and Posterior Assessments of Failure Scenario Probabilities and Environmental Risks at Hazardous Industrial Facilities. *IOP Conference Series: Earth and Environmental Science*, 988(3).  
<https://doi.org/10.1088/1755-1315/988/3/032066>
- Margaret, I., Schoubben, F., & Verwaal, E. (2024). When do investors see value in international environmental management certification of multinational corporations? A study of ISO 14001 certification after the Paris Agreement. *Global Strategy Journal*, 14(1). <https://doi.org/10.1002/gsj.1490>
- Matuszak-Flejszman, A., & Paliwoda, B. (2022). Effectiveness and Benefits of the Eco-Management and Audit Scheme: Evidence from Polish Organisations. *Energies*, 15(2). <https://doi.org/10.3390/en15020434>
- Muzanni, A., Soesilo, T. E. B., Martono, D. N., Hamzah, U. S., Berkademi, W., & Febraldo, D. (2022). Review of Environmental Management System Implementation in the Oil and Gas Company in Indonesia. *IOP Conference Series: Earth and*

*Environmental Science*, 1111(1). <https://doi.org/10.1088/1755-1315/1111/1/012018>

- Namvar, H., & Bamdad, S. (2021). Performance evaluation of process industries resilience: Risk-based with a network approach. *Journal of Loss Prevention in the Process Industries*, 71. <https://doi.org/10.1016/j.jlp.2021.104474>
- Nithin, A. H., Obisesan, A., Sriramula, S., & Ebinum, T. (2021). Reliability and cost estimation for maintenance planning of oil and gas assets. *Proceedings of the International Conference on Offshore Mechanics and Arctic Engineering - OMAE*, 2. <https://doi.org/10.1115/OMAE2021-63119>
- Nobrega, S., Morocho, C., Robertson, M. M., Kurowski, A., Rice, S., & Punnett, L. (2020). *Using a Mixed Method Approach to Tailor the Implementation of a Participatory Total Worker Health® Program in Public Healthcare Facilities*. <https://doi.org/10.21203/rs.3.rs-113352/v1>
- Nzubechukwu Chukwudum Ohalet, Adebayo Olusegun Aderibigbe, Emmanuel Chigozie Ani, Peter Efosa Ohenhen, & Abiodun Akinoso. (2023). Advancements in predictive maintenance in the oil and gas industry: A review of AI and data science applications. *World Journal of Advanced Research and Reviews*, 20(3). <https://doi.org/10.30574/wjarr.2023.20.3.2432>
- Ociepa-Kubicka, A., Deska, I., & Ociepa, E. (2021). Organizations towards the evaluation of environmental management tools iso 14001 and emas. *Energies*, 14(16). <https://doi.org/10.3390/en14164870>
- Oduoza, C. F., Alamri, R., & Oloke, D. (2023). Best practice for safety management – case of major oil processing country in the Middle East. *Engineering, Construction and Architectural Management*. <https://doi.org/10.1108/ECAM-02-2023-0126>
- Petchrompo, S., Li, H., Erguido, A., Riches, C., & Parlikad, A. K. (2020). A value-based approach to optimizing long-term maintenance plans for a multi-asset k-out-of-N system. *Reliability Engineering and System Safety*, 200. <https://doi.org/10.1016/j.ress.2020.106924>
- Priyanta, D., Zaman, M. B., & Semin. (2021). The development of a risk-based maintenance flowchart to select the correct methodology to develop maintenance strategies of oil and gas equipment. *IOP Conference Series: Materials Science and Engineering*, 1052(1). <https://doi.org/10.1088/1757-899x/1052/1/012042>
- Qureshi, M. M. R. (2023). Building proactive organizational resilience against the risk of major process safety incidents. *Process Safety Progress*, 42(1). <https://doi.org/10.1002/prs.12411>
- Saboo, S. (2023). Unlocking the Value of Cloud-Enabled Emission Monitoring Systems for Sustainable Operations in the Oil and Gas Industry. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/216053-MS>

- Sasidharan, M., Burrow, M. P. N., Ghataora, G. S., & Marathu, R. (2022). A risk-informed decision support tool for the strategic asset management of railway track infrastructure. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, 236(2). <https://doi.org/10.1177/09544097211038373>
- Shankar, R., Gvk, S., Ramanathan, C., & Bapat, J. (2022). Context Aware Site-visit Scheduling for Asset Management in Oil & Gas Sector. *Proceedings - 2022 IEEE 5th International Conference on Industrial Cyber-Physical Systems, ICPS 2022*. <https://doi.org/10.1109/ICPS51978.2022.9817008>
- Silva, D. S., Bispo, L., Dias, A. C., & Silveira, H. (2020). ENVIRONMENTAL MANAGEMENT SYSTEM (EMS): A PROPOSAL FOR IMPLEMENTATION IN A LARGE ADMINISTRATOR OF CONDOMINIUMS IN THE STATE OF RIO DE JANEIRO – BRAZIL. *Journal on Innovation and Sustainability RISUS*, 11(2). <https://doi.org/10.23925/2179-3565.2020v11i2p61-75>
- Soedarsono, J. W., Wijaya, A., Aditiyawarman, T., SetiawanKaban, A. P., Riastuti, R., Ramdhani, R. T., & Ayende. (2023). DEVELOPMENT OF RISKBASED INSPECTION OF 28-YEARS-OLD SUBSEA SALES GAS PIPELINES TO SUPPORT THE ENERGY DEMAND. *Eastern-European Journal of Enterprise Technologies*, 2(3-122). <https://doi.org/10.15587/1729-4061.2023.277256>
- Sousa Lira, J. M., Salgado, E. G., Beijo, L. A., & Sanches Da Silva, C. E. (2021). Shedding light on the diffusion of ISO 14001 across Africa, Asia and Oceania. *Journal of Cleaner Production*, 289. <https://doi.org/10.1016/j.jclepro.2020.125724>
- Tasmin, R., Muazu, M. H., Nor Aziati, A. H., & Zohadi, N. L. (2020). The mediating effect of enterprise risk management implementation on operational excellence in the Malaysian oil and gas sector: a conceptual framework. *Future Business Journal*, 6(1). <https://doi.org/10.1186/s43093-020-00011-2>
- Tenney, L., Dexter, L., Shapiro, D. C., Dally, M., Brown, C. E., Schwatka, N. V., Huebschmann, A. G., McMillen, J., & Newman, L. S. (2021). Impact of Advising on Total Worker Health Implementation. *Journal of Occupational and Environmental Medicine*, 63(8). <https://doi.org/10.1097/JOM.0000000000002212>
- Tverytnykova, E., Demidova, Y., & Drozdova, T. (2021). MANAGEMENT SYSTEM OF OCCUPATIONAL SAFETY AT UKRAINIAN ENTERPRISES: INTERNATIONAL AND EUROPEAN DIMENSION. *Advanced Information Systems*, 5(1). <https://doi.org/10.20998/2522-9052.2021.1.06>
- Ushakov, D., Goryunova, E., & Shatila, K. (2021). Assessing the impact of environmental management systems on corporate and environmental performance. *IOP Conference Series: Earth and Environmental Science*, 937(2). <https://doi.org/10.1088/1755-1315/937/2/022038>
- Viterbo, L. M. F., Dinis, M. A. P., Vidal, D. G., Costa, A. S., Oliveira, P. V. G., do Nascimento, J. G., & Simões, H. (2020). Health Risk Assessment in Oil Industry in Bahia, Brazil:

- The Worker's Health Risk Index (WHRI). In *Studies in Systems, Decision and Control* (Vol. 277). [https://doi.org/10.1007/978-3-030-41486-3\\_34](https://doi.org/10.1007/978-3-030-41486-3_34)
- Viterbo, L. M. F., Vidal, D. G., Costa, A. S., Dinis, M. A. P., & Leal Filho, W. (2021). Development of an innovative index to assess worker's health risk: the WHRI applied to an oil industry in Bahia, Brazil. *Revista de Administração Da UFSM*, 14(1). <https://doi.org/10.5902/1983465963715>
- Waly, O., Aly, M., El-Fadaly, E., & El-Dardiry, M. (2021). Design Environmental Impacts Model of Chemicals in Integrated Management System (Case Study: in Chemicals Industry). *Journal of Environmental Studies and Researches*, 11(2). <https://doi.org/10.21608/jesr.2021.244285>
- Wang, X., Huang, X., Zhang, Y., Pan, X., & Sheng, K. (2021). A Data-Driven Approach Based on Historical Hazard Records for Supporting Risk Analysis in Complex Workplaces. *Mathematical Problems in Engineering*, 2021. <https://doi.org/10.1155/2021/3628156>
- Yemelin, P. V., Kudryavtsev, S. S., & Yemelina, N. K. (2021). The methodological approach to environmental risk assessment from man-made emergencies at chemically hazardous sites. *Environmental Engineering Research*, 26(4). <https://doi.org/10.4491/eer.2020.386>



# Environmental and Health Risk Management in the Oil and Gas Sector

Chapter

10

Bachtari Alam Hidayat, Mutiara Kartika Dewi

The importance of environmental and health risk management in the oil and gas sector through the application of advanced technology, strengthening regulations, and risk-based training to reduce negative operational impacts. The mitigation strategy focuses on the integration of environmentally friendly technologies, cross-sector collaboration, and the development of data-driven monitoring systems to support operational sustainability.

## 10.1. Identification of Environmental and Health Risks in Oil and Gas Operations

Risk identification in oil and gas operations include an analysis of potential hazards that can impact the environment and human health. Environmental risks such as soil and water contamination often occur due to oil and chemical leaks during oil drilling and transportation activities. In addition, greenhouse gas emissions (such as CO<sub>2</sub> and CH<sub>4</sub>) as well as toxic gases such as hydrogen sulfide (H<sub>2</sub>S) increase the risk to the health of workers and the community around the site. Oil spills are also one of the main threats to marine life and coastal ecosystems, which can result in significant economic losses for local communities (Ferguson et al., 2020). In health, exposure to toxic substances and work accidents involving heavy equipment are the main risks faced by workers, especially in extreme environmental conditions (Zheng et al., 2019)

Reducing risks in oil and gas operations involve developing a robust health, safety and environment (HSE) framework. Initial steps include risk identification, implementation of preventive measures, and ensuring emergency response readiness. Risk assessments should be carried out thoroughly using methods such as systemic causality models to identify potential hazards at the drilling, hydraulic fracturing, and production stages (Hill et al., 2021). Training and awareness for workers about environmental hazards and health risks is also essential, among other things, exposure to toxic substances and ergonomic safety (Benson et al., 2021). In addition, infrastructure readiness by ensuring equipment meets environmental and safety standards, as well as installing real-time monitoring systems for environmental impacts and health risks, such as emissions of volatile organic compounds (VOCs) and methane, is a critical step (Gorlenko et al., 2020).

Parameters to evaluate the effectiveness of these preparations include compliance with safety standards, the level of training completed by workers, and the frequency of incidents such as oil spills and work accidents (Aryaee & Ravanshadnia, 2021; Gadalla, 2024). Monitoring greenhouse gas emissions, such as CH<sub>4</sub> and CO<sub>2</sub>, using advanced technology is also an important parameter (Mein et al., 2021). Another indicator is health measurements, among other things, regular worker check-ups to monitor conditions such as respiratory and cardiovascular diseases associated with exposure to hazardous materials (Tayab et al., 2021).

Table 10.1. Readiness Parameters for Managing Environmental and Health Risks of Oil and Gas Operations

| Parameter                  | Indicator                                                                                                                                                                              |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Safety Standard Compliance | Number of audits and level of compliance with safety regulations (Aryaee & Ravanshadnia, 2021)                                                                                         |
| Worker Training            | The percentage of safety training completed by workers at various stages of oil and gas operations (Benson et al., 2021).                                                              |
| Incident Frequency         | The number of oil spills, work accidents, or chemical leaks per year (Gorlenko et al., 2020).                                                                                          |
| Emissions Monitoring       | Greenhouse gas (CO <sub>2</sub> , CH <sub>4</sub> ) emission levels use technologies such as UAVs, sensors, or LiDAR (Mein et al., 2021)                                               |
| Health Screening           | Regular check-ups to detect respiratory and cardiovascular diseases due to toxic exposure (Tayab et al., 2021).                                                                        |
| Infrastructure Supervision | Reliability of gas leak monitoring systems and sustainability of operational infrastructure (Honeycutt et al., 2021; Liu et al., 2021).                                                |
| Emission Risk Reduction    | The application of emission reduction technologies such as optical gas detection systems (OGI) or solid oxide fuel cell integration (SOFC) (Al-Khori et al., 2021; Ang & Kumar, 2022). |

Source : Author's Search, 2024

Implementation is carried out through the integration of HSE policies into operations to ensure smooth implementation (Popescu et al., 2020). Continuous monitoring using sensors to detect leaks and emissions early should be installed on the job site (Gorlenko et al., 2020). In addition, emergency response teams and simulations for incidents such as oil spills or toxic gas leaks should be prepared regularly. Feedback mechanisms through incident data collection as well as revision of risk management practices based on lessons learned from previous incidents are also important parts of this process (Khvostina et al., 2021). This structured approach, supported by academic research, helps mitigate significant Environmental and Health Risks in oil and gas operations. You can read more details of this strategy through the connected source.

The integration of HSE policies in oil and gas operations begin with the preparation of structured operational guidelines to ensure the smooth implementation of the policy. This process involves an HSE management system that



focuses on risk identification, hazard mitigation, and controlling impacts on the environment and occupational safety. Studies show that integrity management-based approaches, such as the "100% Integrity Assurance" method, can reduce the failure rate of critical equipment by up to 60% within six years (Amad et al., 2020). Continuous monitoring is an important element in the implementation of HSE policies, carried out by installing advanced sensors to detect harmful gas leaks and emissions early. Modern technologies such as drones, LiDAR cameras, and artificial intelligence (AI)-based systems are effective for monitoring methane emissions and significantly reducing operational risks (Ang & Kumar, 2022). In addition, wearable devices also provide great benefits for workers by providing early warning of potential hazards on the job site (Thiruchelvam et al., 2022).

Emergency response teams are trained to deal with incidents such as oil spills or toxic gas leaks. Periodic simulations involving various emergency scenarios help ensure operational readiness to handle high-risk situations. The implementation of an emergency response system based on the emergency planning zone (EPZ), involving local communities and government agencies, has proven to be effective in addressing existing risks (Ahmad et al., 2020). Feedback mechanisms play a crucial role in ensuring continuous improvement. Incident data collection and artificial intelligence-based analysis enable root cause identification as well as proactive actions to mitigate future risks. This data-driven system has shown significant results in improving operational reliability and efficiency (Agusalim et al., 2023). This structured approach is supported by international standards such as ISO 45001 and 14001, which ensure that all processes are carried out according to safety and environmental guidelines. Internal and external audits help identify areas of improvement while ensuring compliance with applicable regulations (Cherubin et al., 2020). With these measures, the implementation of HSE policies can minimize risks and improve the overall sustainability of oil and gas operations.

The implementation of HSE policies in the oil and gas industry has been carried out by various companies through various innovative approaches. For illustration, ADNOC successfully implemented a comprehensive HSE management process during the drilling and testing of a sour gas well with a hydrogen sulfide (H<sub>2</sub>S) content of more than 30% in Abu Dhabi. The steps taken include safety evaluation, preparation of EPZ protocols, installation of fire and gas detection systems, and development of emergency communications involving the government and the surrounding community. As a result, this activity ran without HSE incidents, which demonstrated the effectiveness of an audit-based systematic approach and technical training (Ahmad et al., 2020). Another illustration is the use of the "100% Integrity Assurance" methodology to ensure the reliability of critical equipment such as safety valves and wellheads. This methodology involves cross-disciplinary collaboration for real-time maintenance and surveillance frequency standards, which has successfully reduced

equipment failure rates by up to 60% in the last six years (Amad et al., 2020). Digitalization is also the key to the successful implementation of HSE. PETRONAS, for illustration, has developed an AI-based system to proactively identify HSE risks and mitigate potential incidents. This approach reduced the number of accidents by more than 50% in the last two years, demonstrating the importance of data-driven decision-making in HSE risk management (Agusalim et al., 2023). In addition, the approach of using drone technology in environmental inspection and monitoring has been adopted by several companies to reduce workers' exposure to hazardous environments. This technology is also used to detect greenhouse gas emissions and improve the overall integrity of assets (Saadawi, 2020).

In the ASEAN region, several examples of the implementation of HSE policies in the oil and gas industry can be used as a reference for successful effective implementation. The Risk Management Project in Sarawak, Malaysia, in Bintulu, Sarawak, has developed an HSE competency evaluation tool for contractor workers in the oil and gas industry. Using a quantitative survey approach, this study highlights the importance of education level, work experience, and competence in improving HSE performance. This tool assists operators in ensuring the selection of competent workers to minimize work risks (Saini et al., 2021). Digitization of HSE by PETRONAS, PETRONAS in Malaysia has utilized AI technology through the AIIRA (Artificial Intelligence Incident & Risk Analysis) system. The system enables HSE risk prediction and provides data-driven insights for preventive interventions. The use of AIIRA has managed to reduce the number of accidents by more than 50% in 2021 and 2022, compared to the average of the previous three years (Agusalim et al., 2023). HSE management at the Pertamina RU IV Refinery in Cilacap, Indonesia, at the largest oil refinery in Southeast Asia, the mental workload management of HSE workers is the focus. The survey results show that the majority of workers experience a high mental workload, which affects the effectiveness of safety supervision in the field. This study highlights the importance of regular mental monitoring to improve HSE efficiency (Fajrin, 2020). The CCUS initiative in Sukowati Field, Indonesia, the CO<sub>2</sub>-EOR and Carbon Capture Use Storage (CCUS) project in Sukowati, East Java, has become the first pilot project in Indonesia. The project integrates the safety design of the well based on the evaluation of actual conditions and lessons learned from international standards. The results are used to design the service life of wells and support the development of regulations related to this environmentally friendly technology (Marbun et al., 2021). This concrete implementation shows that the implementation of HSE policies that are integrated with advanced technology and a systematic approach can significantly reduce risks and improve operational efficiency in the oil and gas industry.

The implementation of the HSE policy in BUMD in the oil and gas sector in the Riau Islands Province and Wajo Regency can be carried out with a strategy that is

tailored to local needs. In the Riau Islands, as an area with significant oil and gas activities, the implementation of digital-based management systems such as Supervisory Control and Data Acquisition (SCADA) is very relevant. SCADA systems allow for real-time monitoring of operations, which can improve efficiency and reduce environmental risks and work accidents. The feasibility study shows that the implementation of SCADA significantly reduces operational losses due to oil leaks or human mistake in Indonesia's national oil and gas companies (Tungkagi et al., 2021). In Wajo Regency, South Sulawesi, HSE management endeavors can focus on developing worker competencies through intensive training and performance assessments. Previous research has highlighted the importance of measuring the competencies of HSE workers to ensure a thorough understanding of safety and emergency response procedures. This assessment allows operators to place workers according to their competencies in high-risk tasks (Saini et al., 2021). In addition, the application of AI technology for risk and incident analysis has succeeded in reducing incidents by up to 50% in several oil and gas projects in ASEAN, thus becoming a reference for risk management in Wajo Regency (Agusalim et al., 2023).

The integration of technology with data-driven management is also important to ensure fast and precise decision-making. In both regions, the implementation of regular audits and evaluations of HSE policies should be a priority to identify weaknesses and improve compliance with operational standards. An ISO 14001-based management model, which involves all stakeholders in planning and implementation, can be an effective step to achieve sustainability in oil and gas operations at the regional level (Muzanni et al., 2022).

## **10.2. Risk Assessment and Its Impact on the Environment and Health**

Risk assessment in oil and gas operations involve various methods to analyze the potential impact of identified risks. Quantitative Risk Analysis (QRA) is used to measure the likelihood of incidents and potential losses. In addition, Environmental Impact Assessment (EIA) helps identify environmental impacts before the project begins, while Health Risk Assessment focuses on health impacts on workers and the surrounding community. More sophisticated risk assessment methods such as the systemic approach using the STAMP (Systems-Theoretic Accident Model and Process) model are highly recommended to map more effective risk control and mitigate adverse impacts on the environment and human health (Hill et al., 2021).

Risk assessment in oil and gas operations requires thorough preparation that includes risk identification, initial data collection, and planning of the analysis structure. Risk identification can be done using methods such as Hazard and Operability Studies (HAZOP) to map potential hazards, among other things, leaks, explosions, and toxic exposures. Operational and environmental data need to be collected to support risk modeling, for illustration through a Bayesian approach that

to estimate the impact of degradation on security barriers (Di Maio et al., 2020). In addition, an analysis structure based on Failure Mode and Effects Analysis (FMEA) or a theoretical model must also be designed to analyze risk uncertainty (Ko et al., 2020). Key parameters in the risk assessment include technical indicators such as the probability of system failure, public health impacts, and environmental vulnerability to pollution. Evaluation of the performance of security barriers based on key performance indicators (KPIs) is also needed to identify degradation levels, both on technical and operational barriers (Di Maio et al., 2020). In addition, social factors such as public awareness of safety are also an important aspect in risk analysis ((Bi et al., 2023).

Table 10.2. Oil and Gas Operations Risk Assessment Model

| Parameter                    | Analysis Stages           | Methods Used                              | Rated Indicators                                                                       | Application.                                                                                                               |
|------------------------------|---------------------------|-------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Risk Indicators              | Risk Identification       | Hazard Identification (HAZID)             | Probability of technical failure                                                       | Create a map of technical risks and affected areas for mitigation priorities (Qin et al., 2020).                           |
|                              |                           | Analisis Bow-Tie                          | Locations with a high-risk of leaks                                                    |                                                                                                                            |
|                              | Impact Analysis           | - Simulation QRA                          | Health impacts on workers and the surrounding community                                | Assessment of health effects of exposure to chemicals such as Pb and Cr using a simulation approach (Khalili et al., 2021) |
|                              |                           |                                           | Concentration of environmental pollution                                               |                                                                                                                            |
|                              | Result Validation         | - 5x5 probability-impact matrix           | Economic and environmental losses due to leaks                                         | Technical design adjustments and risk mitigation measures based on the results of the risk matrix (Philip et al., 2021).   |
|                              |                           |                                           | Health risks based on chemical exposure                                                |                                                                                                                            |
| Security Barrier Performance | Sustainability Monitoring | - Multistate Bayesian Network             | Technical barrier degradation                                                          | Determination of the need for maintenance and replacement of barrier systems (Di Maio et al., 2020).                       |
|                              |                           |                                           | Probability of failure of operational barriers                                         |                                                                                                                            |
|                              | KPI Analysis              | - Evaluasi KPI                            | Barrier effectiveness in reducing the impact of explosions, fires, and toxic emissions | Facility design adjustments to minimize operational risks (Crivellari et al., 2021).                                       |
|                              | Real-Time Risk Assessment | - Real-time data-driven monitoring system | Barrier reliability level based on monitoring data                                     | Early detection of possible barrier failure and taking preventive measures (Di Maio et al., 2020).                         |

| Parameter                     | Analysis Stages                 | Methods Used                              | Rated Indicators                                                          | Application.                                                                                           |
|-------------------------------|---------------------------------|-------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Environmental and Social Data | Public Awareness Survey         | - Questionnaires and interviews           | The level of public knowledge of environmental risks                      | Strategies to increase public awareness through educational programs ((Bi et al., 2023).               |
|                               | Monitoring Pollution Indicators | - Air and water quality monitoring system | Pollution concentrations due to chemical emissions                        | Pollution mitigation plan through waste management and emission control (Rastmanesh et al., 2020).     |
|                               |                                 |                                           | Risk of chemical exposure in children and adults                          |                                                                                                        |
|                               | Environmental Data Validation   | - Geospatial and statistical analysis     | Distribution of environmental risks based on wind and water flow patterns | Adjustment of facility layout to reduce environmental impact in sensitive areas (Philip et al., 2021). |

Source : Author's Search, 2024

Risk assessment in oil and gas operations can be implemented in real terms, such as in the action study of oil leak risk assessment on an onshore pipeline in Colombia along 17.53 km. The main risks are the potential for fire, explosion and environmental losses around the operational area. This process begins with risk identification using the HAZID method and Bow-Tie analysis, which found that the probability of jet and pool fire risk is quite high with Individual Risk Per Annum (IRPA) reaching  $6.14 \times 10^{-4} \text{ years}^{-1}$  for operational workers (Philip et al., 2021). Risk analysis using SAFETI software simulations generated an F-N curve (Fatality Number) which indicates that social risks near populations require relocation of residents to reduce potential losses (Ko et al., 2020). Furthermore, the performance of the security barrier is evaluated using Multistate Bayesian Networks to assess the degradation of technical and operational barriers. The findings suggest that automatic valve systems have a high probability of failure due to a lack of routine maintenance (Di Maio et al., 2020). From an environmental and social perspective, air and water quality monitoring shows concentrations of heavy metals such as Pb and Cr exceeding the threshold, potentially endangering public health around the pipeline area (Rastmanesh et al., 2020). Based on these results, the proposed mitigation measures include relocating residents in high-risk radius, improving the maintenance of barrier systems, installing real-time sensors for leak detection, and public education programs on oil and gas operational risks. This approach demonstrates the integration of modern risk assessment methods, such as QRA and Bayesian Networks, to detect and mitigate technical, social, and environmental risks. More research supports the importance of data-driven risk assessments to improve operational safety and environmental sustainability (Hill et al., 2021). This systematic

implementation allows for effective decision-making to reduce the adverse impact of oil and gas operations.

In the ASEAN region, the implementation of risk assessment in oil and gas operations has been applied to various case studies, such as in East Java, Indonesia. One illustration is social risk assessments at oil refineries and terminals that load and unload petrochemical products. The main risks identified include fires and explosions due to flammable material filling and processing activities. The approaches used include HAZOP, Fault Tree Analysis (FTA), and Event Tree Analysis (ETA). Simulation of jet and pond fire risk shows the potential for significant impacts with a fire radius that threatens the surrounding community. For mitigation, a gas detector was installed that was able to reduce the failure frequency from  $1.44\text{E-}03$  to  $2.88\text{E-}06$ , so that the risk could be reduced to an acceptable level (Dinariyana et al., 2021).

Another case is the risk of environmental damage due to oil spills in the mangrove ecosystem in Muara Gembong, Bekasi. The assessment using the Habitat Risk Assessment (HRA) with the Euclidean Distance formula shows that the coastal area near the oil spill source has a moderate risk with an area of  $3.7\text{ km}^2$ , while the inner mangrove area has a low risk with an area of  $2.85\text{ km}^2$ . Mitigation strategies are focused on preventing the spread of oil to deeper mangrove areas and strengthening ecosystem resilience through restoration and environmental protection (Indriawan et al., 2021). More research in the region also demonstrates the importance of integrating technical and environmental risk management. For illustration, safety barrier management is applied to reduce the frequency of unwanted events, such as fires and explosions, through a risk-based analysis approach (Hosseinnia Davatgar et al., 2021). This case study shows how modern technical methods and data-driven approaches are used to protect communities, the environment, and the sustainability of oil and gas operations in the ASEAN region.

The risk assessment implementation process involves a QRA that uses software such as SAFETI to detect risks that are difficult to see in static conditions. Dynamic data is then integrated in risk analysis using the Bayesian Networks approach for evaluation updates during the operational period (Bubbico et al., 2020). Furthermore, measurable mitigation measures are implemented, while key risk indicators such as operational stresses and environmental emissions are monitored regularly to ensure the effectiveness of mitigation ((Ko et al., 2020). With this multi-disciplinary approach, risk assessment in oil and gas operations can identify potential hazards early, mitigate them effectively, and minimize adverse impacts on the environment and human health.

The implementation of risk management in BUMD in the oil and gas sector in the Riau Islands Province and Wajo Regency requires an integrated approach that utilizes a data-based framework, cross-agency coordination, and adaptation to local regulations. In the Riau Islands, the management of the oil and gas sector has the

potential to face risks related to licensing, supervision, and environmental damage. One approach that can be applied is the digitization of the supervision process through a real-time management information system, such as the one developed by SKK Migas at the national level. This system allows online operational monitoring, production data management, and early detection of potential operational failures, which has proven effective in reducing risks in Indonesia's oil and gas sector (Amir, 2021). In Wajo Regency, South Sulawesi, key challenges related to risk management can include integrated operational management and alignment with local energy needs. The implementation of an Enterprise Risk Management (ERM) framework can support risk management at the local level, such as mapping technical and non-technical risk factors, among other things, climate change, occupational safety, and socio-culture. Case studies in Banyuwangi show that the implementation of ERM combined with risk-based audits is effective in preventing corruption and increasing local government accountability (Wardhaningrum & Kartika, 2020). In addition, to support the sustainability of operations, bioremediation technology can be used to manage waste generated from oil and gas exploration and production. In Indonesia, this technology has been regulated in profit-sharing contracts and has been proven to be environmentally friendly and by environmental laws (Rayhan et al., 2023). Strategies such as the use of digital systems for risk management and the implementation of bioremediation can improve efficiency and prevent significant environmental losses, both in the Riau Islands and Wajo Regency. Collaboration with regulators, local communities, and investors is key in ensuring the success of this implementation.

### **10.3. Standard Operating Procedures (SOPs) for Health and Environmental Risk Management**

SOPs play an important role in risk management by providing clear operational guidance to minimize health and environmental risks. SOPs include emission control protocols using technologies such as flare gas recovery systems to reduce air pollution. Safe waste management, among other things, the handling of oil and chemical waste, as well as the implementation of occupational health and safety (OHS) policies, are essential to prevent incidents that can harm workers and the environment. Periodic monitoring of water, soil, and air quality is also regulated in SOPs to ensure that no undetected contamination occurs (Rodrigues et al., 2020).

Health and environmental risk management through SOPs requires careful preparation, among other things, the development of policy documents, the provision of infrastructure facilities such as personal protective equipment (PPE) and modern waste treatment technology, as well as intensive training for personnel. SOPs should also include waste classification based on their risk level, emission control systems, and occupational safety procedures to protect workers and the surrounding

environment (Pineiro et al., 2022). Key parameters in this management include air emission levels such as PM<sub>2.5</sub>, wastewater quality, and work accident rates. The quality of management is measured by the effectiveness of emission controls, regulatory compliance, and reduction of hazard incidents (Rada et al., 2021). The implementation process begins with an initial risk assessment to understand potential environmental and health hazards, followed by the integration of SOPs in the organization's daily activities. Continuous training is an important part of ensuring personnel understand and comply with the protocols that have been established (Rodrigues et al., 2020). Furthermore, periodic monitoring and evaluation are carried out to ensure parameters such as pollutant concentration and the effectiveness of waste treatment according to standards (Msapalla et al., 2022). However, this implementation faces various challenges, such as the high cost of procuring advanced technology, lack of staff awareness of the importance of SOPs, and the complexity of regulations that vary between local and international standards (Garbarino et al., 2020). However, the potential benefits are huge. The effective use of SOPs can significantly reduce environmental pollution and improve operational efficiency through better waste management and creating a safer work environment (Ramos et al., 2020). With an integrated approach and the commitment of all parties, effective management of health and environmental risks can be achieved.

The implementation of SOPs for health and environmental risk management in Indonesia requires a structured framework, by international standards such as ISO 14001 for environmental management and ISO 45001 for occupational safety and health, as well as local regulations such as Law Number 32 of 2009 on Environmental Protection and Management. These SOPs cover several key aspects, among other things, waste management, emission control, and occupational safety. In waste management, waste is classified based on risk (e.g., medical waste, non-medical waste, and B3 waste), with collection, storage, and processing procedures that follow regulations such as Government Regulations No. 101 of 2014. Medical waste can be treated using autoclaves or incinerators equipped with emission control technology to reduce environmental impact. For emission control, periodic monitoring of parameters such as PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and CO<sub>2</sub> is carried out using gas analysis tools, as well as the application of technology such as scrubber or flare gas recovery systems to reduce emissions.

In the field of occupational safety and health (K3), SOPs include hazard identification, preparation of emergency procedures, and regular training for workers to ensure the proper use of PPE. The implementation of this SOP must be supported by regular monthly monitoring of waste management, emissions, and the implementation of K3, as well as annual evaluations through internal and external audits. All such activities must be systematically documented to ensure transparency and compliance. Case studies from various international contexts provide relevant



more guidance. For Illustration, SOPs at a children's hospital in Manaus, Brazil, demonstrate the importance of waste classification, packaging, and staff training to reduce risks to the environment and human health (Pinheiro et al., 2022). In addition, the integration of ISO 14001 and ISO 45001 has been proven to reduce bureaucracy and improve operational efficiency in environmental management and occupational safety (Garbarino et al., 2020). The digitization of operational procedures, such as those carried out through the Business Process Modeling and Notation (BPMN) approach in Italian hospitals, allows for better clinical risk monitoring and results in significant economic savings (Cartelli et al., 2023). The implementation of SOPs that are well-designed and consistently implemented in Indonesia will help improve environmental sustainability and worker safety.

Table 10.3. SOPs for health and environmental risk management

| Category                  | Key Indicators                       | Explanation                                                                                                                      |
|---------------------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Waste Management          | Waste Classification                 | Waste is categorized by type and level of hazard (e.g. B3, medical, domestic) (Abdolkhaninezhad et al., 2022)                    |
|                           | Handling and Packaging               | Waste is stored and packaged by applicable regulations to prevent environmental pollution (Crivellari et al., 2021)              |
| Emissions Management      | Emissions Monitoring                 | Parameters such as PM2.5, NOx, and SO2 were monitored using analytical tools (Yu & Zhang, 2021)                                  |
|                           | Emission Control Technology          | Implementation of technologies such as scrubber or flare gas recovery to reduce emissions (Dahalan et al., 2023)                 |
| Safety and Health         | Hazard Identification                | Procedures that identify potential health and safety risks in the workplace (Ji et al., 2022)                                    |
|                           | Emergency Procedures                 | A procedure that establishes emergency response measures for hazardous situations (Wu et al., 2020)                              |
| Environment and Ecosystem | Risk of Soil and Water Contamination | Assessment of soil and water pollution risk with parameters such as nitrates, phosphates, and heavy metals (Louzon et al., 2021) |
|                           | Ecosystem Monitoring                 | Measurement of water, soil, and biodiversity quality to assess operational impacts on ecosystems (Cui et al., 2020)              |
| Social and Economic       | Perception Risk (Persepsi Risiko)    | Assessment of public perception of Environmental and Health Risks (Ruggieri et al., 2021)                                        |
|                           | Energy and Resource Efficiency       | Evaluate the use of resources and energy to improve operational sustainability (Li et al., 2022).                                |

Source : Author's Search, 2024.

SOPs for health and environmental risk management require clear key indicators that can be applied in a variety of operational contexts. One of the main indicators is waste classification, where waste is categorized by type and level of

hazard. For illustration, a hospital in Jakarta classifies medical waste such as used syringes as Hazardous and Toxic Materials waste, which is then packaged in specially labeled containers to avoid contamination. In addition, in the textile industry sector in Bandung, chemical liquid waste is stored in corrosion-resistant metal drums before being transported to authorized processing facilities to prevent leaks that can pollute the environment (Abdolkhaninezhad et al., 2022).

Another important indicator is emissions monitoring. A cement plant in East Java uses gas analysis tools to monitor PM<sub>2.5</sub> and SO<sub>2</sub> concentrations in real-time, with the results reported to the Environment Agency. This step helps ensure factories comply with national emission thresholds. On the other hand, the oil refinery in Balikpapan uses scrubber technology to absorb sulfur gas before it is released into the atmosphere, thus maintaining the air quality around the facility (Crivellari et al., 2021). For occupational safety and health, HAZID is carried out systematically. For illustration, a high-rise building construction project in Jakarta conducted a risk assessment to identify hazards such as falling from a height. Mitigation endeavors such as the installation of safety nets and training in the use of PPE are carried out to minimize accidents. At a chemical plant in Surabaya, fire simulations are regularly conducted to help staff understand efficient emergency evacuation procedures (Ji et al., 2022).

Indicators of soil and water contamination risk are also crucial. A gold mine in Kalimantan monitors the content of heavy metals such as mercury in groundwater to identify potential contamination. When it is found that the results exceed the threshold, the water treatment plant is immediately implemented to protect the surrounding ecosystem. In Papua conservation areas, river water quality is monitored to measure the impact of mining activities on local fish populations. This data is used to limit mining activities to restore the affected ecosystem (Louzon et al., 2021). In the social aspect, people's risk perception is one of the main indicators. For illustration, in a village near a chemical factory in Cilegon, a survey revealed that 70% of residents are worried about air pollution. In response to this, factories are increasing transparency through public reporting and planting more vegetation as a buffer against air pollution. In the resource sector, energy efficiency is a concern. A textile company in Bandung has succeeded in reducing water consumption by recycling treated wastewater, which at the same time lowers operational costs and improves environmental sustainability (Ruggieri et al., 2021). The role of the government and other stakeholders is very important in ensuring the implementation of SOPs for health and environmental risk management runs effectively.

1. The government has the primary responsibility for regulating, monitoring, and enforcing regulations related to health, occupational safety, and environmental protection. Regulations and Policies: The government establishes regulations such as Government Regulation No. 101 of 2014 concerning the Management of

Hazardous and Toxic Waste, Law Number 32 of 2009 concerning Environmental Protection and Management, and Law Number 1 of 1970 concerning occupational safety. This regulation provides a legal framework that serves as a reference for SOPs. Facilitation and Funding: Governments can provide incentives, grants, or technical help to encourage the adoption of environmentally friendly technologies such as modern waste treatment or emission control in the industrial sector. Supervision and Law Enforcement: Through relevant agencies such as the Environment Agency and the Ministry of Staff, the government conducts regular inspections to ensure compliance with SOPs and sanction violators. Education and Socialization: The government educates the public and business actors on the importance of implementing SOPs for health and the environment through regular campaigns and training.

2. Industry and the Private Sector, as the main actors, the industrial and private sectors are responsible for implementing SOPs in their workplaces and facilities. SOP implementation: Companies are vital to integrate compliant SOPs into their operational processes, among other things, waste management, emission monitoring, and occupational accident risk control. Technology Investment: Companies need to invest in technology such as scrubbers, emission monitoring tools, or advanced waste treatment systems to meet environmental standards. Training and Worker Welfare: Provide periodic training to employees on occupational safety and the use of PPE, as well as ensure worker welfare in the workplace.
3. Communities and Societies: Communities play an important role as social watchdogs and direct beneficiaries of environmental and health policies. Participatory Monitoring: The public can report environmental violations such as waste pollution or excessive emissions through official government channels. Awareness and Active Participation: Citizens are expected to participate in government or corporate programs such as reforestation, domestic waste management, and recycling initiatives. Public Consultation: In large projects such as toll road or mine construction, the community plays a role in providing input during the preparation of the EIA.
4. Academics and Researchers, academics and researchers help develop new technologies, methods, and indicators that can be used in SOPs. Research and Innovation: Academics provide research-based solutions to challenges such as B3 waste treatment or more efficient water quality monitoring. For Illustration, studies on the risk of heavy metal contamination in groundwater provide technical recommendations for mine waste management (Louzon et al., 2021). Education and Collaboration: Academics work closely with industry and government to provide training to stakeholders on the implementation of the latest SOPs.

5. Non-Governmental Organizations (NGOs), NGOs are often a bridge between the community and the government in environmental and health issues. Advocacy and Campaigns: NGOs raise public awareness about the adverse effects of pollution and the importance of SOPs. Independent Monitoring: Conduct independent audits of SOP implementation and voice violations found to the public and the government.

Waste Management Project in Jakarta, the government through the Environment Agency is working with private companies and NGOs to build environmentally friendly domestic waste recycling facilities. Oil Refinery in Balikpapan: With the support of academics, oil refinery companies use scrubber technology to reduce sulfur emissions. The project is overseen by the government and involves consultation with local communities to ensure compliance. Reforestation Software in Papua: The government, mining companies, and local communities collaborate in reforesting areas affected by mining to restore ecosystem function. Collaboration between the government, industry, the community, academics, and NGOs is essential in the effective implementation of SOPs. Each party has complementary roles to ensure operational sustainability, occupational safety, and environmental protection. With strong synergy, public health and environmental sustainability goals can be achieved.

#### **10.4. Environmental and Health Risk Mitigation Strategies**

Effective mitigation strategies are needed to reduce the impact and possibility of risks in oil and gas operations. The use of clean and efficient technologies such as exhaust gas recovery systems and the application of renewable energy can reduce the environmental footprint of oil and gas operations. Additionally, the Emergency Response Plan (ERP) is designed to deal with incidents such as oil spills, which includes evacuation procedures and quick countermeasures to minimize environmental losses. Land reclamation and restoration of ecosystems damaged by exploration activities are also important in maintaining environmental balance. Endeavors to increase awareness and training for workers regarding safety procedures can strengthen risk prevention (Popescu et al., 2020). In addition, the use of bioremediation technologies, such as biosurfactants and microorganisms, has been proven to be effective in cleaning up oil pollution in an environmentally friendly manner (Gaur et al., 2022). An ERP is also an important opponent to deal with incidents such as oil spills. ERP is designed to accelerate evacuation, mitigation and ecosystem recovery. Studies on responses to oil spills in cold and warm environments demonstrate the effectiveness of technologies such as underwater dispersants to mitigate ecological impacts in various climatic conditions (Wegeberg et al., 2021). Other strategies include land reclamation and restoration of ecosystems damaged by oil and gas exploration.

These endeavors include sustainable waste management through environmental management systems (EMS), which are able to mitigate impacts on water, soil, and air (Guerrero-Martin et al., 2023). Continuous monitoring using technologies such as Bayesian Networks can also improve the effectiveness of risk management by providing real-time data to update risk assessments (Bubbico et al., 2020). Increasing awareness and training for workers is a preventive measure to ensure safety and minimize exposure to risks. Structured training and the integration of AI technology in risk management have been shown to help workers understand and respond to threats more quickly (Bravo & Hernandez, 2020).

Structured training with the integration of AI in oil and gas operations risk management has shown effectiveness in helping workers understand and respond to threats faster. This model uses historical and real-time data to build a training system based on simulation and predictive analytics. The training stages include risk identification, development of scenario-based training modules, implementation of interactive training, performance evaluation through AI analysis, and updates of training modules. In this model, field workers, occupational safety teams, AI technology developers, and company management collaborate to ensure the success of training. Key benefits include improved safety, reduced training costs, and personalization of programs based on individual worker needs (Tharayil et al., 2023). One illustration of an application is the use of machine learning algorithms to predict and prevent operational failures. An AI-based system can provide specific training recommendations, such as safety measures based on previous incident patterns. The use of technologies such as Augmented Reality (AR) and Virtual Reality (VR) allows workers to practice in safe realistic simulations (Popescu et al., 2020). This training model leverages big data processing and AI to analyze the effectiveness of training and adapt it dynamically. For illustration, the system developed by PETRONAS managed to reduce more than 50% of accident incidents in the work area during 2021-2022 by using a data-based predictive model to minimize risks (Agusalim et al., 2023). This approach not only improves the skills of workers but also facilitates data-driven decision-making by management. Additionally, the integration of AI into training systems results in long-term benefits such as improved operational efficiency and continuous adaptation to new threats, making it an integral part of safety and sustainability strategies in the oil and gas sector (Fortunato et al., 2023). This training approach shows great potential in answering the challenges of oil and gas operational risks in the digital era. Collaboration between technology and operational teams will ensure that this training system continues to adapt to the needs of the industry and workers.

Environmental and health risk mitigation strategies for Oil and Gas BUMDs in Riau Islands Province and Wajo Regency, can be carried out at least consisting of

1. Identification of Environmental and Health Risks, BUMDs in the oil and gas sector in the Riau Islands and Wajo Regency face significant risks to the environment and health. In the Riau Islands, offshore exploration has the potential to result in oil spills that have a negative impact on marine ecosystems. Meanwhile, in Wajo Regency, onshore exploration activities can pollute groundwater sources and cause emissions of toxic gases such as hydrogen sulfide (H<sub>2</sub>S). Studies show that the management of oil and gas industry waste, especially in water, air, and soil aspects, must be carried out sustainably through the use of an integrated environmental management system (Guerrero-Martin et al., 2023). In Wajo Regency, worker health risks such as exposure to hazardous chemicals also need to be a management priority (Fox et al., 2023).
2. Risk Assessment is an important step in understanding the severity of potential impacts. In the Riau Islands, analytical tools such as environmental management matrixes can be used to map the impact of oil and gas activities on local resources, among other things, water use and greenhouse gas emissions (Guerrero-Martin et al., 2023). Studies in the oil and gas sector suggest risk-based approaches such as FMEA to identify and prioritize risks, especially in drilling facilities in environmentally vulnerable areas (Shafiee & Animah, 2022). In Wajo Regency, similar techniques can help manage health risks from wetland drilling.
3. Environmental Risk Mitigation Strategy, the mitigation strategy includes the use of environmentally friendly technology and adaptive approaches. In the Riau Islands, flare gas recovery technology can reduce carbon emissions, while land reclamation strategies can be applied to improve areas affected by exploration (Bravo & Hernandez, 2020). In Wajo Regency, mitigation endeavors involve hazardous waste management by utilizing modern waste management systems. In addition, monitoring air and water quality using data-based technology can increase the effectiveness of environmental risk mitigation (Popescu et al., 2020).
4. Health Risk Mitigation Strategy, to mitigate worker health risks, the implementation of a Health and Safety Management System (HSMS) is highly recommended. The system includes technology-based occupational safety training such as VR to simulate emergency situations (Fox et al., 2023). In addition, the use of telemedicine in remote areas can help provide emergency health services to workers in the field. Studies show that telemedicine is effective in reducing the need for expensive medical evacuation (Bravo & Hernandez, 2020).
5. The role of Local Regulation and Governance, the role of local governments as holders of 10% participating interest in upstream oil and gas activities is very important to ensure compliance with environmental and health standards. In the context of the Riau and Wajo Islands, strengthening sustainability-oriented local regulations and cross-sector cooperation is needed (Hasiholan et al., 2023).

Environmental and health risk mitigation strategies in Riau Islands Oil and Gas BUMDs and Wajo Regency must integrate modern technology, risk-based workforce training, and strong governance. By adopting an adaptive and innovative approach, BUMDs can effectively manage risks while encouraging operational sustainability.

### **10.5. Conclusion and Recommendations**

Chapter 10 discusses environmental and health risk management in the oil and gas sector, with a focus on identification, assessment, risk mitigation, and the implementation of SOPs. The goal is to reduce the adverse impact of oil and gas operations on the environment and health, while ensuring sustainability and operational safety. The findings show that the main risks include oil spills, greenhouse gas emissions, and exposure to hazardous substances in workers. The application of advanced technologies such as real-time emission monitoring systems and bioremediation methods has succeeded in reducing the incidence of accidents and environmental impacts. In addition, technology-based training, such as VR, improves workers' readiness to deal with emergency situations. Recommendations include: Technology enhancement to adopt emission control tools, green technologies, and AI integration to monitor risks; Strengthening Regulations to ensure compliance with national and international standards such as ISO 14001 and 45001; Education and Training by involving the community and workers in continuous training programs to increase risk awareness; Collaboration to increase synergy between government, industry, academia, and society for effective risk management. Going forward, further research is needed to develop more efficient technologies, such as AI-based analytics and new emission sensors. Governments and industry sectors are expected to prioritize data-driven approaches for better risk management and environmental sustainability.

## Reference

- Abdolkhaninezhad, T., Monavari, M., Khorasani, N., Robati, M., & Farsad, F. (2022). Analysis Indicators of Health-Safety in the Risk Assessment of Landfill with the Combined Method of Fuzzy Multi-Criteria Decision Making and Bow Tie Model. *Sustainability (Switzerland)*, 14(22). <https://doi.org/10.3390/su142215465>
- Agusalim, F. F., Hussin, W. A. W., Go, C. H., Chang, E. J. T., Gonasergar, V., & Tukiman, N. (2023). Artificial Intelligence Solutions In Managing HSE Risks and Incidents. *2023 International Conference on Digital Applications, Transformation and Economy, ICDATE 2023*. <https://doi.org/10.1109/ICDATE58146.2023.10248441>
- Ahmad, M. M., Yousfi, F. Z., Albadi, M., Agarwal, A., Ahmad, Z., Al Hosani, A., Pendyala, V., Mandal, C., Gadelhak, A., Shaker, A., Alsaedi, A., Elabrashy, M., Alzeyoudi, M., Alsenaidi, S., Al Muhairi, B., Al Bairaqa, A., Baslaib, M., Al Jeelani, O., Bacioni, M. A., ... Alloghani, J. A. (2020). A successful HSE management process implementation during drilling and well testing operation in sour gas wells. *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference 2020, ADIP 2020*. <https://doi.org/10.2118/202603-ms>
- Al-Khori, K., Al-Ghamdi, S. G., Boulfrad, S., & Koç, M. (2021). Life cycle assessment for integration of solid oxide fuel cells into gas processing operations. *Energies*, 14(15). <https://doi.org/10.3390/en14154668>
- Amad, M. A., Al Daghar, T., Kunhi, S., Iqbal, A., Basit, A., Al-Ketbi, A., & Al Muhannadi, R. (2020). Asset reliability enhancement by implementing 100% integrity assurance approach for well HSE critical equipment. *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference 2020, ADIP 2020*. <https://doi.org/10.2118/203217-ms>
- Amir, M. F. (2021). *Development of Integrated Oil and Gas Plant Information Management System (PIMS) in Indonesia*. <https://doi.org/10.29118/ipa21-f-287>
- Ang, E., & Kumar, M. (2022). Greenhouse gases emissions evaluation for prospective energy projects. *The APPEA Journal*, 62(2). <https://doi.org/10.1071/aj21106>
- Aryaee, S., & Ravanshadnia, M. (2021). Identifying and Ranking Environmental Risks of Oil and Gas Projects Using the VIKOR Method for Multi-Criteria Decision Making. *International Conference on Civil, Structural and Transportation Engineering*. <https://doi.org/10.11159/iccste21.113>
- Benson, C., Dimopoulos, C., Argyropoulos, C. D., Varianou Mikellidou, C., & Boustras, G. (2021). Assessing the common occupational health hazards and their health



- risks among oil and gas workers. *Safety Science*, 140. <https://doi.org/10.1016/j.ssci.2021.105284>
- Bi, A., Huang, S., & Sun, X. (2023). Risk Assessment of Oil and Gas Pipeline Based on Vague Set-Weighted Set Pair Analysis Method. *Mathematics*, 11(2). <https://doi.org/10.3390/math11020349>
- Bravo, O., & Hernandez, D. F. (2020). Risk management strategies required for unconventional oil and gas exploration and development in Latin America. *Society of Petroleum Engineers - SPE International Conference and Exhibition on Health, Safety, Environment, and Sustainability 2020, HSE and Sustainability 2020*. <https://doi.org/10.2118/199430-ms>
- Bubbico, R., Lee, S., Moscati, D., & Paltrinieri, N. (2020). Dynamic assessment of safety barriers preventing escalation in offshore Oil&Gas. *Safety Science*, 121. <https://doi.org/10.1016/j.ssci.2019.09.011>
- Cartelli, V., Longo, L., Tomarchio, O., & Trapani, N. (2023). Digitalization of Healthcare Processes Through BPMN for Clinical Risk Monitoring and Management. *International Conference on Information and Communication Technologies for Ageing Well and E-Health, ICT4AWE - Proceedings, 2023-April*. <https://doi.org/10.5220/0011850300003476>
- Cherubin, P., Presotto, L., & Frattini, L. (2020). Process safety in contaminated groundwater treatment plants. *International Petroleum Technology Conference 2020, IPTC 2020*. <https://doi.org/10.2523/iptc-19575-abstract>
- Crivellari, A., Bonvicini, S., Tugnoli, A., & Cozzani, V. (2021). Key performance indicators for environmental contamination caused by offshore oil spills. *Process Safety and Environmental Protection*, 153. <https://doi.org/10.1016/j.psep.2021.06.048>
- Cui, S., Yu, T., Zhang, F., Fu, Q., Hough, R., An, L., Gao, S., Zhang, Z., Hu, P., Zhu, Q., & Pei, Z. (2020). Understanding the risks from diffuse pollution on wetland eco-systems: The effectiveness of water quality classification schemes. *Ecological Engineering*, 155. <https://doi.org/10.1016/j.ecoleng.2020.105929>
- Dahalan, N. H., Rahman, R. A., Ahmad, S. W., & Che Ibrahim, C. K. I. (2023). Public monitoring of environmental management plan implementation in road construction projects: key performance indicators. *Journal of Engineering, Design and Technology*. <https://doi.org/10.1108/JEDT-06-2023-0225>
- Di Maio, F., Scapinello, O., Zio, E., Ciarapica, C., Decarli, L., & la Rosa, L. (2020). A multistate bayesian network for accounting the degradation of safety barriers in the living risk assessment of oil and gas plants. *Proceedings of the 30th European Safety and Reliability Conference and the 15th Probabilistic Safety Assessment and Management Conference*. [https://doi.org/10.3850/978-981-14-8593-0\\_4878-cd](https://doi.org/10.3850/978-981-14-8593-0_4878-cd)

- Dinariyana, A., Artana, K., Handani, D., Sarasvati, F., & Aprilia, P. (2021). Societal risk assessment of terminal and oil refinery unit. *IOP Conference Series: Materials Science and Engineering*, 1052(1). <https://doi.org/10.1088/1757-899x/1052/1/012025>
- Fajrin, V. C. (2020). The Overview of Mental Workload of Health Safety and Environment Workers in Oil and Gas Industry. *Indonesian Journal of Occupational Safety and Health*, 9(2). <https://doi.org/10.20473/ijosh.v9i2.2020.154-162>
- Ferguson, A., Solo-Gabriele, H., & Mena, K. (2020). Assessment for oil spill chemicals: Current knowledge, data gaps, and uncertainties addressing human physical health risk. *Marine Pollution Bulletin*, 150. <https://doi.org/10.1016/j.marpolbul.2019.110746>
- Fortunato, H. E., Marcomini, K., Soares, G. J., Gremes, M. F., Alberto, P. F., Reis, F. J., & Abbas, C. (2023). Optimizing Industrial Risk Management Through AI and No-Code Platform: A Global Solution for the Oil and Gas Industry. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/216426-MS>
- Fox, J. L., Gurney, T., Kondalsamy-Chennakesavan, S., Pols, T. A. H., Tuffaha, H., Pak, A., & McGrail, M. (2023). A Narrative Review of Health Status and Healthcare Delivery in the Oil and Gas Industry: Impacts on Employees, Employers, and Local Communities. In *Healthcare (Switzerland)* (Vol. 11, Issue 21). <https://doi.org/10.3390/healthcare11212888>
- Gadalla, H. E. (2024). Impact of the Offshore Oil and Gas Working Environment on the Mental Health and Safety Behaviour of Workers. *AIN Journal*, 1(47). <https://doi.org/10.59660/47119>
- Garbarino, E., Orveillon, G., & Saveyn, H. G. M. (2020). Management of waste from extractive industries: The new European reference document on the Best Available Techniques. *Resources Policy*, 69. <https://doi.org/10.1016/j.resourpol.2020.101782>
- Gaur, V. K., Gupta, S., & Pandey, A. (2022). Evolution in mitigation approaches for petroleum oil-polluted environment: recent advances and future directions. In *Environmental Science and Pollution Research* (Vol. 29, Issue 41). <https://doi.org/10.1007/s11356-021-16047-y>
- Gorlenko, N., Murzin, M., & Belyaevsky, R. (2020). Assessment of Environmental Risks at Oil and Gas Production Companies Using an Integrated Method. *E3S Web of Conferences*, 174. <https://doi.org/10.1051/e3sconf/202017402033>
- Guerrero-Martin, C. A., Ortega-Ramírez, A. T., Rodríguez, P. A. P., López, S. J. R., Guerrero-Martin, L. E., Salinas-Silva, R., & Camacho-Galindo, S. (2023). Analysis of Environmental Sustainability through a Weighting Matrix in the Oil and Gas

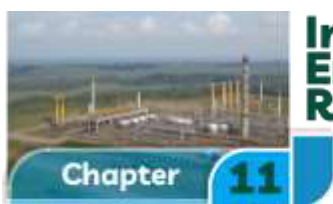
- Industry. *Sustainability* (Switzerland), 15(11).  
<https://doi.org/10.3390/su15119063>
- Hasiholan, A., Murwadji, T., & Sukarsa, D. E. (2023). Environmental Responsibilities of Local Governments as PI Holders in Upstream Oil and Gas Operations. *IOP Conference Series: Earth and Environmental Science*, 1270(1).  
<https://doi.org/10.1088/1755-1315/1270/1/012006>
- Hill, C. B., Yadav, O. P., & Khan, E. (2021). Systemic risk analyses for potential impacts of onshore unconventional oil and gas development on public health and the environment: A critical review. In *Science of the Total Environment* (Vol. 786).  
<https://doi.org/10.1016/j.scitotenv.2021.147512>
- Honeycutt, W. T., Kim, T., Ley, M. T., & Materer, N. F. (2021). Sensor array for wireless remote monitoring of carbon dioxide and methane near carbon sequestration and oil recovery sites. *RSC Advances*, 11(12).  
<https://doi.org/10.1039/d0ra08593f>
- Hosseinnia Davatgar, B., Paltrinieri, N., & Bubbico, R. (2021). Safety barrier management: Risk-based approach for the oil and gas sector. *Journal of Marine Science and Engineering*, 9(7). <https://doi.org/10.3390/jmse9070722>
- Indriawan, D., Taofiqurrohman, A., Riyantini, I., & Faizal, I. (2021). Assessment of Risk Levels of Mangrove Forest Due to Oil Spill in Muara Gembong, Bekasi Regency. *E3S Web of Conferences*, 324.  
<https://doi.org/10.1051/e3sconf/202132401004>
- Ji, Z., Su, H., Wang, Y., Cao, Y., & Yang, S. (2022). Assessing the Risk of Hazards with Multidimensional Consequences for Industrial Processes. *Processes*, 10(6).  
<https://doi.org/10.3390/pr10061145>
- Khalili, S., Faradmal, J., Mahjub, H., Moeini, B., & Ezzati-Rastegar, K. (2021). Overcoming the problems caused by collinearity in mixed-effects logistic model: determining the contribution of various types of violence on depression in pregnant women. *BMC Medical Research Methodology*, 21(1), 154.  
<https://doi.org/10.1186/s12874-021-01325-7>
- Khvostina, I., Oliinyk, V., Semerikov, S., Solovieva, V., Yatsenko, V., & Kohut-Ferens, O. (2021). Hazards and risks in assessing the impact of oil and gas companies on the environment. *IOP Conference Series: Earth and Environmental Science*, 628(1). <https://doi.org/10.1088/1755-1315/628/1/012027>
- Ko, C., Lee, H., Kim, K., & Lee, W. B. (2020). Quantitative risk assessment integrated with dynamic process simulation for reactor section in heavy oil desulfurization process. *Journal of Loss Prevention in the Process Industries*, 66.  
<https://doi.org/10.1016/j.jlp.2020.104158>

- Li, H., Liang, M., Zhang, C., & Cao, Y. (2022). Risk Evaluation of Water Environmental Treatment PPP Projects Based on the Intuitionistic Fuzzy MULTIMOORA Improved FMEA Method. *Systems*, 10(5). <https://doi.org/10.3390/systems10050163>
- Liu, S., Yang, X., & Zhou, X. (2021). Development of a low-cost UAV-based system for CH<sub>4</sub> monitoring over oil fields. *Environmental Technology (United Kingdom)*, 42(20). <https://doi.org/10.1080/09593330.2020.1724199>
- Louzon, M., Pauget, B., Pelfrène, A., Gimbert, F., & de Vaufléury, A. (2021). Combining human and snail indicators for an integrative risk assessment of metal(loid)-contaminated soils. *Journal of Hazardous Materials*, 409. <https://doi.org/10.1016/j.jhazmat.2020.124182>
- Marbun, B. T. H., Santoso, D., Kadir, W. G. A., Wibowo, A., Suardana, P., Prabowo, H., Susilo, D., Sasongko, D., Sinaga, S. Z., Purbantanu, B. A., Palilu, J. M., & Sule, R. (2021). Improvement of borehole and casing assessment of CO<sub>2</sub>-EOR/CCUS injection and production well candidates in Sukowati Field, Indonesia in a well-based scale. *Energy Reports*, 7. <https://doi.org/10.1016/j.egyr.2021.03.019>
- Mein, T. F., Gimenes, A. L. V., Dias, E. M., Rebello Pinho Dias Scoton, M. L., & Udaeta, M. E. M. (2021). Environmental vulnerability in pre-salt oil and gas operations. *Energies*, 14(3). <https://doi.org/10.3390/en14030732>
- Msapalla, A., Azizi, S., Jangu, M., Mbewe, N. J., Matowo, J., Shayo, M. F., Kaaya, R., Mawa, B., Joram, A., Kirby, M. J., Rowland, M. W., & Mosha, F. (2022). Simplified Procedures for Managing Insecticidal Waste: A Case Report of KCMUCo-PAMVERC Vector Control Product Testing Facility in North-Eastern Tanzania. *Environments - MDPI*, 9(6). <https://doi.org/10.3390/environments9060065>
- Muzanni, A., Soesilo, T. E. B., Martono, D. N., Hamzah, U. S., Berkademi, W., & Febraldo, D. (2022). Review of Environmental Management System Implementation in the Oil and Gas Company in Indonesia. *IOP Conference Series: Earth and Environmental Science*, 1111(1). <https://doi.org/10.1088/1755-1315/1111/1/012018>
- Philip, A. C., Ginters, E., & Basdogan, D. (2021). Bayesian acyclic network based environmental footprint risk assessment system for oil and gas industry. *International Journal of Circuits, Systems and Signal Processing*, 15. <https://doi.org/10.46300/9106.2021.15.98>
- Popescu, C., Avram, L., & Mocanu, I. (2020). *Risk Management in the Oil and Gas Industry Related to the AI Tools*. <https://doi.org/10.4018/978-1-7998-5077-9.ch017>

- Qin, G., Zhang, P., Hou, X., Wu, S., & Wang, Y. (2020). Risk assessment for oil leakage under the common threat of multiple natural hazards. *Environmental Science and Pollution Research*, 27(14). <https://doi.org/10.1007/s11356-020-08184-7>
- Rada, E. C., Schiavon, M., & Torretta, V. (2021). A regulatory strategy for the emission control of hexavalent chromium from waste-to-energy plants. *Journal of Cleaner Production*, 278. <https://doi.org/10.1016/j.jclepro.2020.123415>
- Ramos, D., Afonso, P., & Rodrigues, M. A. (2020). Integrated management systems as a key facilitator of occupational health and safety risk management: A case study in a medium sized waste management firm. *Journal of Cleaner Production*, 262, 121346. <https://doi.org/10.1016/j.jclepro.2020.121346>
- Rastmanesh, F., Shalbaf, F., Moradi, R., & Prinzhofer, A. (2020). Health risk assessment of heavy metals in Ahvaz oilfield using environmental indicators. *International Journal of Environmental Science and Technology*, 17(12). <https://doi.org/10.1007/s13762-020-02811-z>
- Rayhan, A., Ramadhan, M. U. C., & Prakasa, T. B. Y. (2023). Bioremediation in Upstream Oil and Gas Enterprises: Indonesian Environmental Law Perspectives. *UNIFIKASI: Jurnal Ilmu Hukum*, 10(2). <https://doi.org/10.25134/unifikasi.v10i2.8592>
- Rodrigues, M. A., Sá, A., Masi, D., Oliveira, A., Boustras, G., Leka, S., & Guldenmund, F. (2020). Occupational Health & Safety (OHS) management practices in micro- and small-sized enterprises: The case of the Portuguese waste management sector. *Safety Science*, 129. <https://doi.org/10.1016/j.ssci.2020.104794>
- Ruggieri, S., Maltese, S., Drago, G., Panunzi, S., Cibella, F., Bianchi, F., Minichilli, F., & Cori, L. (2021). Measuring risk perception in pregnant women in heavily polluted areas: A new methodological approach from the neho birth cohort. *International Journal of Environmental Research and Public Health*, 18(20). <https://doi.org/10.3390/ijerph182010616>
- Saadawi, H. (2020). Drones make a step change on how the oil industry manage safety and environmental risks. *International Petroleum Technology Conference 2020, IPTC 2020*. <https://doi.org/10.2523/iptc-20038-ms>
- Saini, S., Assim, M. I. S. A., Marzuki, O. F., & Yaccob, Y. (2021). Management and Development of an Assessment Tool in Predicting Competencies of Oil and Gas On-Shore Contractor Workers in Sarawak. *International Journal of Academic Research in Business and Social Sciences*, 11(12). <https://doi.org/10.6007/ijarbss/v11-i12/11746>
- Shafiee, M., & Animah, I. (2022). An integrated FMEA and MCDA based risk management approach to support life extension of subsea facilities in high-

- pressure–high-temperature (HPHT) conditions. *Journal of Marine Engineering and Technology*, 21(4). <https://doi.org/10.1080/20464177.2020.1827486>
- Pinheiro, J. , Alencar, D. , Sanches, A. , , J. , Júnior, R. , Lopes, G. , & Alencar, C. (2022). Solid waste management procedures at the medical clinic of children's hospital dr. fajardo. *International Journal of Development Research*. <https://doi.org/10.37118/ijdr.24802.07.2022>
- Tayab, M., Hashem, A., Al Hamoudi, S., Qureshi, F., & Khan, S. (2021). Integration of Health Risk Management Techniques to Address Increasing Numbers and Prevention of Non-Accident Deaths NAD in Oil & Gas Operations. *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference, ADIP 2021*. <https://doi.org/10.2118/208203-MS>
- Tharayil, S. V., Almass, A., Dursun, S., Al Mudaifer, D., & Al Qahtani, R. (2023). Industrial Training Recommendation Systems. *SPE Middle East Oil and Gas Show and Conference, MEOS, Proceedings*. <https://doi.org/10.2118/213266-MS>
- Thiruchelvam, V., Anakkachery, R., Abdulla, R., & Abdullah, Z. (2022). Wearable Technology for the Improvement of HSE Management. *International Conference on Edge Computing and Applications, ICECAA 2022 - Proceedings*. <https://doi.org/10.1109/ICECAA55415.2022.9936081>
- Tungkagi, H., Saragih, J. D., Lubis, R. D. P., & Syamil, A. (2021). A Feasibility Study of SCADA Implementation at an Indonesian Oil Company. *Jurnal Ilmiah Mandala Education*, 7(2). <https://doi.org/10.36312/jime.v7i2.2046>
- Wardhaningrum, O. A., & Kartika. (2020). *Risk Management in the Local Government of Indonesia: Drivers, Conditions, and Strategies*. <https://doi.org/10.2991/assehr.k.200529.210>
- Wegeberg, S., Fritt-Rasmussen, J., Gustavson, K., Wenning, R. J., & Bock, M. (2021). Oil Spill Response Planning in Cold and Warm Water Environments. *International Oil Spill Conference Proceedings, 2021(1)*. <https://doi.org/10.7901/2169-3358-2021.1.688879>
- Wu, H., Liu, S., Liu, D., & Wang, J. (2020). HSE Risk Assessment of Major Sewage Transport Tunnel Projects at the Construction Stage Based on the StructuralEntropy Weight Method and the Cloud Model. *Advances in Civil Engineering, 2020*. <https://doi.org/10.1155/2020/8882903>
- Yu, R., & Zhang, C. (2021). Early warning of water quality degradation: A copula-based Bayesian network model for highly efficient water quality risk assessment. *Journal of Environmental Management*, 292. <https://doi.org/10.1016/j.jenvman.2021.112749>

Zheng, S., Jin, X., Chen, M., Shi, Q., Zhang, H., & Xu, S. (2019). Hydrogen sulfide exposure induces jejunum injury via CYP450s/ROS pathway in broilers. *Chemosphere*, 214. <https://doi.org/10.1016/j.chemosphere.2018.09.002>



## Implications of Health and Environmental Policies on Investment in Regionally Owned Enterprises

Romasta Napitupulu, Rina Kumala Dewi

The impact of health and environmental policies on oil and gas sector BUMD investment, focusing on the need to adopt low-carbon technologies and improve operational efficiency for sustainability. Emphasis on the importance of economic diversification, technological innovation, and strengthening regulations to face environmental challenges and energy cost volatility.

### 11.1. Introduction

The oil and gas sector play a strategic role in supporting the regional and national economies because of its significant contribution to state revenue, job creation, and infrastructure development. Oil and gas is the main source of state revenue through taxes, royalties, and exports. A study by (Rumadan, 2020) shows that optimal management of oil and gas resources can improve people's welfare, although current management has not provided maximum benefits. Revenue from the oil and gas sector (oil and gas) has an important role as a source of state revenue through taxes, royalties, and exports. This can be seen from various international studies that underline the significant economic impact of this sector,

1. Contribution to national revenue, a study by (Pramugar & Sinaga, 2021) shows that petroleum profit tax and royalties are important elements in state revenue. However, the level of tax compliance of oil and gas companies can be affected by variables such as tax rates and violation detection.
2. Effects of royalties and taxes on revenue stability in the context of Latin America and the Caribbean, (Welsby et al., 2021) found that revenues from natural gas royalties are highly dependent on global decarbonization policies. This shows that the government must design a fiscal diversification strategy to reduce dependence on oil and gas revenues.
3. Revenue volatility from oil and gas exports, (Durand-Lasserve & Karanfil, 2023) stated that dependence on oil and gas revenues often creates fiscal instability due to energy cost volatility. For this reason, revenue management must include stabilization mechanisms that ensure economic sustainability even when oil prices fall.



4. Sustainable revenue management, a study by (Amadi & Obutte, 2020) emphasizes the importance of a strong legal framework to ensure that oil and gas revenues are utilized transparently and accountably to improve social and economic development.
5. Revenue in a global and regional context, in Russia, (Olisaeva & Vazagov, 2021) noted that tax revenues from the oil and gas sector contribute greatly to the national budget, but challenges in managing oil and gas deposits Demand Letter reform of the tax system to deal with global shocks.
6. Alternative oil and gas tax management, (Keller, 2022) explores how oil and gas resource revenues interact with non-oil and gas domestic revenues. The results show that countries with large oil and gas sectors need to improve domestic tax administration to reduce dependence on volatile resources.

Oil and gas revenues are a vital element in economic development, but their sustainability and stability are highly dependent on good management and fiscal diversification strategies. A more balanced approach to exploration, transparency, and adaptive policies can maximize the sector's contribution to community well-being.

Regional and National Gross Domestic Product (GDP) Contributors, at the local level, the oil and gas sector is often the main contributor to GDP. For Illustration, in Bojonegoro, Indonesia, the oil and gas sector contributes almost 50% to regional economic growth, although its contribution to employment is only around 4.6% compared to the agrarian sector (Qurbani et al., 2020). The oil and gas sector plays an important role in contributing to GDP both at the regional and national levels, especially in regions with abundant natural resources. In Bojonegoro, Indonesia, the oil and gas sector contributes almost 50% to regional economic growth, although its contribution to employment is only around 4.6% compared to the larger agrarian sector, which is 36% (Qurbani et al., 2020). A similar phenomenon is seen in other countries that depend on the oil and gas sector. A study by (Bilgili et al., 2020) highlights how shale gas production in several states in the United States significantly increases local GDP, showing a direct link between energy sector development and regional economic growth. The study found that oil and gas production drove GDP gains in several states such as Texas and Oklahoma. In Kazakhstan, the contribution of the oil and gas sector to GDP is also very dominant. According to (MARICHEV, 2021), an increase in the market capitalization of oil companies can have a positive impact on social and economic development in the region where the Corporation operates. In Africa, research by (Adeosun & Gbadamosi, 2021) shows that although the oil and gas sector dominate the contribution to GDP, diversification of the non-oil and gas sector is increasingly becoming a priority to reduce dependence on oil and gas. In Nigeria, the oil and gas sector contribute greatly to national GDP, but

fluctuations in oil prices have prompted the government to seek greater economic diversification (Ernest Usoro et al., 2020). These studies confirm that although the oil and gas sector contribute significantly to GDP, global market volatility and environmental challenges drive the need for economic diversification strategies to ensure long-term sustainability. This strategy is particularly relevant in regions that rely on energy resources as a key driver of economic growth.

Table 11.1. The contribution of the oil and gas sector to the GDP in several countries in recent years (2020–2023)

| Country       | 2020 | 2021 | 2022 | 2023 | Note.                                                                                        |
|---------------|------|------|------|------|----------------------------------------------------------------------------------------------|
| Arab Saudi    | 38%  | 42%  | 48%  | 50%  | One of the countries with the highest dependence on the oil and gas sector for national GDP. |
| United States | 5%   | 6%   | 7%   | 8%   | The increase occurred in line with the recovery of oil prices after the pandemic.            |
| Russia        | 17%  | 19%  | 22%  | 21%  | Fluctuating due to international sanctions and geopolitical conflicts.                       |
| Nigeria       | 7%   | 8%   | 9%   | 10%  | The contribution is relatively small but significant to the country's export revenue.        |
| Norway        | 14%  | 15%  | 17%  | 16%  | Most of the contribution comes from the natural gas sector.                                  |

sumber : [Statista](#), 2024, [IEF Report](#), 2023

Important points of interest in the contribution of the oil and gas sector to GDP from table 11.1. is the existence of High Dependence in Major Producing Countries, Countries such as Saudi Arabia and Russia have a high dependence on the oil and gas sector for their GDP. This makes their economies vulnerable to fluctuations in global oil prices. Economic Diversification: Countries such as Norway take advantage of oil and gas profits to diversify their economies, for Illustration through investment in renewable energy. Post-Pandemic Recovery, Oil and Gas' contribution to GDP increased after the pandemic due to rising oil prices and global energy Demand Letter. Challenges and Risks, High dependence creates economic risks, especially when oil prices decline or international sanctions like Russia experienced. These countries need to step up their economic diversification endeavors to mitigate these risks.

Infrastructure and Energy Development, the oil and gas sector support the development of energy infrastructure such as gas distribution networks and oil storage facilities. According to (Pushkar, 2021), investment in the oil and gas sector in Ukraine not only creates jobs but also increases local income through infrastructure development. The oil and gas sector supports the development of energy infrastructure significantly through the development of gas distribution networks, oil storage facilities, and other infrastructure that plays an important role in meeting domestic and international energy needs. For Illustration, investment in the oil and gas sector in Ukraine not only improves energy infrastructure but also creates jobs

and increases local income (Pushkar, 2021). A study by (Mahmood et al., 2023) highlights the importance of sustainable oil and gas infrastructure development. Reliable, risk-resistant, and efficient infrastructure can help meet energy needs, reduce operational costs, and reduce carbon footprints, especially in the transition to renewable energy. In addition, the integration of renewable energy technology into the oil and gas industry is also a major trend, as noted by (Panevnik, 2021). The use of renewable energy in oil and gas operations, such as solar and wind power, allows companies to reduce environmental pollution while improving operational efficiency. Furthermore, the development of efficient oil and gas transportation and storage systems, as explained by (Chen et al., 2023), shows how the sector focuses on reducing energy consumption and carbon footprint. The use of new technologies in oil and gas transportation improves energy efficiency and infrastructure safety. The oil and gas sector not only functions as an energy provider but also as a main driver of the development of resilient and sustainable energy infrastructure. Investments in this infrastructure are critical to ensuring a stable energy supply while supporting the global sustainability agenda.

**Economic and Energy Stability** As the main energy provider, the oil and gas sector play a key role in maintaining energy stability, especially in meeting domestic needs and supporting the industrial sector. A study by (Petrenko et al., 2022) identified that automation and technology-based management will be a top priority in the development of the oil and gas industry to support the sustainability of the national economy. Another study by (Mahmood et al., 2023) emphasizes that reliable and resilient oil and gas infrastructure is an important element in maintaining a stable energy supply, which ultimately supports economic stability. This infrastructure is designed to manage the increasing Demand Letter for energy while keeping sustainability aspects in mind. In a global context, a study by (Guo et al., 2023) identifies that oil and gas companies face major challenges in the era of decarbonization and reglobalization. While Demand Letter for fossil fuels remains high in the short-term, companies need to formulate new strategies to remain relevant in the changing energy market. In Russia, research by (Ilinova & Solovyova, 2021) shows that the oil and gas sector play a central role in maintaining national energy stock. However, global energy cost volatility requires companies to adopt more adaptive strategic planning to manage market risks and meet domestic energy needs. The oil and gas sector remains the backbone of energy and economic stability, despite facing significant challenges in the energy transition era. The integration of advanced technologies, strategic planning, and the development of resilient infrastructure are key to ensuring the sector's vital role in supporting the global and national economy.

Drivers of the energy transition, despite facing challenges from the global energy transition, the oil and gas sector remains a key element in supporting the

transformation toward renewable energy. According to (Cherepovitsyn & Rutenko, 2022), decarbonization strategies implemented by oil and gas companies can support sustainability while ensuring their contribution to the economy. This approach includes strategic planning that focuses on operational efficiency and investment in low-carbon technologies. Another study by (Oruwari & Itsekor, 2023) shows that oil and gas companies can reduce carbon emissions through strategies such as the use of new energy sources, exhaust gas management, improving energy efficiency, and the application of carbon capture and storage (CCS) technology. This strategy accelerates the transition to renewable energy and ensures the Corporation remains relevant in the energy market. The study by (Guo et al., 2023) also highlights the duality challenges facing oil and gas companies: meeting short-term energy needs while navigating regulatory and market pressures to reduce their carbon footprint. They suggest that the integration of new technologies such as hydrogen and renewable energy could be a strategic step to ensure sustainability. Case studies show the success of the energy transition in the oil and gas sector through technology integration. For illustration, (Theodorou et al., 2020) demonstrated how a hybrid energy system that combines wind power, diesel, and hydrogen-based energy storage is able to reduce carbon emissions by up to 10,530 tons of CO<sub>2</sub> per year in remote oil and gas production facilities. Meanwhile, (M. Li et al., 2022) noted that although many large oil and gas companies claim to have adopted clean energy strategies, their investment levels and concrete actions are still not in line with the announced rhetoric. The oil and gas sector has a key role in the energy transition with an effective decarbonization strategy. Investments in low-carbon technologies, business model adaptations, and renewable energy innovations are critical elements to maintain the sustainability of the sector amid global change.

Technological Innovation Catalysts in the oil and gas sector spur the development of new technologies, such as automation and robotics, to improve operational efficiency. This technology is also relevant in supporting clean energy and mitigating environmental impacts (Ainuddin & Suryadilaga, 2021). The oil and gas (oil and gas) sector is spurring the development of innovative new technologies, such as automation, robotics, and artificial intelligence, to improve operational efficiency and support clean energy and environmental impact mitigation. This technology has helped oil and gas companies optimize operations, improve safety, and reduce production costs. According to (Ma et al., 2021), the adoption of robotic inspection systems for drilling equipment has improved inspection efficiency through the use of high-resolution 3D imaging and artificial intelligence. This technology allows for reduced labor costs and improved product quality, reflecting the potential for automation in the oil and gas sector. A study by (Ivanova, 2023) underscores the role of digital technology in oil and gas production to achieve optimal energy efficiency. Digital solutions that include real-time monitoring and strategic management have

enabled companies to improve sustainability through energy conservation. In addition, (Jacobs, 2022) noted that the use of robots in chemical laboratories in the oil and gas sector has created new production lines for chemicals used in oil and gas exploration and production. This robotics technology shows how automation can improve supply chain management and product quality. Another study by (Eley et al., 2023) highlights the implementation of automation systems on offshore platforms, such as Walk to Work (W2W) systems, which enable remote monitoring and maintenance for unmanned installations. This technology helps reduce risks for workers and improve operational efficiency. The adoption of new technologies in the oil and gas sector not only improves efficiency but also allows companies to contribute to global sustainability endeavors. Technologies such as automation, artificial intelligence, and robotics have been key catalysts in the sector's transformation toward more efficient, safe, and environmentally friendly operations.

The oil and gas sector is not only the backbone of national energy but also the main driver of economic development, both at the local and national levels. Sustainability-oriented strategic management will ensure that the sector remains relevant in supporting economic growth in the global energy transition era.

### **11.2. Health and Environmental Policy**

Health and environmental policies have a significant impact on operations and investment in the oil and gas (oil and gas) sector. This policy affects various aspects ranging from investment efficiency, company innovation, to the health impact of people living around the location of operations.

1. Impact on efficiency and investment strategy, strict environmental policies encourage oil and gas companies to be more efficient in investment and innovation. For illustration, research in Canada shows that easing environmental policies improves the efficiency of corporate investment, although it reduces pressure on emission reductions (Dong et al., 2020). On the other hand, policies that incorporate environmental aspects into investment decisions provide long-term competitive opportunities through state incentives and increase the competitiveness of projects in the sector (Beliakov & Shabanov, 2020).

Environmental policies play an important role in directing oil and gas companies toward investment efficiency and long-term sustainability strategies. Companies that are able to integrate these policies into their business models will not only improve operational efficiency but also global competitiveness amid sustainability demands. Investment efficiency, environmental policies put pressure on companies to adapt to energy-efficient technologies (Table 11.2).

Table 11.2. The Impact of Environmental Policy on Investment Efficiency

| Research                      | Study Focus                                      | Key Results.                                                                                                                                  |
|-------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| (Dong et al., 2020)           | Relaxation of environmental policies in Canada   | Improving investment efficiency, but lowering the pressure to reduce emissions.                                                               |
| (Beliakov & Shabanov, 2020)   | Sustainability-based investment strategies       | Environment-based policies improve project competitiveness and long-term efficiency through incentives and effective resource management.     |
| (Jarboui et al., 2022)        | Technical efficiency in US oil and gas companies | Average technical efficiency 75%; This efficiency is influenced by renewable energy and nuclear policies.                                     |
| (Azieva & Taymaskhanov, 2023) | Energy efficiency in the oil and gas sector      | Investments in energy-efficient technologies result in huge savings and increase the profitability of oil and gas companies.                  |
| (H. Tang et al., 2023)        | Innovation and environmental sustainability      | the Corporation's innovation investments increase environmental sustainability; Managerial stock incentives are a significant driving factor. |

Source : Author's Search, 2024

Policy easing such as in Canada improves the efficiency of short-term investments, but reduces environmental sustainability. Strategic advantages, policies that support environmental incentives allow companies to remain economically competitive while mitigating environmental impacts. Technological innovation, policies that encourage innovation accelerate the adoption of sustainable technologies, such as renewable energy, which increases the efficiency and profitability of companies.

2. Innovation and sustainability, policies that emphasize sustainability motivate companies to innovate. Policies that focus on sustainability encourage oil and gas companies to innovate, especially in the context of green technology and energy efficiency. Research shows that investment in innovation has a positive impact on environmental sustainability. For Illustration, in the United States, investment in innovation by oil and gas companies is directly linked to improving environmental sustainability. The study also found that management's stock incentives play an important role in moderating those relationships, creating a stronger motivation to innovate sustainably (H. Tang et al., 2023). Other research shows that the introduction of green innovation not only improves sustainability but also provides a competitive advantage. Innovative technologies such as renewable energy, digitalization, and electrification in the energy supply chain have helped oil and gas companies meet the Sustainable Development Goals (SDGs), while expanding the local innovation ecosystem. A study in Spain, for Illustration, found that these innovations can create regional synergies and drive significant growth in green

industries (Yakovlev & Berezhnov, 2021). Green innovations in the oil and gas sector have been found to have a positive impact on the financial performance of companies in Europe and the United States. This impact is strongest when companies are at a high level of green innovation, demonstrating the importance of a consistent sustainability commitment (Aastvedt et al., 2021).

Another article discusses the potential for transformation of the oil and gas sector through the development of low-carbon technologies, such as CCS and the electrification of operations. This technology not only improves efficiency but also helps companies meet carbon emission reduction targets (Joustra et al., 2022). In Norway, case studies show that business model innovations, among other things, diversification of energy services, can help oil and gas companies adapt to market Demand Letter for more sustainable energy. However, the success of this transformation is highly dependent on the Corporation's internal readiness to change (Sletten et al., 2023). Investments in green technology innovations and sustainability policies provide significant benefits for oil and gas companies. Not only does it improve efficiency and sustainability, but it also expands regional innovation opportunities and strengthens its competitive position in an energy market that is increasingly shifting to low-carbon solutions. Cross-sector collaboration and government support also play an important role in driving this transformation.

3. Health and social impact, oil and gas operations contribute to significant air pollution, increasing health risks such as asthma, cancer, and respiratory diseases. A study in Oklahoma found that unconventional drilling activities directly increase mortality and lower the life expectancy of surrounding communities (Apergis et al., 2021). In addition, policies to reduce methane emissions in the oil and gas sector can provide significant health benefits, such as reducing thousands of deaths from air pollution each year in the United States (Buonocore et al., 2023). Oil and gas (oil and gas) operations contribute significantly to air pollution, which increases the risk of serious diseases such as asthma, cancer, and respiratory disorders. Research in Oklahoma found that unconventional oil and gas development (UNGD) activities led to an increase in mortality, cancer, and cardiovascular disease as well as a decrease in life expectancy in the surrounding community (Apergis et al., 2021). In addition, methane emissions from the oil and gas sector, which is one of the most harmful greenhouse gases, also produce air pollution that has an impact on health. A study in the United States showed that reducing emissions from this sector could prevent more than 7,500 premature deaths per year and reduce thousands of cases of asthma exacerbations, with a total health impact value of \$77 billion per year (J. J. Buonocore et al., 2023). Oil and gas activities also cause significant social impacts, such as increased community dissatisfaction due to light pollution in drilling areas that affect the

quality of sleep and well-being of rural communities (Boslett et al., 2021). In addition, there are conflicts related to compensation and the implementation of Corporate Social Responsibility (CSR) by oil and gas companies, such as what happened in Tuban, Indonesia, although some communities also feel economic benefits, such as increased employment (Patimah et al., 2023). Workers in the oil and gas sector are exposed to a variety of health risks, among other things, respiratory disorders, cancer, and cardiovascular disease due to exposure to chemicals such as mercury, toxic gases, and fine particles during the drilling process (Palathoti et al., 2022). In addition, workers often experience mental health problems such as anxiety and depression due to social isolation in remote workplaces (Alroomi & Mohamed, 2021). To mitigate these health and social impacts, policies that support emission reduction, better waste management, and improved occupational safety standards need to be implemented. In addition, the development of low-emission technologies and investments in environmental stewardship can provide long-term health benefits for communities and workers. Oil and gas operations have a major impact on public health, quality of life, and social dynamics. Effective management policies, among other things, emission reduction and the implementation of green technologies, are essential to mitigate these impacts and support sustainability.

4. Sustainability and ecosystem impacts, oil and gas operations such as those in Brazil's pre-salt regions show long-term impacts on ecosystems through permanent and irreversible disruptions to marine and terrestrial environments. Oil and gas operations in Brazil's pre-salt regions, such as in the Santos and Campos Basins, have a significant impact on marine and terrestrial ecosystems. These impacts are long-term, often permanent, and difficult to reverse. For illustration, research shows that the exploitation of hydrocarbons in this region causes 53 types of environmental impacts that include permanent, partially reversible, and irreversible ecological disturbances. These disturbances include seawater pollution, biodiversity Casualty, and destruction of unique marine habitats in pre-salt areas (Mein et al., 2021). Brazil's pre-salt regions have a complex ecosystem system that includes coral reefs, mangroves, and coastal areas with high biodiversity. Studies show that drilling activities can cause serious damage, among other things, oil leaks that destroy marine habitats and coastal communities. For illustration, an oil spill in 2019 caused damage to more than 3,000 km of Brazil's coastline, among other things, protected ecosystems, with ecological and social consequences that have not been fully restored to date (Soares et al., 2020). Integrated environmental impact evaluation, such as that carried out in the EIA/RIMA (Environmental Impact Assessment/Report on Environmental Impact) procedure, has been proposed as an important tool to minimize ecological impacts. This study identifies the need for a multidisciplinary approach in



assessing environmental vulnerability, especially in pre-salt operations. This method allows for the identification of impacts in the early stages of the project so that mitigation actions can be planned before permanent impacts occur (F. Oliveira et al., 2023). Low-carbon technologies and sustainable exploitation methods can be used to reduce the impact of oil and gas operations in the region. An illustration is the CO<sub>2</sub> injection method which not only increases oil production but also reduces carbon emissions through geological storage (Godoi & dos Santos Matai, 2021). In addition, the development of a strict environmental policy is necessary to ensure that these operations are in line with sustainability principles. Oil and gas operations in Brazil's pre-salt region pose a major challenge to ecosystem sustainability. However, through integrated impact evaluation, the implementation of sustainable technologies, and strict environmental policies, damage can be minimized. This approach not only protects biodiversity but also supports climate change mitigation endeavors and responsible development.

5. Role of government policy, In China, the government's attention to the environment has been proven to contribute to improving public health by increasing investment in environmental management and creating a significant positive effect on the health of the population in areas that are less open to globalization (Tian et al., 2022). The Chinese government has played an important role in improving public health through various environmental management policies. These policies have been designed to address the adverse health impacts of environmental pollution, particularly in underdeveloped or underexposed areas of globalization. For illustration, the implementation of the Two Control Zones (TCZ) policy shows that strict environmental regulations have succeeded in reducing the incidence of respiratory diseases by 5.7% in the target area, with long-term lasting impacts (Yang et al., 2023).

An analysis of data panels from 30 provinces in China shows that environmental regulations not only improve air quality but also lower public health costs. For illustration, improvements in waste gas and wastewater treatment contribute to reduced health costs, with air pollution being shown to have a more significant negative impact compared to water pollution (L. Tang et al., 2020). In addition, carbon trading policies also show great benefits. For illustration, emissions trading system (ETS) policies in China reduce the incidence of respiratory diseases and improve public health, especially in rural areas near pollution sources (Huang & Li, 2022). Environmental policies not only improve physical health but also the subjective well-being of the community. Studies show that economic incentive-based regulation has a greater impact on public health and economic development compared to order-based regulation. These regulations create a positive regulatory effect through pollution reduction and better environmental management (Xu et al., 2022). However, the implementation of environmental

policies faces challenges in underdeveloped areas. In these regions, increased environmental regulation is often accompanied by negative effects on people's incomes, despite significant health benefits. To address this, the government can introduce more subsidies or workforce training to support communities directly affected by these regulations (Pei et al., 2023). The Chinese government's policies in environmental management have proven to be successful in improving public health through pollution reduction and environmental quality improvement. However, more measures are needed to support the economically affected communities from this policy, as well as to ensure the sustainability of its benefits in the future.

Health and environmental policies have a great influence in shaping the operational direction and investment strategy in the oil and gas (oil and gas) sector. Companies in this sector are vital to balance environmental sustainability with economic efficiency. Environmental policies that pay attention to sustainability not only reduce negative impacts on ecosystems but also open up opportunities for innovation and increased efficiency. Research in Canada shows that easing environmental policies can improve the investment efficiency of oil and gas companies. However, these policies often reduce pressure on emission reductions, which negatively impacts environmental sustainability in the long-term ((Dong et al., 2020). Instead, the integration of environmental aspects in investment policies allows companies to take advantage of state incentives to support greener projects. This policy strengthens the competitiveness of companies in the global energy market (Beliakov & Shabanov, 2020).

Policies that emphasize sustainability encourage oil and gas companies to innovate. Investments in green innovation have been shown to improve environmental efficiency and long-term profitability. Studies in the United States show that managerial stock incentives strengthen the positive relationship between innovation and sustainability, allowing for the faster development of environmentally friendly technologies (H. Tang et al., 2023). Policies to reduce methane emissions in the oil and gas sector provide great health benefits. For Illustration, reducing methane emissions in the United States is estimated to prevent more than 7,500 deaths from air pollution each year, with health benefits worth \$77 billion per year (J. J. Buonocore et al., 2023). In addition, public health around oil and gas operating areas can be improved through stricter policies on air and water pollution (L. Tang et al., 2020). While health and environmental policies provide significant benefits, their implementation faces challenges such as increased investment costs and resistance from local communities. Governments and oil and gas companies need to address these challenges through transparent communication, adequate incentives, and the adoption of innovative technologies such as CCS to minimize environmental impacts

(Mein et al., 2021). Health and environmental policies are key elements in determining the sustainability and profitability of the oil and gas sector. Through the implementation of balanced policies and sustainable innovation, oil and gas companies can play an important role in supporting environmentally friendly development and contributing to public health at large.

Revenue policies from the oil and gas sector have a significant influence on investment in oil and gas BUMD. Dependence on oil and gas revenues often triggers fiscal instability due to fluctuations in energy prices. Therefore, stabilization mechanisms are needed to reduce the impact of oil cost volatility and ensure economic sustainability (Durand-Lasserve & Karanfil, 2023). In addition, fiscal policies that rely too much on oil and gas taxes can limit sustainable domestic investment, so incentives are needed to diversify investment into the renewable energy and non-oil and gas sectors. This incentive has proven to be able to increase the investment efficiency of oil and gas companies and support the development of other sectors that are more stable (Dong et al., 2020; Keller, 2022). Furthermore, diversification and energy transition are important keys. State-owned oil and gas companies in BRICS countries have proven to be slow in carrying out clean energy innovations due to their dependence on oil revenues, so government policies that support the low-carbon energy transition are very important (Jaffe et al., 2023). Foreign direct investment (FDI) also plays an important role in improving the competitiveness of the oil and gas sector, but balanced regulation is needed to ensure national benefits while preventing the dominance of foreign investors (Otarbayeva & Arupov, 2020; YIRAN & HAO, 2023). However, environmental policy also plays a strategic role. Loose environmental policies can improve the investment efficiency of oil and gas companies but reduce pressure to reduce emissions. Therefore, the balance between economic incentives and environmental responsibility should be a primary concern (Dong et al., 2020). To increase the competitiveness of oil and gas BUMDs, strategic measures are needed such as diversifying investment portfolios into the non-oil and gas sector, increasing investment in low-carbon technologies, reviewing tax policies, and strengthening the legal framework to encourage accountability and transparency in oil and gas revenue management. With a holistic, innovative, and adaptive approach, the oil and gas sector can continue to make a significant contribution to sustainable economic development.

### **11.3. Implementation of Health and Environmental Policy in the Oil and Gas Sector**

Health and environmental policies in the oil and gas sector aim to manage worker health risks as well as environmental impacts from oil and gas activities involving exploration, production, processing, and transportation of resources. The

concept of Health and Environmental Policy in the Oil and Gas Sector at least includes the following important things.

1. Occupational health and safety management

The OSH policy aims to protect workers from high occupational risks, such as exposure to hazardous chemicals, noise, as well as physical hazards such as explosions and fires. Studies show that the implementation of international standards such as ISO 45000 and comprehensive training are essential to reduce work accidents in the sector (Oduoza et al., 2023). Additionally, initiatives such as regular worker health monitoring have been shown to improve health and safety in the workplace (G. M. Oliveira et al., 2020). Occupational Health and Safety Management in the oil and gas sector aims to protect workers from various high occupational risks. These risks include exposure to hazardous chemicals, high levels of noise, explosions, fires, and physical injuries. As one of the sectors with a high level of danger, the effective implementation of the OSH system is crucial to ensure worker safety and operational efficiency. The application of international standards, such as ISO 45001:2018, is an important foundation in the OSH management system. These standards require companies to integrate safety in operational processes, mitigate risks, and promote a sustainable safety culture. A study shows that the implementation of ISO 45001 in oil and gas companies has been shown to reduce accident rates and improve compliance with occupational safety regulations (Tverytnykova et al., 2021). Auditing of OSH systems based on these standards also helps identify weaknesses in safety management and provides opportunities for continuous improvement (Balkat & Khaleel, 2021).

In addition, regular monitoring of workers' health is an important element in maintaining work safety. Case studies show that health surveillance programs, such as risk assessments and routine health checks, are effective in preventing occupational injuries and occupational diseases in the oil and gas industry (G. M. Oliveira et al., 2020). Research in Nigeria also highlights the importance of mandatory medical examinations to monitor exposure to hazards such as chemicals and noise, which can lead to long-term illnesses such as respiratory distress and cardiovascular disease (Benson et al., 2021). Occupational safety training is another vital element in OSH management. Research shows that regular training on risk management and the correct use of personal protective equipment (PPE) increases workers' awareness and compliance with safety procedures. In Ghana, safety training has proven effective in reducing the number of occupational accidents and increasing workers' awareness of operational risks (Quaigrain et al., 2024). Leadership also plays a key role in K3 management. Studies in the oil and gas sector show that good communication between leaders and workers increases commitment to occupational safety and advises active participation in the implementation of OSH programs. Leadership that involves workers directly in the formulation of safety policies has been shown to

create a better safety culture in the workplace (Abdul Rashid et al., 2023). The successful implementation of OSH management in the oil and gas sector depends on a combination of the implementation of international standards, regular training, health monitoring, and effective leadership. With integrated OSH management, the Corporation not only protects workers from occupational risks, but also ensures the sustainability of safe and efficient operations.

## 2. Environmental impact management

The oil and gas industry has a significant impact on the environment, such as water, soil, and air pollution. Effective environmental policies should include EIAs to mitigate these risks. EIA is used to identify and plan measures to reduce the environmental impact of oil and gas activities (Kislyakova & Usatova, 2022). In the United States, reducing methane emissions has been identified as an important policy that provides significant health and environmental benefits (J. Buonocore et al., 2021). Environmental impact management in the oil and gas (oil and gas) sector is an important step to mitigate the risk of water, soil, and air pollution resulting from fossil fuel exploration, production, and transportation. A good environmental policy should include an EIA as a strategic tool for identifying risks and planning mitigation measures. The following is a more detailed overview based on the latest literature: first, the Concept of EIA, EIA is an important tool in managing the operational impact of the oil and gas sector. This assessment allows for the initial identification of risks to the environment and the preparation of mitigation plans. For Illustration, in the oil and gas facility construction industry, significant environmental aspects, such as soil and water pollution, must be evaluated using a priority-based approach to reduce ecological impacts (Vorobeve et al., 2021). A similar approach is used to evaluate the impact of oil and gas on the northern regions of Russia, where the resulting level of anthropogenic impact requires specific mitigation recommendations (Gilyova & Podkovyrova, 2020). Second, Emission Reduction and Its Impact, Methane emission reduction policies have great benefits for the environment and health. Studies in the United States show that this policy can significantly reduce air pollution and provide economic benefits for oil and gas companies (J. Buonocore et al., 2021). On the other hand, technology-based approaches, such as multi-parameter integration methods, can be used to assess and mitigate harmful emissions from oil and gas production facilities (Gubar & Tupitsyna, 2022). Third, Environmental Risk Management: The implementation of an integrated environmental risk management system allows for more efficient management. For Illustration, a study in the Eastern Siberia region used a combined methodology to evaluate the environmental risks of oil and gas operations, resulting in more effective mitigation strategies in reducing anthropogenic impacts (Gorlenko et al., 2020). In addition, a rapid impact matrix-based approach can help decision-making in managing the environmental impact of oil and gas facilities, such as those applied in Iraq (Resen et al., 2023). Fourth, Relevance to Sustainability,

Good environmental management also supports economic and social sustainability. By using environmental management frameworks, such as Environmental Management Systems (EMS), companies can improve efficiency while reducing their ecological footprint (Guerrero-Martin et al., 2023). In addition, the application of this methodology helps to increase the Corporation's attractiveness to investors by ensuring compliance with responsible environmental principles (Nazarova & Tikhomirov, 2022).

Environmental impact management in the oil and gas sector must be comprehensive and integrated, among other things, risk assessment, emission reduction, and the implementation of an environmental management system. Through evidence-based policies and cutting-edge technology, the industry can minimize its negative impact on the environment while supporting operational sustainability.

### 3. Risk management and supporting technologies

Technologies such as artificial intelligence (AI) can help monitor and manage health and environmental risks in real-time. The use of AI in predicting damage to infrastructure can reduce the risk of operational failures that can adversely affect workers and the environment (Popescu et al., 2020). Risk management in the oil and gas (oil and gas) industry is an essential step to identify, assess, and manage risks that can affect operations, safety, and the environment. With the development of technology, AI is increasingly being used to support risk management, especially in monitoring and analyzing data in real-time. The following is a detailed explanation of the supporting technologies and their benefits based on the application of AI in risk management, among other things:

#### a. Real-Time Risk Monitoring

AI enables real-time risk monitoring through data analysis from various sensors. This technology can detect anomalies, such as leaks in infrastructure, to prevent operational failures. Research shows that AI-based on deep learning algorithms can be used to predict damage to physical assets in the oil and gas industry, improving prediction accuracy and significantly reducing risk (Popescu et al., 2020).

#### b. Reduction of Work Accidents

In an effort to prevent work accidents, AI has been used to recognize risky situations, such as workers without PPE or vehicles violating speed limits. This AI-based system is able to provide automated alerts and reports for safety audits, thereby improving operational efficiency (Fortunato et al., 2023).

#### c. Production Prediction and Optimization

In the upstream sector, AI is used to optimize the exploration and development of oilfields. Machine learning algorithms can predict production dynamics, improve

planning, and support decision-making to minimize operational risks (Koroteev & Tekic, 2021).

d. Environmental Health and Safety Risk Management

AI-based technology is also used for health, safety, and environmental (HSE) risk management. At PETRONAS, the AIIRA platform was developed to predict HSE risks through big data analysis. The platform has managed to reduce accidents by up to 50% in the last two-year period (Agusalim et al., 2023).

e. Big Data Analysis and Dynamic Risk Prediction

By leveraging big data from various operational processes, AI enables information integration for dynamic risk management. For illustration, well drilling and construction risks can be analyzed in real-time to identify potential hazards and provide proactive solutions (Hutchins et al., 2022).

f. Cost Optimization and Operational Efficiency

AI applications, such as predictive models for more oil recovery (EOR), can improve production efficiency and reduce operating costs. This helps companies to achieve maximum results with minimal resources (H. Li et al., 2021).

While AI has provided many benefits, key challenges include the limitations of quality data, lack of cross-departmental collaboration, and the need to build trust among workers in this technology. With the continued development of AI technology, the prospects for its future use include further automation, cross-functional integration, and more efficient reduction of environmental impact (Gupta et al., 2023). The use of AI in risk management in the oil and gas sector has brought significant changes, from risk prediction to operational optimization. With this technology, companies can improve occupational safety, reduce environmental impact, and maximize production efficiency, making it a highly relevant solution for the future of the industry.

4. Empowerment of Workers and Local Communities

The welfare of local communities is also a concern in oil and gas policy. For illustration, in Brazil, health and safety policies after major incidents have been focused on involving workers in planning and decision-making to reduce the negative impact of work on their physical and mental health (Guida et al., 2020). The policy of empowering workers and local communities in the oil and gas (oil and gas) sector aims to ensure the physical, mental, and social well-being of workers and surrounding communities directly affected by industrial activities. This policy focuses on the involvement of workers and communities in the decision-making process, upskilling, and handling occupational health and safety risks. Some references to the concept and implementation of empowerment policies that can be used as references include:

a. Worker Involvement in Occupational Safety and Health Policy

After the major incident in Brazil, oil and gas companies implemented a more inclusive policy by involving workers in planning and decision-making related to occupational safety. Research shows that although investment in safety is increasing, direct worker involvement in these processes is still limited, so there is a need to integrate a more robust participatory approach (Guida et al., 2020).

b. Local Community Involvement in Governance

Local community empowerment involves managing relationships between communities and companies through collaborative governance. Research in Uganda shows that community participation in decision-making increases collaboration with other actors, thereby creating a positive impact on social and environmental sustainability in the oil and gas sector (Coleman et al., 2023).

c. Capacity Building and Worker Training

Training is a key element for worker empowerment. Studies in the oil and gas sector show that skill development through safety training not only reduces the risk of work accidents but also increases workers' confidence in handling emergency situations (Oduoza et al., 2023).

d. Community Empowerment for Health Promotion

In Palu, Indonesia, after the disaster, community empowerment was carried out by involving various stakeholders such as religious organizations and local governments to support the Healthy Living Community Movement program. This program increases public awareness of health by providing incentives for health cadres and involving them in environmental sustainability initiatives (Ardiansyah Arif et al., 2020).

e. Use of Technology in Worker Well-being

Technologies such as telehealth and telemedicine are being used to improve workers' access to healthcare, especially in remote locations. Studies show that these services not only reduce costly medical evacuations but also improve worker satisfaction and health outcomes (Fox et al., 2023).

Policies to empower workers and local communities in the oil and gas sector must be inclusive, community-based, and use a collaborative approach to ensure sustainable social, environmental, and health benefits. Increased worker engagement, community capacity building, and health technology adoption are important steps to achieve this goal.

5. Social and Ethical Impact

Environmental policies that ignore social and ethical justice, such as in the UK on shale gas exploration, often fail to address health and environmental impacts holistically. This highlights the importance of, among other things, social justice aspects in the formulation of environmental policies (Watterson & Dinan, 2020). Social and ethical impacts in the oil and gas sector are of great concern, especially



since exploration and production activities often give rise to social injustices as well as complex environmental problems. Policies that do not incorporate social justice and ethical principles tend to fail to address overall health, social, and environmental impacts. The importance of Social Justice and Ethics in Oil and Gas Policy is of special concern with several considerations, among other things:

a. Policy Failure on Shale Gas Exploration in the UK

Studies in the United Kingdom show that policies governing shale gas exploration often ignore public health impacts and environmental justice. Regulations that do not prioritize ethical and social justice elements lead to failures in addressing the impact of air pollution and environmental damage holistically. Industry often influences policies to avoid strict regulations, so the impact on public health is negligible (Watterson & Dinan, 2020).

b. The Importance of CSR

CSR is one of the approaches to integrate social and ethical values in oil and gas company operations. A study in Nigeria shows that the implementation of non-transparent CSR often creates conflicts between companies and local communities. An ethical approach is needed to ensure that CSR provides tangible benefits to the host community, not just the fulfillment of formalities (Izidor, 2021).

c. Environmental Sustainability Through an Ethical Approach

Another study highlights how companies can improve environmental sustainability through the implementation of Environmental Social Governance (ESG) systems. ESG includes ethical principles and transparency to ensure that companies comply with environmental, social, and governance sustainability standards. The implementation of ESG has been shown to increase a corporation attractiveness to investors and improve public relations (Nazarova & Tikhomirov, 2022).

d. Positive Social Impact Through Environmental Sensitivity

A study in Oman shows that governments that promote social sustainability policies help create more innovative practices in the oil and gas industry supply chain. However, regulatory pressure alone is not enough; the Corporation must also demonstrate initiative in meeting the social needs of the local community (Rentizelas et al., 2020).

e. Human Rights in Supply Chains

Human rights violations are frequent in the oil and gas sector, especially in the supply chain. The implementation of human rights principles by companies such as PETRONAS, among other things, safety training and evaluation of contractor practices, is an important illustration of how ethics can be integrated in a corporation value chain to improve social sustainability (Carpenter, 2020).

Environmental policies in the oil and gas sector require the integration of social justice and ethical principles to comprehensively address social, health, and

environmental impacts. CSR, ESG, and human rights-based approaches are important tools to create fairer and more sustainable industry practices. Thus, oil and gas companies can minimize social conflicts and improve relationships with local communities and other stakeholders.

Health and environmental policies in the oil and gas sector must be holistic, among other things, worker protection, environmental impact mitigation, adoption of modern technology, and empowerment of local communities. With the implementation of the right policies, health and environmental risks from this sector can be minimized. The health of workers in the oil and gas sector is a major concern in the Occupational Safety and Health (OHS) policy which aims to protect them from high risks due to physical, chemical, ergonomic, and psychosocial hazards. Relevant policies and their implementation based on OSH Standards in the Oil and Gas Sector have been carried out in several respects which are the Implementation of International Standards and other important matters. Standards such as ISO 45001:2018 and OHSAS 18001 are the cornerstones of the occupational health and safety management (OHSM) system. The implementation of these standards has been shown to be effective in reducing occupational accidents and improving compliance with workplace safety regulations (Tverytnykova et al., 2021). In Iraq, an audit of the OSH system based on ISO 45001 identified gaps in implementation that could be opportunities for improvement (Balkat & Khaleel, 2021). Ergonomic, physical, and chemical hazards are the main risks in the oil and gas sector. Studies in Nigeria found that workers often experience short-term disorders such as skin irritation and headaches, as well as long-term risks such as respiratory distress and cardiovascular disease. Regular medical surveillance and risk assessment are important recommendations to minimize the impact (Benson et al., 2021). Effective communication between leaders and workers plays an important role in building a commitment to safety. Research shows that leadership that advises active participation of workers in safety programs can improve safety culture and reduce workplace accidents (Abdul Rashid et al., 2023). Worker motivation has a great influence on the effectiveness of OSH practices. Regular training on work hazards and the implementation of safety procedures is an important step to improve compliance. In Ghana, it was found that workers with high knowledge were more compliant with safety practices, although their effects on comprehensive implementation still need to be improved (Quaigrain et al., 2024). The oil and gas industry presents psychosocial challenges such as isolation and high pressure. Innovative approaches such as mental hygiene can help workers manage stress and prevent mental health disorders, which are often higher in this sector than in the general population (Khalid et al., 2022). OSH policies in the oil and gas sector must include a holistic approach involving the application of international standards, occupational hazard management, safety training, and attention to the psychosocial well-being of workers. This consistent,

evidence-based implementation not only protects workers but also ensures the sustainability of the Corporation's operations.

In the oil and gas (oil and gas) industry, various regulations and initiatives have been implemented to reduce environmental impacts related to carbon emissions, pollution prevention, waste management, and the adoption of renewable energy (Table 11.3). Some descriptions of various relevant endeavor, among other things, carbon emission regulations play an important role in mitigating climate change. Studies show that the adoption of environmental taxes can significantly reduce CO<sub>2</sub> emissions, such as in China, where environmental tax policies and related sector management have succeeded in reducing SO<sub>2</sub> by up to 24.5% and CO<sub>2</sub> by up to 11% in certain scenarios (G. Li et al., 2021). The oil and gas industry has also begun to implement methane reduction technology, which accounts for about 30% of global warming, with methane intensity emission results decreasing by up to 28% in recent years in the United States (Presley, 2023).

Table 11.3. Environmental policies related to emission thresholds, exploration regulations, oil and gas production, energy transition policies

| Categories Policy                                   | Description                                                                                                                                                                                                                                                                                                                                    | Scientific References                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Emission Threshold                                  | Setting thresholds for carbon dioxide (CO <sub>2</sub> ) emissions and other greenhouse gases in the industrial sector, among other things, oil and gas. This policy aims to reduce environmental impact by mandating the use of low-emission technologies such as desulfurization and SO <sub>x</sub> and NO <sub>x</sub> monitoring systems. | Studies show that limiting SO <sub>x</sub> emissions through scrubbers and switching to low-sulfur fuels in the oil and gas industry significantly reduces air pollution, but requires improved energy efficiency and infrastructure investment (Kanaboshi et al., 2021; Liu, 2022).                                                                      |
|                                                     | Determination of CO <sub>2</sub> , SO <sub>x</sub> , and NO <sub>x</sub> emission limits through national regulations, such as the Clean Air Regulation (CAR 2014) in Malaysia. In addition, pollution control technologies such as Flue Gas Desulfurization (FGD) and Ammonia Desulfurization have begun to be implemented.                   | Technologies such as Caustic Scrubber have significantly reduced SO <sub>x</sub> emissions as per the 2014 CAR regulations, while global threshold policies help guide the transition to cleaner technologies (Haji Nawawi & Jaafar, 2021).                                                                                                               |
| Oil and Gas Exploration and Production Regulations. | Regulations related to oil and gas exploration and production, such as limiting methane emissions and managing drilling waste. This includes methane emission reduction technologies and sustainable waste management through pyrolysis or waste reinjection.                                                                                  | The use of drilling waste management technology, such as thermal processing and bulk transfer, has been proven to reduce carbon emissions by up to 48% compared to traditional methods (Innes et al., 2021). Reduction in methane emission intensity is also achieved through leak detection technology with drones and infrared cameras (Presley, 2023). |

| Categories Policy            | Description                                                                                                                                                                                                          | Scientific References                                                                                                                                                                                                                                                                                                                          |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | Regulations on more environmentally friendly oil and gas exploration and production, such as the management of drilling waste through reinjection or pyrolysis, as well as stricter monitoring of methane emissions. | Reinjection of drilling waste is proven to be a carbon-saving alternative at drilling sites. In addition, pyrolysis and drone monitoring technologies to detect methane leaks provide tangible results in reducing emission intensity (Chew et al., 2021; Presley, 2023).                                                                      |
| Energy Transition Policy.    | Push for the adoption of renewable energy in oil and gas operations, among other things, the integration of solar, hydrogen, and biomass energy to support net-zero emissions targets.                               | Solar energy and hydrogen are identified as the most effective transitional energy sources to support the decarbonization of oil and gas operations (Temizel et al., 2023). Biomass, when used with coal (co-firing), is able to reduce carbon emissions by up to millions of tons per year at the national level (Mohd Idris & Hashim, 2021). |
|                              | Global initiatives such as the use of renewable energy in the oil and gas industry (e.g., co-firing biomass with coal) and the use of biochar as a low-carbon solution.                                              | Studies show that biochar from biomass can improve soil efficiency and reduce carbon emissions, while biomass co-firing reduces CO <sub>2</sub> emissions by up to 29 million tons per year in countries that adopt this policy (Mohd Idris & Hashim, 2021; Sri Shalini S et al., 2021).                                                       |
| Low-Carbon Initiative.       | CCS programs to capture and store carbon from underground oil and gas production processes, supported by public-private partnerships in regions such as Houston, USA.                                                | ExxonMobil announced a major investment in a \$100 billion CCS hub in Houston, while Talos Energy began exploring the potential of CCS in the Gulf of Mexico. This technology has great potential to help achieve net-zero targets (Wright, 2022).                                                                                             |
| Green Energy Infrastructure. | The development of green energy, such as solar and hydrogen power plants, as well as the electrification of oil and gas operations with renewable energy to reduce emissions directly.                               | Technologies such as hydrogen for fossil fuel replacement and electrification of oil and gas operations provide significant emission efficiency, while solar integration strengthens green energy stability (Temizel et al., 2023).                                                                                                            |

Source : Author's Search, 2024

New technologies and methods have been developed to deal with waste and pollution in the oil and gas sector. The treatment of biomass waste through pyrolysis, for illustration, produces products such as biochar that can significantly reduce greenhouse gas emissions, making this process more environmentally friendly than direct combustion or disposal at landfills (Chew et al., 2021). In the oil and gas drilling sector, cuttings processing technology is able to reduce carbon emissions by up to 48% compared to traditional methods such as waste transportation to onshore facilities (Innes et al., 2021). The use of renewable energy in the oil and gas industry is starting to increase to support the carbon neutrality target. Studies show that technologies such as the use of solar and hydrogen energy have been integrated into

oil and gas processes to reduce the operational carbon footprint (Temizel et al., 2023). In addition, co-firing biomass with coal in power plants can also reduce CO<sub>2</sub> emissions by up to 29 million tons per year on a national scale such as in Malaysia (Mohd Idris & Hashim, 2021). Carbon emission regulations, waste management, and the adoption of renewable energy in the oil and gas sector show great potential to achieve environmental sustainability. These endeavors, involving advanced technology and strict policies, can significantly reduce negative environmental impacts and support the green energy transition in the oil and gas industry. In table 11.3. has summarized environmental policies related to emission thresholds, oil and gas exploration and production regulations, and energy transition policies.

Policies related to emission thresholds have a significant impact on the activities of BUMDs in the oil and gas sector. To meet greenhouse gas emission standards such as SO<sub>x</sub> and NO<sub>x</sub>, BUMDs must invest in emission control technologies, such as FGD and scrubbers. This technology increases operational costs, but provides long-term environmental benefits and helps ensure compliance with international regulations such as the Clean Air Regulation (CAR 2014) (Haji Nawawi & Jaafar, 2021). On the other hand, oil and gas exploration and production regulations require major adjustments in operations, such as waste management through reinjection or pyrolysis. This method not only requires more infrastructure but also increases the initial capital burden for regional oil and gas companies (Innes et al., 2021). The energy transition policy also poses a big challenge for BUMDs. Initiatives to adopt renewable energy sources such as solar panels, hydrogen, or biomass require significant investment in new technologies and supporting infrastructure. However, this can provide long-term energy efficiency and tax incentives that support the sustainability of the Corporation's operations (Mohd Idris & Hashim, 2021). In addition, the implementation of low-carbon technologies such as CCS opens up opportunities for BUMDs to earn income from carbon credits, even though these technologies require very large initial financing (Wright, 2022). In legal compliance, BUMDs must allocate more resources for stricter supervision and reporting. For Illustration, the use of drone-based methane emission monitoring technology and infrared cameras requires significant investments, but it helps ensure regulatory compliance and significantly reduce environmental impacts (Presley, 2023). Overall, this policy pressures BUMDs to improve operational efficiency and sustainability, although with significant challenges in the form of increased operational costs and investment needs.

#### **11.4. Conclusions and Recommendations**

Chapter 11 discusses the implications of health and environmental policies on investment in oil and gas sector Regionally-Owned Enterprises (BUMDs), focusing on how these policies affect operational, sustainability, and economic aspects. Chapter

11 highlights the high dependence on the oil and gas sector as a major source of revenue, which creates fiscal vulnerabilities due to energy cost volatility. Current management is considered not optimal in maximizing community welfare. In addition, there are challenges in the implementation of environmental policies that require large investments in green technologies, but often contradict the short-term efficiency of companies. Chapter 11 aims to evaluate the impact of health and environmental policies on investment efficiency, innovation, and operational sustainability of BUMDs. This includes identifying opportunities and challenges in supporting more sustainable economic development through adaptive policies. The novelty in this chapter lies in a strategic approach that integrates environmental and health policies with technological innovations such as CCS and the use of renewable energy. This chapter also highlights the importance of diversifying BUMD investment toward the non-oil and gas and low-carbon energy sectors. Chapter 11 recommends increased investment in low-emission technologies such as scrubbers and pyrolysis, strengthening regulatory frameworks to ensure legal compliance, and involving local communities in decision-making processes to support social sustainability. Tax incentives and collaboration with the private sector are also recommended to support policy implementation.

Some important things that need to be done for the future,, among other things, the development of innovative technologies such as artificial intelligence-based automation systems for operational efficiency and emission reduction. Portfolio diversification strategy to reduce dependence on oil and gas. Strengthening green energy infrastructure such as solar power and hydrogen. Increasing regulatory and governance capacity to support effective environmental policies. An ongoing assessment of social and economic impacts, among other things, an analysis of public health risks due to oil and gas activities. Chapter 11 focuses on the importance of synergy between environmental policies and investment strategies to support economic sustainability and mitigate environmental and social impacts in the oil and gas sector.

## Reference

- Aastvedt, T. M., Behmiri, N. B., & Lu, L. (2021). Does green innovation damage financial performance of oil and gas companies? *Resources Policy*, 73. <https://doi.org/10.1016/j.resourpol.2021.102235>
- Abdul Rashid, R., Salleh, R., & Md Nordin, S. (2023). Influence of Leadership Communication in Fostering Employees' Safety Commitment in Oil and Gas Industry. *KnE Social Sciences*. <https://doi.org/10.18502/kss.v8i20.14611>
- Adeosun, O. T., & Gbadamosi, I. I. (2021). Impact of non-oil sectors on GDP/capita in selected African countries: evidence from panel analysis. *World Journal of Science, Technology and Sustainable Development*, 18(3). <https://doi.org/10.1108/WJSTSD-03-2021-0037>
- Agusalim, F. F., Hussin, W. A. W., Go, C. H., Chang, E. J. T., Gonasergar, V., & Tukiman, N. (2023). Artificial Intelligence Solutions In Managing HSE Risks and Incidents. 2023 *International Conference on Digital Applications, Transformation and Economy, ICDATE 2023*. <https://doi.org/10.1109/ICDATE58146.2023.10248441>
- Ainuddin, A., & Suryadilaga, M. A. (2021). Oil and Gas in the Dynamics of Time and Development. *Scientific Contributions Oil and Gas*, 44(2). <https://doi.org/10.29017/scog.44.2.564>
- Alroomi, A. S., & Mohamed, S. (2021). Predictors of mental health and fatigue among isolated oil and gas workers. *Safety and Reliability*, 40(2). <https://doi.org/10.1080/09617353.2020.1858390>
- Amadi, L., & Obutte, P. C. (2020). Framing petroleum revenue management law for energy sector reform in Nigeria. *Journal of Sustainable Development Law and Policy (The)*, 10(2). <https://doi.org/10.4314/jsdlp.v10i2.5>
- Ardiansyah Arif, Muhammad Syafar, Erniwati Ibrahim, Suriah, Anwar Mallongi, & Muhammad Alwy. (2020). Analysis of Community Empowerment in the Implementation of Healthy Living Movement Programs (GERMAS) in the Regional Post-Disaster Palu City. *Medico-Legal Update*, 20(4). <https://doi.org/10.37506/mlu.v20i4.1885>
- Apergis, N., Mustafa, G., & Dastidar, S. G. (2021). An analysis of the impact of unconventional oil and gas activities on public health: New evidence across Oklahoma counties. *Energy Economics*, 97. <https://doi.org/10.1016/j.eneco.2021.105223>
- Azieva, R. K., & Taymaskhanov, Z. K. (2023). Impact of energy efficiency on activities of enterprise. *Vestnik of Astrakhan State Technical University. Series: Economics*, 2023(1). <https://doi.org/10.24143/2073-5537-2023-1-28-35>
- Balkat, F. S., & Khaleel, A. S. (2021). THE INTERNAL AUDIT OF THE HEALTH AND SAFETY MANAGEMENT SYSTEM (ISO 45001: 2018) IN THE DEPARTMENT OF STUDIES, PLANNING AND FOLLOWUP - IRAQI MINISTRY OF OIL. *International Journal of Business Management and Economic Review*, 04(05). <https://doi.org/10.35409/ijbmer.2021.3317>

- Beliakov, S., & Shabanov, S. (2020). Formation of the company's investment policy taking into account the impact of environmental aspects of its activities. *E3S Web of Conferences*, 164. <https://doi.org/10.1051/e3sconf/202016410028>
- Benson, C., Dimopoulos, C., Argyropoulos, C. D., Varianou Mikellidou, C., & Boustras, G. (2021). Assessing the common occupational health hazards and their health risks among oil and gas workers. *Safety Science*, 140. <https://doi.org/10.1016/j.ssci.2021.105284>
- Bilgili, F., Koçak, E., & Bulut, Ü. (2020). The shale gas production and economic growth in local economies across the US. *Environmental Science and Pollution Research*, 27(11). <https://doi.org/10.1007/s11356-020-07776-7>
- Boslett, A., Hill, E., Ma, L., & Zhang, L. (2021). Rural light pollution from shale gas development and associated sleep and subjective well-being. *Resource and Energy Economics*, 64. <https://doi.org/10.1016/j.reseneeco.2021.101220>
- Buonocore, J. J., Reka, S., Yang, D., Chang, C., Roy, A., Thompson, T., Lyon, D., McVay, R., Michanowicz, D., & Arunachalam, S. (2023). Air pollution and health impacts of oil & gas production in the United States. *Environmental Research: Health*, 1(2). <https://doi.org/10.1088/2752-5309/acc886>
- Buonocore, J., Reka, S., Yang, D., Chang, C., Roy, A., Thompson, T., Lyon, D., McVay, R., Michanowicz, D., & Arunachalam, S. (2021). *Air Quality and Health Benefits of Methane Policies in the United States Oil & Gas Sector*. <https://doi.org/10.21203/rs.3.rs-199686/v1>
- Carpenter, C. (2020). Human Rights as a Sustainability Goal. *Journal of Petroleum Technology*, 72(05). <https://doi.org/10.2118/0520-0018-jpt>
- Chen, X., Wang, M., Wang, B., Hao, H., Shi, H., Wu, Z., Chen, J., Gai, L., Tao, H., Zhu, B., & Wang, B. (2023). Energy Consumption Reduction and Sustainable Development for Oil & Gas Transport and Storage Engineering. In *Energies* (Vol. 16, Issue 4). <https://doi.org/10.3390/en16041775>
- Cherepovitsyn, A., & Rutenko, E. (2022). Strategic Planning of Oil and Gas Companies: The Decarbonization Transition. *Energies*, 15(17). <https://doi.org/10.3390/en15176163>
- Chew, K. W., Chia, S. R., Chia, W. Y., Cheah, W. Y., Munawaroh, H. S. H., & Ong, W. J. (2021). Abatement of hazardous materials and biomass waste via pyrolysis and co-pyrolysis for environmental sustainability and circular economy. *Environmental Pollution*, 278. <https://doi.org/10.1016/j.envpol.2021.116836>
- Coleman, E. A., Schultz, B., Rani Parker, A., Manyindo, J., & Mukuru, E. M. (2023). How Communities Benefit from Collaborative Governance: Experimental Evidence in Ugandan Oil and Gas. *Journal of Public Administration Research and Theory*, 33(4). <https://doi.org/10.1093/jopart/muac050>
- Dong, X., Dong, W., & Lv, X. (2020). Impact of environmental policy on investment efficiency: Evidence from the oil and gas sector in Canada. *Journal of Cleaner Production*, 252. <https://doi.org/10.1016/j.jclepro.2019.119758>



- Durand-Lasserve, O., & Karanfil, F. (2023). *Fiscal Policy in Oil and Gas-Exporting Economies: Good Times, Bad Times and Ugly Times*. <https://doi.org/10.30573/KS--2023-DP11>
- Eley, G., Moran, J., & Kaub, S. (2023). Walk to Work and the Automation of the Offshore Oil and Gas Market. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/217028-MS>
- Ernest Usoro, A., Akintunde Yusuf, W., & O. N. Okafor, B. (2020). Nexus between Non-Oil Sectoral Contribution and Economic Growth in Nigeria 1981-2018. *The Economics and Finance Letters*, 7(1). <https://doi.org/10.18488/journal.29.2020.71.13.22>
- Fortunato, H. E., Marcomini, K., Soares, G. J., Gremes, M. F., Alberto, P. F., Reis, F. J., & Abbas, C. (2023). Optimizing Industrial Risk Management Through AI and No-Code Platform: A Global Solution for the Oil and Gas Industry. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/216426-MS>
- Fox, J. L., Gurney, T., Kondalsamy-Chennakesavan, S., Pols, T. A. H., Tuffaha, H., Pak, A., & McGrail, M. (2023). A Narrative Review of Health Status and Healthcare Delivery in the Oil and Gas Industry: Impacts on Employees, Employers, and Local Communities. In *Healthcare (Switzerland)* (Vol. 11, Issue 21). <https://doi.org/10.3390/healthcare11212888>
- Gilyova, L., & Podkovyrova, M. (2020). Assessment of the impact of the northern territories of oil and gas facilities on the environment. *E3S Web of Conferences*, 164. <https://doi.org/10.1051/e3sconf/202016407020>
- Godoi, J. M. A., & dos Santos Matai, P. H. L. (2021). Enhanced oil recovery with carbon dioxide geosequestration: first steps at Pre-salt in Brazil. In *Journal of Petroleum Exploration and Production* (Vol. 11, Issue 3). <https://doi.org/10.1007/s13202-021-01102-8>
- Gorlenko, N., Murzin, M., & Belyaevsky, R. (2020). Assessment of Environmental Risks at Oil and Gas Production Companies Using an Integrated Method. *E3S Web of Conferences*, 174. <https://doi.org/10.1051/e3sconf/202017402033>
- Gubar, E. V., & Tupitsyna, O. V. (2022). A multi-parameter approach to assessing the environmental performance of oil and gas production facilities. *RUDN Journal of Ecology and Life Safety*, 30(3). <https://doi.org/10.22363/2313-2310-2022-30-3-345-356>
- Guerrero-Martin, C. A., Ortega-Ramírez, A. T., Rodríguez, P. A. P., López, S. J. R., Guerrero-Martin, L. E., Salinas-Silva, R., & Camacho-Galindo, S. (2023). Analysis of Environmental Sustainability through a Weighting Matrix in the Oil and Gas Industry. *Sustainability (Switzerland)*, 15(11). <https://doi.org/10.3390/su15119063>
- Guida, H. F. S., Figueiredo, M. G., & Hennington, É. A. (2020). Work fatalities in a brazilian oil and gas company: Analysis of workers' health and safety policy. *Ciencia e Saude Coletiva*, 25(5). <https://doi.org/10.1590/1413-81232020255.34942019>
- Guo, Y., Yang, Y., Bradshaw, M., Wang, C., & Blondeel, M. (2023). Globalization and decarbonization: Changing strategies of global oil and gas companies. In *Wiley Interdisciplinary Reviews: Climate Change* (Vol. 14, Issue 6). <https://doi.org/10.1002/wcc.849>

- Gupta, S. D., Sharma, S. K., Kumar, S., Sharma, N., & Jain, A. (2023). Self-assessment of Public Healthcare Facility in Conformity with Accreditation Guidelines for Quality Services. *Journal of Health Management*, 25(2). <https://doi.org/10.1177/09720634231175750>
- Haji Nawawi, N. H. B., & Jaafar, M. N. (2021). Assessment of air pollution control technologies to reduce SOx emission from thermal oxidizer for oil and gas industry. *IOP Conference Series: Materials Science and Engineering*, 1195(1). <https://doi.org/10.1088/1757-899x/1195/1/012046>
- Huang, Y., & Li, S. (2022). Can Marketization of Environmental Governance Improve Public Health?—Empirical Analysis Based on the Emission Trading System. *International Journal of Environmental Research and Public Health*, 19(23). <https://doi.org/10.3390/ijerph192315518>
- Hutchins, R., Holbrough, D., Jenkins, M., & Saini, P. (2022). Artificial Intelligence and Machine Learning Used as an Enabler for Dynamic Risk Management. *International Petroleum Technology Conference, IPTC 2022*. <https://doi.org/10.2523/IPTC-22056-MS>
- Ilinova, A. A., & Solovyova, V. M. (2021). STRATEGIC PLANNING AND FORECASTING: CHANGING ROLE UNDER INSTABILITY OF ENERGY SECTOR. *Sever i Rynok: Formirovanie Ekonomiceskogo Poradka*, 24(2). <https://doi.org/10.37614/2220-802X.2.2021.72.005>
- Innes, G., Nesse, S., & Eia, J. T. (2021). A Comparative Emissions Assessment - Drill Cuttings Treatment Alternatives. *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference, ADIP 2021*. <https://doi.org/10.2118/207519-MS>
- Ivanova, T. (2023). Digital technologies in oil and gas production as a tool to ensure optimal energy efficiency and sustainability. *E3S Web of Conferences*, 419. <https://doi.org/10.1051/e3sconf/202341901007>
- Izidor, S. (2021). Multinational Corporations and Social Responsibilities Discharge: Ethical Appraisal in Nigeria's Oil/Gas Communities. *The International Journal of Humanities & Social Studies*, 9(3). <https://doi.org/10.24940/theijhss/2021/v9/i3/hs2103-030>
- Jacobs, T. (2022). Robo-Labs, Mysterious Bakken Scale, and New Nano-Detectors All Highlight the Innovative Thinking in Oilfield Chemistry. *Journal of Petroleum Technology*, 74(02). <https://doi.org/10.2118/0222-0024-jpt>
- Jaffe, A. M., Myslikova, Z., Qi, Q., Zhang, F., Oh, S., & Ellass, J. (2023). Green innovation of state-owned oil and gas enterprises in BRICS countries: a review of performance. *Climate Policy*, 23(9). <https://doi.org/10.1080/14693062.2022.2145261>
- Jarboui, S., Ghorbel, A., & Jeribi, A. (2022). Efficiency of U.S. Oil and Gas Companies toward Energy Policies. *Gases*, 2(2). <https://doi.org/10.3390/gases2020004>
- Joustra, T., Tienhaara, M., Henry, T., Kanestrøm, E., & Reid, D. (2022). The Energy Transition: An Opportunity for Technology Development and Deployment to Achieve Impact at Scale. *Proceedings of the Annual Offshore Technology Conference*. <https://doi.org/10.4043/32147-MS>

- Kanaboshi, H., Sano, F., Oda, J., Akimoto, K., & Onishi, N. (2021). Cost-efficient measures in the oil refinery and petrochemical sectors for the reduction of CO<sub>2</sub> emissions under the Paris Agreement and air pollution under the MARPOL Convention. *Energy and Climate Change*, 2. <https://doi.org/10.1016/j.egycc.2021.100027>
- Keller, M. (2022). Oil revenues vs domestic taxation: Deeper insights into the crowding-out effect. *Resources Policy*, 76. <https://doi.org/10.1016/j.resourpol.2022.102560>
- Khalid, A., Felfernig, M., Purra, A., Ramirez, F. E., Alshamsi, M., & Dwedari, Z. (2022). Shifting Paradigm of Mental Hygiene; A Novel Approach to Mitigate Workers' Distress in Oil and Gas Industry. *Society of Petroleum Engineers - ADIPEC 2022*. <https://doi.org/10.2118/210788-MS>
- Kislyakova, Yu. G., & Usatova, I. Y. (2022). ENVIRONMENTAL IMPACT ASSESSMENT IN THE OIL AND GAS SECTOR. *Social'no-Ekonomiceskoe Upravlenie: Teoria i Praktika*, 18(1). <https://doi.org/10.22213/2618-9763-2022-1-36-41>
- Koroteev, D., & Tekic, Z. (2021). Artificial intelligence in oil and gas upstream: Trends, challenges, and scenarios for the future. *Energy and AI*, 3. <https://doi.org/10.1016/j.egyai.2020.100041>
- Li, G., Zhang, R., & Masui, T. (2021). CGE modeling with disaggregated pollution treatment sectors for assessing China's environmental tax policies. *Science of the Total Environment*, 761. <https://doi.org/10.1016/j.scitotenv.2020.143264>
- Li, H., Yu, H., Cao, N., Tian, H., & Cheng, S. (2021). Applications of Artificial Intelligence in Oil and Gas Development. *Archives of Computational Methods in Engineering*, 28(3). <https://doi.org/10.1007/s11831-020-09402-8>
- Li, M., Trencher, G., & Asuka, J. (2022). The clean energy claims of BP, Chevron, ExxonMobil and Shell: A mismatch between discourse, actions and investments. *PLoS ONE*, 17(2 February). <https://doi.org/10.1371/journal.pone.0263596>
- Liu, X. (2022). The supervision and multi-sectoral guarantee mechanism of the global marine sulphur limit—assessment from Chinese shipping industry. In *Frontiers in Marine Science* (Vol. 9). <https://doi.org/10.3389/fmars.2022.1028388>
- Ma, M., Murphy, J., Salman, N., Li, Z., Chatar, C., & Chatagnier, J. (2021). Digitization of drill bit inspections; user-centered design methods to automate robotic inspections. *Proceedings - SPE Annual Technical Conference and Exhibition, 2021-September*. <https://doi.org/10.2118/206261-MS>
- Mahmood, Y., Afrin, T., Huang, Y., & Yodo, N. (2023). Sustainable Development for Oil and Gas Infrastructure from Risk, Reliability, and Resilience Perspectives. In *Sustainability (Switzerland)* (Vol. 15, Issue 6). <https://doi.org/10.3390/su15064953>
- MARICHEV, S. G. (2021). Market attractiveness of oil and gas companies as a factor affecting the socio-economic development in regions of their business operations. *Economic Analysis: Theory and Practice*, 20(1). <https://doi.org/10.24891/ea.20.1.124>

- Mein, T. F., Gimenes, A. L. V., Dias, E. M., Rebello Pinho Dias Scoton, M. L., & Udaeta, M. E. M. (2021). Environmental vulnerability in pre-salt oil and gas operations. *Energies*, 14(3). <https://doi.org/10.3390/en14030732>
- Mohd Idris, M. N., & Hashim, H. (2021). Integrating palm oil biomass waste utilization in coal-fired power plants for meeting near-term emission targets. *Journal of Environmental Management*, 296. <https://doi.org/10.1016/j.jenvman.2021.113118>
- Nazarova, V. V., & Tikhomirov, E. D. (2022). The impact of environmental performance of oil and gas companies on their financial performance. *Moscow University Economics Bulletin*, 5. <https://doi.org/10.38050/01300105202258>
- Oduoza, C. F., Alamri, R., & Oloke, D. (2023). Best practice for safety management – case of major oil processing country in the Middle East. *Engineering, Construction and Architectural Management*. <https://doi.org/10.1108/ECAM-02-2023-0126>
- Olisaeva, A. ., & Vazagov, V. . (2021). Oil and gas complex of Russia:fiscal instruments and taxation system. *Siberian Financial School*, 4. <https://doi.org/10.34020/1993-4386-2021-4-155-161>
- Oliveira, F., Nascimento, A., & Oliveira, M. P. (2023). *The importance of studies on the mitigation of environmental impacts in the Santos Basin region: focus on pre-salt oil and natural gas activities*. <https://doi.org/10.56238/homeinternationalanais-046>
- Oliveira, G. M., Vidal, D. G., Viterbo, L. M. F., Costa, A. S., & Ferraz, M. P. (2020). Health Monitoring and Intervention Plan on Oil Industry Workers: Results from a Case-Study. In *Studies in Systems, Decision and Control* (Vol. 277). [https://doi.org/10.1007/978-3-030-41486-3\\_29](https://doi.org/10.1007/978-3-030-41486-3_29)
- Oruwari, H. O., & Itsekor, L. (2023). Strategies for Decarbonizing the Oil and Gas Industries. *Society of Petroleum Engineers - SPE Nigeria Annual International Conference and Exhibition, NAIC 2023*. <https://doi.org/10.2118/217179-MS>
- Otarbayeva, A., & Arupov, A. (2020). Analysis of the influence of direct foreign investments on the development of the oil and gas industry of Kazakhstan. *The Journal of Economic Research & Business Administration*, 134(4). <https://doi.org/10.26577/be.2020.v134.i4.06>
- Palathoti, S., Al-Rawahi, M., Mahfud, R., & Otitolaiye, V. O. (2022). Effects of Mercury Concentration on the Health and Safety of Oil and Gas Workers. In *International Journal of Occupational Safety and Health* (Vol. 12, Issue 3). <https://doi.org/10.3126/ijosh.v12i3.40325>
- Panevnik, O. V. (2021). Analysis of integration processes of renewable energy technologies in the oil and gas industry. *Prospecting and Development of Oil and Gas Fields*, 4(81). [https://doi.org/10.31471/1993-9973-2021-4\(81\)-7-15](https://doi.org/10.31471/1993-9973-2021-4(81)-7-15)
- Patimah, A. S., Murti, S. H., & Prasetya, A. (2023). Study of Socio-Economic-Cultural Impacts and Community Health Due to Oil and Natural Gas Exploration Activities in the Tuban Oil and Gas Field. *Indonesian Journal of Geography*, 55(1). <https://doi.org/10.22146/ijg.70639>

- Pei, Y., Chen, H., Liu, Z., & Hu, H. (2023). Does environmental regulation improve residents' health? Evidence from China. *Frontiers in Public Health*, 11. <https://doi.org/10.3389/fpubh.2023.973499>
- Petrenko, Y., Denisov, I., & Metsik, O. (2022). Foresight Management of National Oil and Gas Industry Development. *Energies*, 15(2). <https://doi.org/10.3390/en15020491>
- Popescu, C., Avram, L., & Mocanu, I. (2020). *Risk Management in the Oil and Gas Industry Related to the AI Tools*. <https://doi.org/10.4018/978-1-7998-5077-9.ch017>
- Pramugar, R. N., & Sinaga, R. Y. (2021). E-GOVERNMENT IN OPTIMIZING NON-TAX REVENUE OF THE MINING SECTOR IN INDONESIA. *JAF- Journal of Accounting and Finance*, 5(1). <https://doi.org/10.25124/jaf.v5i1.3743>
- Presley, J. (2023). Innovative Thinking Drives Emissions Mitigation. *Journal of Petroleum Technology*, 75(08). <https://doi.org/10.2118/0823-0016-jpt>
- Pushkar, T. (2021). OIL AND GAS INDUSTRY OF UKRAINE IN REGIONAL DEVELOPMENT. *Eastern Europe: Economy, Business and Management*, 4(31). <https://doi.org/10.32782/easterneurope.31-13>
- Quaigrain, R. A., Owusu-Manu, D. G., Edwards, D. J., Hammond, M., Hammond, M., & Martek, I. (2024). Occupational health and safety orientation in the oil and gas industry of Ghana: analysis of knowledge and attitudinal influences on compliance. *Journal of Engineering, Design and Technology*, 22(3). <https://doi.org/10.1108/JEDT-11-2021-0664>
- Qurbani, I., Sumarno, T., & Cassy, R. (2020). Regional Economic Development Strategy: Increasing Local Generated Domestic Revenue of the Regional-Owned Enterprises in the Oil and Gas Sector. *Brawijaya Law Journal*, 7(1), 70–81. <https://doi.org/10.21776/ub.blj.2020.007.01.05>
- Rentizelas, A., de Sousa Jabbour, A. B. L., Al Balushi, A. D., & Tunı, A. (2020). Social sustainability in the oil and gas industry: institutional pressure and the management of sustainable supply chains. *Annals of Operations Research*, 290(1–2). <https://doi.org/10.1007/s10479-018-2821-3>
- Resen, E. J., Abdulrazzaq, M. S., & Abbood, H. Q. (2023). Environmental Impact Assessment for Industrial Organizations using Rapid Impact Assessment Matrix. *Ecological Engineering and Environmental Technology*, 24(2). <https://doi.org/10.12912/27197050/156964>
- Rumadan, I. (2020). DEMOCRATIZATION OF NATURAL OIL AND GAS NATURAL RESOURCES MANAGEMENT FOR PEOPLE'S WELFARE. *UNTAG Law Review*, 4(1). <https://doi.org/10.36356/ulrev.v4i1.1524>
- Sletten, S., Wangen Jonasmo, K., & Solheim, M. C. W. (2023). Changing industrial trajectories through business model innovation: a case study of the oil and gas industry in Norway. *European Planning Studies*, 31(7). <https://doi.org/10.1080/09654313.2023.2185503>
- Soares, M. de O., Teixeira, C. E. P., Bezerra, L. E. A., Paiva, S. V., Tavares, T. C. L., Garcia, T. M., de Araújo, J. T., Campos, C. C., Ferreira, S. M. C., Matthews-Cascon, H., Frota, A.,

- Mont'Alverne, T. C. F., Silva, S. T., Rabelo, E. F., Barroso, C. X., Freitas, J. E. P. de, Melo Júnior, M. de, Campelo, R. P. de S., Santana, C. S. de, ... Cavalcante, R. M. (2020). Oil spill in South Atlantic (Brazil): Environmental and governmental disaster. *Marine Policy*, 115. <https://doi.org/10.1016/j.marpol.2020.103879>
- Sri Shalini S, Palanivelu K, Ramachandran A, & Raghavan, V. (2021). Biochar from biomass waste as a renewable carbon material for climate change mitigation in reducing greenhouse gas emissions—a review. In *Biomass Conversion and Biorefinery* (Vol. 11, Issue 5). <https://doi.org/10.1007/s13399-020-00604-5>
- Tang, H., Rasool, Z., Sindhu, M. I., Naveed, M., & Babar, S. F. (2023). Implications of corporate innovation investment on environment sustainability with moderating role of managerial stock incentives: A case of the oil and gas sector of the United States of America. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.962258>
- Tang, L, Li, K., & Jia, P. (2020). Impact of environmental regulations on environmental quality and public health in China: Empirical analysis with panel data approach. *Sustainability (Switzerland)*, 12(2). <https://doi.org/10.3390/su12020623>
- Temizel, C., Aydin, H., Hosgor, F., Yegin, C., & Kabir, C. S. (2023). Green Energy Sources Reduce Carbon Footprint of Oil & Gas Industry Processes: A Review. *Journal of Energy and Power Technology*, 05(01). <https://doi.org/10.21926/jept.2301004>
- Theodorou, L., McGeachie, S., Gill, J., & McKenna, K. (2020). The Energy Transition, lessons learned from other heavy industries and the opportunities they present for Oil and Gas Operators demonstrated by associated case studies. *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference 2020, ADIP 2020*. <https://doi.org/10.2118/203409-ms>
- Tian, J., Zhang, S., Wei, X., Zhuang, S., & Zhang, M. (2022). The impact of government environmental attention on public health: Implications for corporate sustainable development. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.973477>
- Tverytnykova, E., Demidova, Y., & Drozdova, T. (2021). MANAGEMENT SYSTEM OF OCCUPATIONAL SAFETY AT UKRAINIAN ENTERPRISES: INTERNATIONAL AND EUROPEAN DIMENSION. *Advanced Information Systems*, 5(1). <https://doi.org/10.20998/2522-9052.2021.1.06>
- Vorobeva, Y. A., Drapalyuk, N. A., Burak, E. E., Zherlykina, M. N., & Isanova, A. V. (2021). Assessment of the importance of environmental aspects in the construction of oil and gas facilities. *IOP Conference Series: Earth and Environmental Science*, 723(5). <https://doi.org/10.1088/1755-1315/723/5/052004>
- Watterson, A., & Dinan, W. (2020). Lagging and flagging: Air pollution, shale gas exploration and the interaction of policy, science, ethics and environmental justice in England. In *International Journal of Environmental Research and Public Health* (Vol. 17, Issue 12). <https://doi.org/10.3390/ijerph17124320>

- Welsby, D., Solano, B., Pye, S., & Vogt-Schilb, A. (2021). *High and Dry: Stranded Natural Gas Reserves and Fiscal Revenues in Latin America and the Caribbean*. <https://doi.org/10.18235/0003727>
- Wright, B. (2022). Talos Eyes Big Carbon Capture Role in the US and Beyond. *Journal of Petroleum Technology*, 74(02). <https://doi.org/10.2118/0222-0032-jpt>
- Xu, H., Pan, W., Xin, M., Hu, C., Pan, W. L., Dai, W. Q., & Huang, G. (2022). The Mediating Role of Public Health between Environmental Policy Tools and Economic Development. *Energies*, 15(3). <https://doi.org/10.3390/en15030835>
- Yakovlev, V. A., & Berezhnov, D. A. (2021). Implementation of the greening process at oil and gas industry enterprises. *Journal of Physics: Conference Series*, 1889(3). <https://doi.org/10.1088/1742-6596/1889/3/032024>
- Yang, N., Liu, Z., Lin, Y., & Yang, Y. (2023). Does environmental regulation improve public health? Evidence from China's Two Control Zones policy. *Frontiers in Public Health*, 11. <https://doi.org/10.3389/fpubh.2023.1059890>
- YIRAN, B., & HAO, S. (2023). Impact of foreign direct investment on competitive advantage in the oil and gas industry. *Economic Analysis: Theory and Practice*, 22(1). <https://doi.org/10.24891/ea.22.1.139>



# Implementation of Blue Economy Principles in Oil and Gas Management

Asriani , Indah Gilang Pusparani

The application of blue economy principles in the oil and gas sector to reduce environmental impact through environmentally friendly technologies, such as Carbon Capture and Storage (CCS) and ocean-based renewable energy, as well as a circular economy approach. This approach is supported by cross-sector collaboration, strengthening regulations, and the use of dormant oil and gas infrastructure to create a sustainable ecosystem and support the green energy transition.

## 12.1. Blue Economy Principles in the Context of Oil and Gas

The concept of the blue economy was first introduced by Professor Gunter Pauli in 1994 at the United Nations University (UNU) to respond to the need for sustainable development and global challenges such as global warming and environmental degradation. Later, the concept gained global recognition after the United Nations Conference on Sustainable Development (Rio+20) in 2012, where attention was focused on the expansion of the concept of a green economy into the ocean space. On this occasion, the main goal is to promote the sustainable use of marine resources for economic growth, improving community welfare, and preserving marine ecosystems (Blue Economy Policy of India, 2022). The emergence of this concept is driven by concerns over uncontrolled exploitation of the ocean, such as overfishing, ocean pollution, and climate change, which threaten the long-term capacity of marine ecosystems to support economic activity. In addition, the development of the global economy, which increasingly requires alternative resources, is also the main driver. The blue economy aims to create a balance between ocean-based economic growth and marine environmental conservation, as well as bridge social disparities by creating jobs in innovative sectors such as renewable energy, marine biotechnology, and sustainable aquaculture (Lee et al., 2020). In international discourse, the blue economy is considered an important response to the degradation of marine ecosystems and as an opportunity to utilize the ocean as a "new economic frontier". The emphasis on sustainability and efficiency in marine resource management has been the basis of many policies, among other things, the European Union's strategy to reduce waste and promote a circular economy model in the maritime sectors (Djoric, 2022). However, this concept also faces challenges. In



many cases, the implementation of the blue economy is still influenced by a hegemonic approach that prioritizes economic growth, often ignoring local social and environmental impacts. A study in Seychelles, for illustration, shows how the blue economy is being used to reframe the ocean as an "economic frontier", which can create tensions between economic development goals and environmental conservation (Schutter et al., 2021). With increasing awareness of the potential of the ocean as a sustainable resource, the blue economy continues to evolve as a strategic approach to address global economic, social, and environmental challenges in an integrated manner.

The oil and gas industry has long been a pillar of the global economy, but its operations often have a significant impact on marine ecosystems. Issues such as oil spills, high carbon emissions, and damage to marine habitats are major concerns, especially in vulnerable coastal areas. This condition arises because the exploitation of oil and gas resources is often not accompanied by adequate environmental mitigation measures. In addition, the global dependence on fossil energy adds to the pressure on marine ecosystems and the urgent need for a transition to more sustainable practices (Kislyakova & Usatova, 2022). This increase in environmental impact is also triggered by low operational efficiency in the oil and gas sector and the lack of application of green technology. In this context, the development of a blue economy that utilizes environmentally friendly technologies and circular economy approaches is a potential solution. For illustration, research shows that the implementation of a circular economy through waste reduction, recycling, and reuse can significantly reduce environmental impacts and improve the operational sustainability of the oil and gas industry (Al Rashid, 2023). Furthermore, the concept of the blue economy is also relevant in the energy transition, as explained by (Fusco et al., 2022). Their study shows that technological experience developed in the oil and gas industry can be transferred to support the development of ocean-based renewable energy, such as offshore wind power and ocean wave energy. This not only helps the energy transition, but also improves the narrative of the oil and gas industry as the main contributor to marine pollution. On the other hand, technology-based approaches, such as the integration of Solid Oxide Fuel Cells (SOFC), offer opportunities to reduce emissions from oil and gas operations. This technology improves energy efficiency by utilizing the direct conversion of chemical energy into electricity, thereby significantly reducing carbon emissions (Al-Khori et al., 2020). However, major challenges remain, among other things, resistance to change, cost constraints, and a lack of regulation that drives the adoption of green technologies in the industry. The proposed solutions include strengthening environmental policies, investing in green technologies, and cross-sector collaboration to accelerate the transition to a sustainable blue economy (Temizel et al., 2022). Thus, although the oil and gas industry face severe challenges regarding its impact on marine ecosystems,

the principles of the blue economy offer a transformational approach that can mitigate these impacts and promote sustainability in the energy sector.

Research on the transformation from a linear economy to a circular economy in the European Union (EU) shows that this move not only helps replace fossil fuels but also supports the preservation of marine biodiversity. This is in line with the vision of the European Green Deal (EGD), which aims to achieve carbon neutrality by 2050 with a strategy to reduce greenhouse gas emissions, efficient resource management, and ecosystem conservation. One of the main elements is the development of ocean-based renewable energy such as offshore wind and bioenergy from biomass. A study by (Zheliezna, 2021) emphasizes that EGD gives priority to the mobilization of renewable energy potential, among other things, green hydrogen and biomass, which is relevant to the concept of the blue economy. In addition, the application of the blue economy concept in energy management can be seen in the development of circular cities in Europe. Research shows that improving environmental efficiency through material lifecycle management, such as concrete recycling and construction waste, is a strategic step toward a more sustainable economic transition (Bonoli et al., 2021). In Canada, a study by (Fusco et al., 2022) illustrates how regions such as Newfoundland and Labrador are leveraging blue economic principles to reduce dependence on oil and gas. The integration of innovative technologies, such as the use of ocean-based renewable energy, demonstrates the potential of the blue economy as an energy transition tool that supports the sustainability of the marine and social environment. The study also highlights the ongoing tensions between sustainability and oil and gas development in the region. In the global context, the EGD also has an influence on EU Joint Venturer countries, among other things, those that depend on fossil fuels. An analysis by (Rybski, 2023) shows that this energy transition advises international collaboration to reduce dependence on fossil energy and promote the diversification of renewable energy in regions such as the Middle East and North Africa. In both the EU and Canada, blue economy principles play an important role in supporting a sustainable energy transition and the preservation of marine biodiversity, with an emphasis on technological innovation, efficient resource management, and the development of ocean-based renewable energy. This shows the great potential of the blue economy to accelerate the achievement of global climate targets.

Waste management in the oil and gas industry through a circular economy approach aims to maximize the benefits of resources with the principles of reduce, reuse, recycle. This process includes the reuse of waste from oil and gas production as new raw materials, material recycling, and waste reduction with environmentally friendly technology. The following are the forms and applications of circular economy-based management in the oil and gas sector:

## 1. Forms of Waste Management

Waste such as plastics, metals, and used oil are recycled into raw materials for new products. Research by (Al Rashid, 2023) shows that oil and gas facilities such as Abqaiq Plants have successfully integrated the circular economy to reduce waste and greenhouse gas emissions by utilizing recycled materials for internal operational purposes. Produced Water Management: Water produced during the oil and gas production process is treated using a constructed wetlands-based system to remove contaminants such as hydrocarbons. This waste can be reused for agricultural irrigation, reducing clean water consumption (Waly et al., 2023). Secondary Material Use, Components such as scrap catalysts and metals can be reworked for use in new operations. This process helps reduce the need for primary materials that reduce the environmental impact of raw material mining (Minunno et al., 2020).

## 2. Application in Industry

Operational Redesign, oil and gas companies, such as Eni, have implemented circular economy-based decommissioning by conducting feasibility studies on old assets to ensure that potentially recyclable materials are utilized optimally before the final phase of their life cycle (Friederichs, 2023). Innovative technologies, such as plasma gasification, are used to process hydrocarbon waste into synthetic fuels and other high-value products. This helps create a closed system with minimal emissions and waste (Ginga et al., 2020). Cross-Sector Collaboration, Oil and gas companies collaborate with the construction sector to utilize waste such as fly ash as concrete additives, reducing hazardous waste transported to landfills (Poranek et al., 2021).

Economic and Environmental Impacts, Circular economy approaches in the oil and gas sector are able to: Reduce carbon emissions and ecological footprint; Saving operational costs through reducing the use of primary raw materials; and support the sustainability of the industry by complying with strict environmental regulations.

### **12.2. Environmental Challenges in Oil and Gas Exploration and Production in Coastal Areas**

Oil and gas exploration and production activities in coastal areas present significant environmental challenges, among other things, marine pollution, coastal habitat destruction, and carbon emissions. Some of the approaches that can be used to address these challenges include technological innovation, strict environmental management, and the implementation of international regulations. This approach can significantly reduce negative impacts on the environment, such as marine pollution, coastal habitat destruction, and carbon emissions.

Technological innovation plays an important role in reducing pollution and improving waste management efficiency. Produced water treatment technologies, such as gravitational sedimentation, hydrochlorination, and membrane filtration, have shown success in lowering hydrocarbon levels by up to 90%, thereby reducing

the ecological impact on marine ecosystems (Liu et al., 2021). In addition, approaches such as rigs-to-reefs can take advantage of defunct oil and gas infrastructure as artificial habitats that support marine biodiversity. This strategy reduces the need for total platform lifting, which often damages underwater ecosystems (Pereira et al., 2023).

Rigorous environmental management includes regular monitoring and data-driven environmental impact analysis. For illustration, the use of eDNA (environmental DNA) to monitor the impact of oil and gas activities allows for fast and accurate detection of changes in biodiversity in affected areas. This method has been proven effective in identifying bioindicator species that indicate ecosystem conditions disturbed by oil and gas activities. In addition, the use of GIS-based monitoring technology and fluoroscopic sensors can improve efficiency in detecting and managing oil spills on the coast (Asif et al., 2022).

The implementation of international regulations is needed to ensure uniform standards in environmental management across countries. The regulations include the implementation of stricter carbon emission limits and waste management, as proposed in the Effluent Standards for Oil-Bearing Wastewater and other international treaties. Research mentions the importance of risk-based regulation to manage potential damage due to production water waste and hydrocarbons (Beyer et al., 2020). In addition, global energy transition programs that adopt a net-zero operations approach, among other things, carbon capture and storage (CCS) technology, are an important step in reducing climate impacts and ensuring industrial sustainability (Halsey et al., 2023). A combination of technological innovation, data-driven environmental management, and strong international regulations is a key approach to reducing the environmental impact of oil and gas exploration and production in coastal areas, while supporting global energy sustainability.

Marine pollution often occurs due to oil spills and produced water, which contains hydrocarbons and other toxic compounds. As a solution, technology-based production water treatment methods, such as gravitational sedimentation, hydrochlorination, and membrane filtration, have shown high efficiency in reducing contaminants by up to 90% (Liu et al., 2021). Coastal habitat damage, especially due to infrastructure development and exploration activities, can be minimized through rigs-to-reefs programs. This approach transforms an unused oil platform into an artificial habitat that supports marine biodiversity (Pereira et al., 2023). Carbon emissions resulting from oil and gas activities require the application of environmentally friendly technologies such as CCUS. This technology is recognized as part of the energy transition toward sustainability (Halsey et al., 2023). Regulation and management of environmental risks are also very important. Studies in Norway show the importance of environmental DNA-based monitoring to assess the impact of oil and gas exploration efficiently and accurately. On the other hand,

environmental risk evaluation based on physico-chemical data is also the basis for strategic decision-making (D. L. McLean et al., 2020). Effective management of oil and gas activities in coastal areas requires a combination of innovative technologies, strategic environmental planning, and the implementation of strong regulations to protect coastal ecosystems.

Mitigation strategies to reduce environmental risks while maintaining the productivity of the energy sector require a systematic approach that includes technological innovation, process optimization, and the implementation of supportive environmental policies. Some of the important mechanisms for achieving this goal are described below based on recent research.

#### 1. Technological Innovation in Clean Energy and Efficiency

The development of technologies such as CCS and renewable energy systems (such as solar panels and wind turbines) plays an important role. Studies in Taiwan show that increasing the capacity of renewable energy, among other things, photovoltaic power, is able to significantly reduce greenhouse gas emissions through an integrated approach based on policy and technology (Tsai, 2021). In addition, the optimization of industrial processes, such as the use of electric arc furnaces in the steel sector, can increase energy efficiency by up to 13% and reduce carbon emissions by up to 38 million tons by 2050 (Talaei et al., 2020).

#### 2. Environmental Risk Management with Data-Driven Analysis

The use of data-driven analysis models, such as stochastic approaches and sustainable energy planning programs, enables better decision-making regarding investments in clean energy and carbon mitigation. For illustration, a stochastic optimization model in Zhejiang Province, China, shows how strategic investments can reduce fossil energy consumption while maintaining operational cost stability (Ji et al., 2020).

#### 3. Implementation of Proactive Policies for Decarbonization

Supportive environmental policies, such as incentives for low-carbon technologies and the elimination of fossil fuel subsidies, can accelerate the transition to clean energy. In India, cross-scenario analyses show that early action in decarbonizing the electricity sector can prevent carbon lock-in, allowing for a direct switch from coal to renewable energy at a lower cost than a delayed action scenario (Mathur, 2023).

#### 4. Resource Optimization and Efficiency Improvement

Circular economy-based approaches to minimizing waste and maximizing recycling in the industrial sector have shown great potential to reduce carbon emissions. In a study in Quebec, the application of circular strategies on the steel value chain was able to reduce greenhouse gas emissions by up to 55% through a combination of material recycling and carbon-efficient material substitution (Binet et al., 2021).

## 5. The Role of Digital Technology and Industry 4.0

The implementation of digital technologies such as blockchain, digital twins, and smart networks improves the operational efficiency of energy companies. This technology allows for an increase in energy efficiency of up to 30%, a reduction in operating costs, and an extension of the life of energy plants that are more environmentally friendly (Borowski, 2021). An effective mitigation strategy requires a combination of technological innovation, data-driven operational optimization, proactive policies, and the adoption of digital technology. This approach not only maintains energy productivity but also reduces negative impacts on the environment and supports the long-term sustainability of the energy sector.

### **12.3. Implementation of Environmentally Friendly Technology in Oil and Gas Activities**

The implementation of Environmentally Friendly Technology in Oil and Gas Activities refers to the application of innovations that aim to reduce the negative impact on the environment from oil and gas exploration and production activities. This technology not only reduces carbon emissions and pollution, but also supports resource efficiency and operational sustainability in the oil and gas sector. Here are the relevant eco-friendly technologies in this context:

1. **CCS Technology.** CCS is the main solution to reduce greenhouse gas emissions from burning fossil fuels in the oil and gas sector. This technology captures the CO<sub>2</sub> produced during the production process and stores it underground to prevent release into the atmosphere. Research shows that CCS can reduce carbon emissions by up to 90% in certain installations (Ji et al., 2020).
2. **Use of Renewable Energy for Oil and Gas Operations,** the integration of renewable energy, such as diesel and wind, in oil and gas operations reduces dependence on fossil-based energy. An illustration of this implementation is the use of solar energy to support pump or lighting systems in oil and gas facilities (Pires Manso et al., 2023).
3. **Waste Recycling Technology (Circular Economy),** a circular economy approach in oil and gas activities maximize the reuse and recycling of operational waste, such as water used in drilling and fracking processes. Studies show that this circular-based waste management significantly reduces natural resource consumption and ecological impact (Al Rashid, 2023).
4. **Green Technology for Production Water Treatment:** Production water, as a by-product of oil and gas exploration, contains harmful pollutants. Membrane technology-based treatment and carbon filtration have proven their efficiency in reducing toxic levels in water before it is disposed of or reused (Oruwari, 2023).
5. **Leveraging Old Infrastructure for the Blue Economy,** oil and gas platforms that are no longer in use can be converted into artificial habitats to support marine

biodiversity, renewable energy plants, or marine research centers. This transformation supports sustainable management of marine space and helps reduce the carbon footprint of the oil and gas sector (Carpenter, 2022).

6. Digital Technology and Industry 4.0, the application of digital technologies such as the Internet of Things (IoT) and artificial intelligence (AI) improves operational efficiency and minimizes waste in oil and gas processes. This technology allows for real-time monitoring and management of the environment, thereby providing early warning of potential environmental risks (Emad et al., 2023).

The implementation of environmentally friendly technology in the oil and gas sector is not only a strategy to comply with regulations, but also an important step toward industrial sustainability. This allows companies to contribute to environmental preservation while ensuring operational efficiency and economic sustainability. Technologies that support the principles of the blue economy aim to utilize marine resources in a sustainable manner for economic growth, improving people's welfare, and preserving marine ecosystems. Some of the technologies that are relevant in the context of oil and gas activities include marine renewable energy, multifunctional platforms, circular economy, and innovation-based green technology. The following is a discussion of related technologies based on the latest research.

1. Marine Renewable Energy: Renewable energy technologies such as offshore wind, ocean waves, and ocean currents are key elements in the blue economy. This energy replaces the use of fossil fuels that contribute to carbon emissions. The implementation of this system has shown efficiency in reducing the carbon footprint of the marine sector and the sea-based economy (Pires Manso et al., 2023).
2. Multi-Purpose Platforms (MPPs), multifunctional platforms integrate various sectors such as renewable energy and aquaculture. This technology enables efficient management of marine space by utilizing shared infrastructure, reducing operational costs, and supporting environmental sustainability (Abhinav et al., 2020).
3. Circular Economy in Oil and Gas, a circular economy approach is applied to reduce waste and maximize recycling in oil and gas facilities. This includes the reuse of construction materials and the optimization of energy waste to reduce environmental impacts (Al Rashid, 2023). Studies show that circular economy principles also extend the life of infrastructure and support operational efficiency.
4. Green Technology for Oil and Gas Operations, green technologies such as ecological-based waste treatment methods and greenhouse gas emission reduction support sustainable oil and gas operations. This technology enables pollution reduction through innovations such as alternative fuels and integrated emission management (Oruwari, 2023).

5. The application of industry 4.0 to the Blue Economy, the application of digital technologies such as the IoT and AI allows for increased efficiency and sustainability of marine economic activities. This technology is used to monitor the condition of the marine environment in real-time and maximize the use of marine resources (Emad et al., 2023).
6. Use of Old Infrastructure, dormant oil and gas facilities can be transformed into blue economy support structures, such as renewable energy plants or marine research centers. This transformation supports the transition from an oil and gas-based economy to an economy based on marine sustainability (Carpenter, 2022).

The implementation of this environmentally friendly technology supports the principles of the blue economy by balancing economic development, environmental protection, and social welfare in the oil and gas sector and other marine activities.

#### **12.4. The Role of BUMD in Sustainable Oil and Gas Management**

The role of BUMDs in sustainable oil and gas management includes the ability to integrate blue economy principles into policies and operational practices. The blue economy emphasizes the sustainable use of marine resources to improve local economic welfare, preserve marine ecosystems, and meet clean energy needs. Encouraging the Development of Sea-Based Renewable Energy, BUMD can be a catalyst in adopting renewable energy sources such as offshore wind and ocean wave power. These technologies not only reduce dependence on fossil energy, but also support ocean sustainability through reduced carbon emissions and increased investment in the green energy sector (Basu & Sharman, 2021). Repositioning Oil and Gas Infrastructure for the Blue Economy, Inactive oil and gas infrastructure can be reused for blue economy activities, such as renewable energy plants or marine research centers. This approach reduces the cost of building new infrastructure and improves the efficiency of resource use (Carpenter, 2022). Implementing the Circular Economy, BUMD can integrate circular economy principles in oil and gas activities by reusing industrial waste and optimizing existing resources. An Illustration is utilizing oil and gas waste for the production of alternative fuels or construction materials, thereby supporting the sustainability of the local economy (Lindauere et al., 2020). Strengthening Environment-Based Governance, BUMD has a great opportunity to improve environmental governance through the application of digital technologies such as IoT and AI. This technology allows for real-time operational monitoring and data-driven decision-making to minimize environmental impacts (Vazhenina et al., 2023). Multisectoral Collaboration for Sustainable Policy, BUMDs can lead collaboration between local governments, communities, and the private sector to develop strategies that support the blue economy. This collaboration includes investments in green technology, sustainable waste management, and public



education on the importance of ocean sustainability (Djoric, 2022a). BUMD has a strategic role in encouraging the implementation of the blue economy in oil and gas management through the adoption of innovative technologies, sustainable infrastructure management, and multisectoral collaboration. This approach not only supports environmentally friendly oil and gas management, but also contributes to the economic and social well-being of local communities.

Table 12.1. Implementation of Green Technology

| Green Technology                          | Description.                                                                                                                          | Benefit                                                                                                                    |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| AI-based Digital Twin                     | A digital system to model and monitor physical assets in real-time, among other things, ecological impacts on the marine environment. | Monitor environmental impacts, optimize ecosystem restoration, improve operational efficiency (Wilmink et al., 2023)       |
| Seagrass Restoration and Artificial Reefs | Using technology to rehabilitate critical marine habitats such as seagrass and coral reefs.                                           | Increasing biodiversity, reducing the impact of climate change, increasing local fisheries yields (D. McLean et al., 2021) |
| Offshore Renewable Energy                 | Installation of wind turbines or sea wave energy plants to support the operation of oil and gas platforms.                            | Reducing carbon emissions, diversifying energy sources in the oil and gas sector (McAfee et al., 2022)                     |
| Low-Carbon Fuel                           | Development and use of low-carbon alternative fuels in oil and gas exploration and production activities.                             | Reducing carbon footprint, improving energy sustainability (Danovaro et al., 2021)                                         |
| Sensors and IoT for Monitoring            | The application of digital sensors and the IoT to monitor the condition of the marine environment around oil and gas operations.      | Provide real-time data to identify environmental impacts and guide mitigation actions (Rosa et al., 2020)                  |
| Circular Economy in Oil and Gas Waste     | Processing waste from oil and gas production to be used as alternative fuels or construction materials.                               | Reduce waste, support sustainable business models (Lindauere et al., 2020)                                                 |
| Automation for Decarbonizing Operations   | The use of automation in oil and gas production activities to reduce greenhouse gas emissions and improve energy efficiency.          | Reduce emissions, increase operational productivity (Bayraktarov et al., 2020)                                             |

The initiative of BUMD in supporting sustainable oil and gas management involves the involvement of coastal communities and investment in green technology. This approach aims to ensure the recovery of marine ecosystems and support more environmentally friendly oil and gas exploration and production. Here is a description of the initiative based on recent research:

#### 1. Involvement of Coastal Communities in Marine Ecosystem Restoration

The involvement of coastal communities in the restoration of marine ecosystems plays an important role in increasing local awareness and involvement,

which supports the success of long-term restoration. A real illustration is coral reef and seagrass restoration that involves local communities to manage and protect critical habitats. Studies show that community-based recovery programs provide economic and ecological benefits, such as increased fishery stocks and marine biodiversity (McAfee et al., 2022). The initiative also includes educating the public on the importance of marine habitat conservation and sustainable use of natural resources.

## 2. Investing in Green Technology

Investments in green technology include the use of renewable energy and technology-based solutions to reduce the environmental impact of oil and gas activities.

Table 12.2. Marine Ecosystem Restoration through Oil and Gas Infrastructure

| Oil and Gas Infrastructure                             | Initiative Description.                                                                                                                                          | Benefit                                                                                                                  |
|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Offshore Platform                                      | Transforming dormant oil and gas platforms into artificial habitats that resemble natural coral reefs, supporting marine species such as fish and invertebrates. | Increasing marine biodiversity, creating new habitats, and supporting local fisheries (van Elden et al., 2022)           |
| Submarine Pipeline                                     | Using underwater pipelines to create ecological corridors for marine species, paying attention to structures that support benthic life.                          | Helps regenerate seabed habitats, creating a protection zone from trawls (D. McLean et al., 2021)                        |
| Facility Conversion to Marine Research Center          | Leveraging offshore facilities to support research related to marine conservation and climate change, with a focus on monitoring marine ecosystems.              | Support marine research, environmental conservation, and science-based education (Danovaro et al., 2021)                 |
| Multifunctional Habitat                                | Integrating various functions in oil and gas infrastructure, such as artificial reefs, fish protection areas, and marine biotechnology research sites.           | Optimizing the use of infrastructure for ecological, social, and economic benefits (McAfee et al., 2022)                 |
| Artificial Reef Management                             | Providing artificial substrates that support marine species in forming new ecosystems, as well as increasing local fishery stocks.                               | Increasing fisheries productivity and supporting the rehabilitation of damaged marine ecosystems (Saunders et al., 2020) |
| Use of Oil and Gas Infrastructure for Renewable Energy | Integrate dormant infrastructure with renewable energy plants such as offshore wind turbines or solar panels.                                                    | Reduce carbon emissions, support the transition to clean energy, and provide environmental benefits (Pires & Lima, 2022) |

Source : Author's Search, 2024

For illustration, the implementation of the AI-based Digital Twin system allows oil and gas companies to monitor ecological impacts in real-time and integrate ecosystem restoration solutions such as seagrass and artificial reef rehabilitation

(Wilmink et al., 2023). This technology provides strategic insights to optimize environmental investments while improving operational efficiency. Other initiatives involve converting dormant oil and gas infrastructure (table 12.2.) into artificial habitats, such as artificial coral reefs or marine research centers. Studies in Australia show that offshore oil and gas platforms can be transformed into unique habitats that support biodiversity and prevent further ocean degradation (van Elden et al., 2022).

Table 12.3. Implementation of Large-Scale Marine Ecosystem Restoration

| Restoration Projects                           | Initiative Description.                                                                                                                                                    | Benefit                                                                                                                              |
|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| Oyster Reef Restoration in Australia           | A collaborative project to restore lost oyster reefs, involving governments, local communities, and scientists.                                                            | Improving biodiversity, fisheries productivity, and seawater quality (McAfee et al., 2022)                                           |
| Seagrass Restoration in Europe                 | Restoration of damaged seagrass beds by involving the private sector and coastal communities for the rehabilitation of marine habitats.                                    | Improve fish habitat, increase carbon sequestration, and reduce coastal erosion (Danovaro et al., 2021)                              |
| Mangrove Rehabilitation in Southeast Asia      | Restoration of damaged mangroves through community-based programs supported by BUMD and international conservation agencies.                                               | Protecting beaches from storms, supporting fishing ecosystems, and increasing blue carbon stocks (Sheaves et al., 2021)              |
| Coral Reef Restoration in the Caribbean        | A large-scale initiative to improve coral reefs through coral transplantation with the involvement of the tourism sector and fishing communities.                          | Supporting the sustainability of marine tourism, increasing fish stocks, and protecting beaches from erosion (Saunders et al., 2020) |
| Management of Marine Protected Areas in Africa | Developing community-based marine conservation areas that involve BUMD in biodiversity monitoring and marine habitat management.                                           | Supporting the conservation of endangered species, increasing local income from ecotourism (Rosa et al., 2020)                       |
| Shallow Sea Recovery in Japan                  | Using green technology to accelerate the recovery of shallow marine ecosystems by involving the local fisheries industry.                                                  | Improve seawater quality, increase fish stocks, and reduce anthropogenic pressure (Lester et al., 2020)                              |
| MERCES Deep Sea Restoration, EU                | A pilot program in Europe to restore deep-sea habitats, among other things, seagrass meadows, algae forests and coral reefs, with the support of governments and academia. | Reducing the impact of climate change, supporting ecosystem services, and increasing biodiversity (Danovaro et al., 2021)            |

Source : Author's Search, 2024

BUMDs can contribute to large-scale restoration, such as the one undertaken by an oyster reef restoration project (table 12.3.) in Australia involving a wide range of stakeholders. This collaborative approach has succeeded in integrating ecological, social, and economic values in marine resource management (Danovaro et al., 2021).

BUMD's initiative through coastal community involvement and investment in green technology reflects a real effort to integrate sustainability principles in oil and gas activities. By involving local communities, adopting modern technology, and rehabilitating marine ecosystems, BUMDs can make a significant contribution to environmental conservation while supporting local economic development.

### **12.5. Synergy Between the Oil and Gas Sector and Marine Conservation**

The synergy between the oil and gas sector and marine conservation is an increasingly relevant topic in endeavors to manage ecosystems sustainably. This collaboration aims to align the exploitation of oil and gas resources with the preservation of marine ecosystems through an ecosystem-based approach (EBA). This approach involves a wide range of stakeholders, among other things, governments, local communities, and the private sector, to create policies that consider environmental, economic, and social aspects. The EBA emerged in response to the global challenge of maintaining a balance between the exploitation of natural resources and environmental conservation. The background of this approach is the increasing pressure on ecosystems due to human activities such as deforestation, climate change, and pollution. This approach aims to ensure sustainable resource management by considering the interconnectedness of complex ecosystems and the social and economic values associated with them (Walz et al., 2021). The implementation of EBA is carried out through the integration of ecosystem principles in planning and policy, such as data-driven management, Shareholder engagement, and area-based management that considers ecological relationships between habitats. In Europe, for illustration, this implementation model involves the use of specific indicators to assess environmental, social, and economic impacts, as well as the development of adaptive frameworks to support ecosystem-based planning in the fisheries and marine conservation sectors (Howell et al., 2021). The main objectives of EBA are to maintain the health of ecosystems, ensure sustainable use of resources, and create long-term benefits for present and future generations. This approach also aims to support sustainable development by mitigating the impacts of climate change and increasing socio-ecological resilience through ecosystem-based solutions (Woods, 2022). EBAs are needed because traditional approaches are often focused on a single sector without considering the complex interactions between ecosystems. With increasing global threats such as climate change and overexploitation, the EBA provides an adaptive framework to support a balance between conservation and sustainable resource use (Rodriguez-Perez et al., 2023). An EBA is an important step to integrate sustainability principles in natural resource management, support ecosystem resilience, and ensure benefits for society at large.

Studies show that offshore oil and gas infrastructure can have significant habitat value, but the challenges associated with decommissioning (elimination) of

infrastructure are often underregulated and expensive. Coordinated global endeavors for research on ecosystem impacts due to this infrastructure are essential to ensure sustainable decommissioning practices and by international agreements on environmental protection (D. L. McLean et al., 2020). In addition, the action of the management of Marine Protected Areas (MPAs) in Azores, Portugal, shows that the implementation of EBM involving collaboration with local stakeholders can improve ecosystem sustainability and meet various policy objectives (McDonald et al., 2020). Elsewhere, in the North Sea, participatory approaches to marine spatial management have succeeded in enhancing cross-sectoral dialogue and understanding of ecosystem and Shareholder relationships, providing a strong basis for sustainable policy planning (Slater et al., 2020). The conflict between offshore oil and gas exploitation and the protection of marine ecosystems is also raised as a major challenge. Studies in Atlantic Canada found that these conflicts are often caused by unbalanced priorities between oil and gas interests and conservation, resulting in the need for more integrated marine spatial planning (Kapoor et al., 2021). Overall, synergy between the oil and gas sector and marine conservation requires inclusive, data-driven, and cross-sectoral collaboration to ensure ecosystem sustainability and equitable social and economic benefits. Collaboration models like this show the potential to create more effective ecosystem-based solutions in the future.

Case studies from several countries that have applied blue economy principles in the oil and gas sector, among other things, the implementation of no-exploration zones in ecologically sensitive areas. Case studies in table 12.1. providing insight into how the principles of the blue economy are applied in the oil and gas sector to achieve a balance between the exploitation of natural resources and the protection of the marine environment. Each country faces unique challenges based on their geographical, socio-economic, and political conditions. Practices such as restricting exploration in sensitive ecosystem zones and adopting environmentally friendly technologies are important elements in realizing the blue economy.

Canada, the integration of technology from the oil and gas sector with renewable energy in NL highlights the potential for a blue economic transition. However, without a clear transition plan, there is a risk of negative impacts on marine ecosystems. Then for the EU through marine spatial planning, the EU advises a ban on exploration in areas that are at high risk of environmental damage, such as coral habitats and MPAs. Australia places an emphasis on local policies tailored to specific ecosystems, such as no-exploration zones to prevent environmental degradation in high-biodiversity coastal areas. India's blue economy approach is focused on economic integration and environmental conservation, with strict policies to limit exploitation in sensitive areas.

Table 12.4. Case Study of Blue Economy Implementation in the Oil and Gas Sector

| Country/Region                                         | Implementation of the Blue Economy.                                                                                                                                                   | Key Principles.                                                                                       |
|--------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Kanada (Fusco et al., 2022)                            | Newfoundland and Labrador (NL) are integrating technologies from the oil and gas industry to support the transition to renewable energy, but face criticism regarding sustainability. | Emphasis on technological innovation to balance exploitation and environmental sustainability.        |
| EU (Djoric, 2022b)                                     | The application of blue economy principles in the EU's Maritime Policy includes a ban on exploration in sensitive ecosystem zones to support ocean sustainability.                    | Implementation based on holistic marine spatial planning and marine economic sustainability planning. |
| Australia (Voyer et al., 2021)                         | Blue economy policies are being tested in coastal areas with an EBA that involves limiting exploration in areas with high biodiversity.                                               | Local context-based policies to avoid conflicts between sectors.                                      |
| India ("Blue Economy Policy of India," 2022)           | The Blue Economy policy is focused on protecting marine biodiversity while increasing the contribution of the marine economy to national GDP.                                         | Transformation of the marine economy through a circular approach and ecosystem protection.            |
| Indonesia & China (Khairunnisa, 2022)                  | Adopt blue economy policies to reduce the impact of oil and gas activities, among other things, marine waste management and the protection of sensitive areas.                        | A combination of ecosystem approach and strict regulations on marine pollution.                       |
| Norwegia (Engen et al., 2021)                          | Norway has implemented a no-exploration zone in the Barents Sea to protect habitats important for marine biodiversity, among other things, fish and marine mammal populations.        | Strict regulations based on marine spatial planning to protect ecologically sensitive areas.          |
| South Africa (Gammage & Jarre, 2021)                   | The implementation of marine conservation zones as part of the marine spatial planning policy aims to reduce oil and gas exploration in areas that are important habitats.            | Cross-sector collaboration and the use of community-based approaches for conservation.                |
| Amerika Serikat (Gulf of Mexico) (Howell et al., 2021) | A temporary ban on oil exploration in ecologically sensitive areas that are important nurseries for various marine species after the Deepwater Horizon oil spill.                     | Emphasis on reducing the risk of damage to marine ecosystems through no-exploration zones.            |
| Timor Leste (Voyer et al., 2021)                       | The implementation of the blue economy includes restrictions on exploration in biodiversity-rich coastal waters as well as international collaboration for ocean conservation.        | Prioritizing ecological sustainability through local engagement and data-driven management.           |
| Uni Emirat Arab (Lee et al., 2021)                     | The development of marine conservation areas in the Persian Gulf is part of a blue economy policy that limits oil and gas exploration in sensitive zones.                             | Focus on managing the risk of marine ecosystem damage and mitigating climate change.                  |

Source : Author's Search, 2024

Indonesia and China are collaborating and comparative studies show how regulation of marine pollution and management of sensitive areas can help improve ocean-based economies while protecting ecosystems. Norway as a country with a long history of oil and gas exploration, Norway has implemented a ban on exploration in ecologically sensitive areas such as the Barents Sea, supporting long-term sustainability through comprehensive marine spatial planning. Then South Africa with a policy based on marine spatial planning with a collaborative approach aims to

protect the habitat of endemic marine species and balance exploration with ecosystem conservation. The United States, after the Deepwater Horizon oil spill, the temporary ban on exploration in sensitive areas shows the importance of risk mitigation to protect important marine habitats. Timor Leste with its community-based approach to blue economy policies is an illustration of how small countries can protect marine ecosystems while managing natural resources sustainably. The United Arab Emirates as an oil and gas-rich country, the UAE shows that diversification of energy policies through the blue economy can support the preservation of marine ecosystems in the Persian Gulf. These case studies highlight that a no-exploration zone-based approach, marine spatial planning, and local involvement can help reduce the negative impacts of oil and gas exploration on marine ecosystems.

#### **12.6. Policy Recommendations to Support the Blue Economy in Oil and Gas**

Policy recommendations to support the implementation of the blue economy in the oil and gas sector include strategic measures to ensure the sustainability of marine ecosystems while meeting energy needs and economic development.

##### **1. Strengthening the Legal and Policy Framework**

The implementation of Marine Spatial Planning (MSP) aims to regulate human activities in marine areas in a coordinated manner, especially in the oil and gas sector, to minimize negative impacts on sensitive ecosystems and protect marine biodiversity. MSP provides an EBA to planning and managing the use of marine space in a sustainable way. MSP is a strategic approach designed to manage human activities in the ocean in a sustainable manner, especially in the oil and gas sector, to protect sensitive ecosystems and marine biodiversity. MSP minimizes conflicts between sectors by regulating oil and gas activities in areas prone to ecosystem damage. For illustration, in the Atlantic Ocean, this policy is used to balance the protection of conservation areas with the management of oil and gas exploration licenses, reducing pressure on critical habitats (Kapoor et al., 2021). In addition, MSPs integrate analytical tools such as cumulative impact evaluation to identify human activity stressors on marine ecosystems, aiding in effective data-driven management planning (Hansen & Bonnevie, 2020).

MSP is also used to plan the restoration of marine ecosystems such as seagrass beds and mangrove forests that support ecosystem services, among other things, coastal protection and carbon sequestration. This restoration is planned through the selection of strategic locations that maximize the benefits of the ecosystem (Lester et al., 2020). In addition, MSPs facilitate the connectivity of marine habitats through the construction of ecological corridors that allow the migration of marine species and increase ecosystem resilience to human stress (Podda & Porporato, 2023). In Europe, MSPs have been part of the EU's blue economy strategy

that supports the protection of marine biodiversity and coastal ecosystems, while accommodating other economic activities (Kyriazos & Poga, 2023). In New Zealand, MSP in Hauraki Bay involves local communities and the government in developing conservation areas to protect the main habitats of the sea (Tablada et al., 2022). Meanwhile, in the Brazilian Amazon Shelf region, MSP is used to manage the exploitation of natural resources such as oil and gas while still paying attention to the sustainability of coastal ecosystem biodiversity (Araujo et al., 2021). MSPs provide a systematic framework to protect marine ecosystems while accommodating human needs, among other things, the oil and gas sector. By leveraging data-driven analytical tools, engaging communities, and adopting adaptive conservation policies, MSPs are key in creating the sustainability of marine ecosystems globally.

Offshore infrastructure decommissioning regulations are a critical step in ensuring the recovery of marine ecosystems after the cessation of oil and gas (oil and gas) activities. Oil and gas infrastructure that has reached the terminate of its operating life, such as platforms and undersea pipelines, often has a significant ecological impact. This regulation is designed to manage these impacts by regulating the removal, management in situ, or even reuse of the oil and gas structure.

In some regions, the decommissioning approach includes options for full removal, partial removal, or in-place structure containment. The choice should be evaluated based on environmental impact, safety, and technical feasibility. Examples in Australia show that in situ alternatives, such as maintaining infrastructure as artificial reefs, can increase marine biodiversity and provide more ecosystem benefits (Watson et al., 2023). However, this approach requires strong evidence of its long-term impact on marine ecosystems. One of the major challenges is the presence of contaminants such as natural radioactive materials (NORMs) and heavy metals that are often found in oil and gas pipelines. Research in Australia shows that risk assessment of these contaminant residues is critical to determining whether in situ decommissioning options can be implemented without harming the environment (Cresswell et al., 2021).

Decommissioning regulations also aim to protect marine ecosystems by ensuring that the chosen management options minimize disruption to seabed habitats. Research in Norway and the United Kingdom underscores the importance of integrating ecosystem studies in every stage of the decommissioning process, among other things, monitoring impacts on ecological connectivity and marine habitat productivity (D. L. McLean et al., 2022). In addition, infrastructure decommissioning can open up opportunities to create new ecosystems. Studies in Australia show that oil and gas structures left in place can develop into unique ecosystems with high levels of biodiversity, resembling natural habitats such as coral reefs (van Elden et al., 2022). Offshore infrastructure decommissioning regulations are an important tool to ensure that the cessation of oil and gas operations not only



reduces environmental impacts but also provides significant ecosystem benefits. An evidence-based approach, long-term monitoring, and Shareholder engagement are key elements to ensure the success of sustainable decommissioning.

## 2. Transition to Renewable Energy

The integration of renewable energy into the oil and gas (oil and gas) sector is an important step in the transition to sustainability, especially through the adoption of technologies such as blue hydrogen and carbon storage. In Canada, the implementation of blue hydrogen derived from natural gas reform with carbon capture and storage technology (CCUS) has shown great potential in reducing carbon emissions while maintaining energy efficiency. This technology allows for a significant reduction in CO<sub>2</sub> emissions from the hydrogen production chain and is considered a cost-effective alternative compared to green hydrogen produced from renewable energy-based electrolysis (Yu et al., 2021). Blue hydrogen technology has also been integrated with multi-energy systems to improve operational efficiency. A study in the United Kingdom shows that the combination of gas-to-gas (G2G) processes with CCUS can significantly reduce operational costs, while supporting the large-scale integration of renewable energy capacity such as wind (Fu et al., 2020). In addition, the development of technologies such as sorcery-based methane reform with carbon capture (SE-SMR) has shown the potential to achieve efficiency of up to 94% in carbon capture, making it a superior solution for decarbonizing the oil and gas sector (Yan et al., 2020). In remote areas that depend on oil and gas, the integration of renewable energy and green hydrogen can also provide sustainable energy solutions. Studies show that green hydrogen technology can reduce dependence on fossil fuels, generate low-carbon electricity, and provide flexible energy storage options for applications in high-carbon emission sites (Velarde, 2021). The integration of renewable energy in oil and gas areas also supports sustainability goals through the development of hydrogen economy as an alternative fuel. Research shows that hydrogen from low-carbon-based processes not only reduces emissions but also expands the natural gas infrastructure network to support the clean energy transition globally (Ehlig-Economides & Hatzignatiou, 2021). The integration of renewable energy such as blue and green hydrogen into the oil and gas sector presents a great opportunity for decarbonization. This technology allows the oil and gas sector to remain relevant in the energy transition, while mitigating the environmental impact of oil and gas industry activities.

Diversification of energy portfolios is an important element in the transition to energy sustainability. Encouraging investment in renewable energy through fiscal incentives and green financing is a strategic step that supports the reduction of carbon emissions and improves national energy Stock. (Hughes & Zabala, 2023)) highlight that fiscal incentive, such as subsidies and tax reductions, significantly increase the attractiveness of investment in the renewable energy sector. Green

financing, among other things, the issuance of green bonds and green credits, provides more support to accelerate capital flows to sustainable energy projects. In addition, other research shows that energy portfolio diversification not only serves to reduce risks to fluctuations in global energy prices but also supports long-term economic stability. (Rianti Kartika et al., 2023) in their study mentioned that diversification that includes technologies such as solar, wind, and biomass provides economic benefits while reducing environmental risks. Risk-based management strategies for renewable energy portfolios have proven to provide significant benefits, especially in the face of global dynamic challenges. This approach also requires consistent long-term policy support to increase investor confidence and encourage research and development of new technologies. (Ririh et al., 2021) underlined the importance of developing regulations that support the implementation of green financing as a measure to mitigate environmental impacts. Another study by (Nafisa & Teguh Wibowo, 2020) noted that the implementation of innovative financing models, such as the Capital Asset Pricing Model (CAPM), can help measure risk and optimize investment returns in renewable energy portfolios. Furthermore, the transformation of energy portfolios requires multi-sector collaboration. The government, financial institutions, and the private sector need to work together to create a conducive investment environment. A study by (Thufailah et al., 2022) shows that an integrated approach to investment management based on the Markowitz model is able to create an optimal portfolio that maximizes returns while minimizing risks. Diversification of energy portfolios through fiscal incentives and green financing is an important foundation for achieving energy Stock and environmental sustainability. Solid policy support, accompanied by strategic fund allocation, can accelerate the energy transition and encourage green economic growth.

### 3. Shareholder Engagement

The involvement of stakeholders, particularly local communities in the planning and management of marine resources, plays an important role in ensuring economic and social sustainability. An illustration of the success of this approach can be seen in Norway, where the participation of coastal communities is key in protecting marine ecosystems while improving the well-being of surrounding communities (Evans et al., 2023). The community-based approach allows for the integration between local knowledge and conservation policy, creating governance oriented to local needs and potentials. A study by (Kurniawan et al., 2021) underscores the importance of local wisdom in marine resource management. In Kedonganan Village, Bali, for illustration, sustainability benchmarks include social, economic, and ecological aspects combined with local customary practices. The results show that community participation improves the effectiveness of overall resource management. Meanwhile, (Fazayanti et al., 2020) emphasized that group-

based approaches, such as Forest Farmer Groups, can also be applied to coastal communities to support economic resilience and environmental conservation.

In Indonesia, the application of customary law such as in the Weh Island Marine Tourism Park based on Hukom Adat Laot shows a positive impact on the sustainability of natural resource management (Aris et al., 2020). This custom-based system creates a balance between ecological conservation and economic use by actively involving local communities. (Hidayati, 2020) added that the dynamics of fishing community groups, such as communication and social cohesion, are determinants of resilience in facing the challenge of marine ecosystem damage. A participatory, community-based approach not only builds economic resilience but also creates stronger social solidarity. The involvement of local communities in the management of marine resources not only promotes ecological sustainability but also ensures that economic and social benefits can be felt equally. To strengthen this approach, synergy between the government, communities, and local organizations is needed by providing adequate policy support and resources.

Multisectoral collaboration between industry, government, and civil society is an approach that is increasingly recognized as important for creating inclusive and sustainable decision-making. (Harris & Thompson, 2023) highlight that this collaboration allows synergies between sectors that enrich the policy-making process with a broader perspective. In its implementation, this approach requires careful management to ensure that all parties have a balanced voice in the decision-making process. Other studies support the importance of pentahelix-based collaboration involving academia, community, government, business, and the media as key pillars of success. For illustration, research by (Sidiq et al., 2023) shows that the active involvement of local communities together with the government and the private sector in the management of tourism resources provide significant results in increasing local economic benefits. On the other hand, (Pajarianto et al., 2023) show that collaborative approaches can be used to create social awareness, such as in smoke-free campaigns that integrate educational, legal, and health aspects. In addition, (Rahardi, 2022) explained that the success of multi-sector collaboration requires the inclusion of multimodalities in decision-making models to take into account various social, cultural, and economic dimensions. This allows for more innovative and responsive solutions to the needs of the community. The research also highlights the importance of a community-based approach in maximizing the benefits of this collaboration, as discussed in the study of strengthening tobacco-free areas in Indonesia. Multisectoral collaboration not only supports inclusivity but also strengthens decision-making effectiveness by integrating different perspectives and expertise. Well-managed collaboration can be a powerful tool to achieve sustainable development and better solutions to the challenges of modern society.

#### 4. Green Technology Development

The use of digital technology in the oil and gas industry is one of the important innovations to improve energy efficiency and reduce environmental impact. (Evseeva et al., 2023) highlight that the digitization of oil and gas processes, among other things, the use of technologies such as AI, enables real-time monitoring, operation optimization, and carbon emission reduction. This technology enables energy savings through predicting energy consumption patterns and handling operational disruptions before they occur. Other studies show that the use of clean technologies such as IoT-based management systems is able to reduce industrial waste and reduce operational costs. (Pratama et al., 2023) explained that the implementation of information technology governance based on the COBIT five framework helps improve data management for more efficient strategic decision-making. This is very relevant in the oil and gas industry to manage environmental and operational risks. In addition, (Malau et al., 2024) showed that AI is making a major contribution to innovations in environmental data analysis, allowing for more thoughtful management of resources. For illustration, AI can be used to detect potential oil leaks or pollution more accurately and quickly than conventional methods. The application of digital technology can also strengthen sustainability by supporting the development of renewable energy in the oil and gas industry. The process of digital integration into oil and gas operations helps transition to greener practices without sacrificing efficiency. Digitalization in the oil and gas industry through clean technology and AI provides effective solutions to increase efficiency and reduce negative impacts on the environment. Policy support and investment in these technologies will accelerate the transformation toward a more sustainable energy industry.

Clean energy innovations, such as investments in carbon storage technologies and green hydrogen production, are important steps to accelerate the transition to green energy. (Safari et al., 2021) highlight that carbon storage, which involves capturing CO<sub>2</sub> emissions from burning fossil fuels and storing them underground, has the potential to significantly reduce the carbon footprint. This technology enables sustainable emission management in sectors that are difficult to replace, such as heavy industry. Green hydrogen, which is produced using renewable energy to separate water into hydrogen and oxygen, offers a versatile clean energy solution. (Evseeva et al., 2023) explain that green hydrogen can be used as a fuel for transportation, an energy source for industry, and an energy storage medium, making it a key technology in achieving global decarbonization targets. In addition, a study by (Malau et al., 2024) highlights the role of AI technology in improving the efficiency of green hydrogen production and minimizing operational costs. This technology allows for the optimization of the electrolysis process and data analysis to improve production yields. On the other hand, the integration of these technologies requires a strong regulatory framework and policy incentives to drive widespread adoption.

(Rahardi, 2022) highlighted that government support, both through innovation financing and subsidy policies, is very important in accelerating the development and adoption of clean energy technology. Investments in carbon storage and green hydrogen production, supported by advanced technologies such as AI, are a strategic step toward creating a more sustainable energy system. Policy support and synergy between the private sector and the government are key to accelerating this energy transformation.

## 5. Raising Awareness and Education

The oil and gas workforce training program to develop skills in the renewable energy sector is an important step in supporting a just economic transition. (Krawchenko & Gordon, 2022) highlight that retraining the workforce from the oil and gas sector can prepare individuals to adapt to new job opportunities in the renewable energy sector, such as solar, wind, and green hydrogen. This move not only helps workers maintain the relevance of their skills but also ensures no group is left behind in the shift toward a low-carbon economy. (Sunarto & Ansori, 2020) emphasized that training based on community empowerment is able to increase individual productivity and skills. In the context of the oil and gas workforce, this approach can be applied through vocational education and training programs focused on renewable energy technologies. In addition, Pratama et al. (2023) mentioned that training management based on a clear governance framework, such as COBIT 5, can improve efficiency in training programs by ensuring that the material delivered is relevant to industry needs. In addition, research shows that training should involve elements of digital technology to teach new skills relevant to jobs in the clean energy sector. (Rahardi, 2022) highlights the importance of a multimodality approach in learning to accelerate the skill adaptation process. This can include online or simulation-based training to introduce oil and gas workers to advanced technologies in the renewable energy sector. The retraining program for oil and gas workers is a strategic step that supports the energy transition in an inclusive and equitable way. With the support of governments, the private sector, and the right policy framework, the program can pave the way for the workforce to adapt in a sustainability-focused economy.

Public awareness campaigns play an important role in increasing public understanding of the sustainability of marine ecosystems, which is the cornerstone of blue economy policies. (Schutter et al., 2021) emphasized that the success of these campaigns depends on collaboration between governments, community organizations, and the private sector to deliver information that is easily accessible and relevant to coastal communities and the wider community. The campaign aims to strengthen awareness of the importance of protecting marine ecosystems for economic sustainability and social well-being. In addition, (Hidayati, 2020) in her study shows that the resilience of fishing communities is greatly influenced by group

dynamics and good communication, which can be strengthened through campaigns that highlight the value of marine ecosystems. In a more specific context, (Aris et al., 2020) found that customary law systems such as Hukom Adat Laot on Weh Island can be used as an effective approach in sustainable marine resource management, as long as it is integrated with policies supported by public awareness. A campaign-based approach can also utilize digital platforms to reach a wider audience, as noted by (Triguswinri & Afrizal, 2021), who stated that online platforms can be used to convey environmental philanthropic messages and create connections between communities and sustainability agendas. In addition, (Marlisa & Wijaya, 2021) said that legal awareness and public compliance with rules that support sustainability are important indicators of the success of this campaign. Effective public awareness campaigns require multi-Shareholder collaboration, the use of digital media, and the strengthening of local values to encourage the protection of marine ecosystems and support the implementation of blue economy policies more broadly.

### **12.7. Conclusion and Recommendations**

Chapter 12 discusses the importance of applying blue economy principles in the oil and gas sector to support the sustainability of marine ecosystems and meet energy needs in a sustainable manner. The main issues raised include marine pollution, high carbon emissions, habitat destruction due to oil and gas activities, as well as challenges such as resistance to change, cost constraints, and lack of adequate environmental regulations. To address these challenges, this chapter suggests strengthening regulations, investing in environmentally friendly technologies such as CCS and ocean-based renewable energy, as well as the use of old oil and gas infrastructure for blue economy-based activities, such as creating artificial marine habitats. A circular economy-based approach is also recommended to manage waste more efficiently and support resource sustainability.

The conclusion of this chapter emphasizes that the application of blue economy principles can reduce the environmental impact of the oil and gas sector while supporting sustainable operations. Cross-sector collaboration and strengthening environmental policies are key factors in the successful implementation of this strategy. The novelties proposed in this chapter include the use of advanced technologies such as the IoT and AI for real-time monitoring of environmental impacts, as well as the use of dormant oil and gas infrastructure as marine habitats to increase biodiversity. Case studies from various countries provide concrete examples of the implementation of MSP policies based on the blue economy to support environmental conservation.

For the foreseeable future, this chapter recommends the development of an energy transition to renewable sources such as green hydrogen, increased international collaboration to create uniform environmental regulations, and the

active involvement of local communities in blue economy-based ocean management. In addition, further research and development is needed to create more innovative and efficient blue economy solutions, to support overall economic, social, and ecological sustainability.

## Reference

- Abhinav, K. A., Collu, M., Benjamins, S., Cai, H., Hughes, A., Jiang, B., Jude, S., Leithead, W., Lin, C., Liu, H., Recalde-Camacho, L., Serpetti, N., Sun, K., Wilson, B., Yue, H., & Zhou, B. Z. (2020). Offshore multi-purpose platforms for a Blue Growth: A technological, environmental and socio-economic review. In *Science of the Total Environment* (Vol. 734). <https://doi.org/10.1016/j.scitotenv.2020.138256>
- Al Rashid, M. (2023). *Mapping Circular Economy in Oil and Gas Facility*. <https://doi.org/10.2118/213265-ms>
- Al-Khori, K., Bicer, Y., & Koç, M. (2020). Integration of Solid Oxide Fuel Cells into oil and gas operations: needs, opportunities, and challenges. In *Journal of Cleaner Production* (Vol. 245). <https://doi.org/10.1016/j.jclepro.2019.118924>
- Araujo, L. S., Magdalena, U. R., Louzada, T. S., Salomon, P. S., Moraes, F. C., Ferreira, B. P., Paes, E. T. C., Bastos, A. C., Pereira, R. C., Salgado, L. T., Lorini, M. L., Yager, P., & Moura, R. L. (2021). Growing industrialization and poor conservation planning challenge natural resources' management in the Amazon Shelf off Brazil. *Marine Policy*, 128. <https://doi.org/10.1016/j.marpol.2021.104465>
- Aris, M., Fahrudin, A., Riani, E., & Muttaqin, E. (2020). ANALISIS KEBERLANJUTAN PENGELOLAAN TAMAN WISATA ALAM LAUT (TWAL) PULAU WEH BERDASARKAN HUKOM ADAT LAOT (Sustainability Analysis of the Marine Recreational Park (MRP) Management in Weh Island Based on Local Customary Law of the Sea (Hukum Adat Laot). *Jurnal Manusia Dan Lingkungan*, 25(1). <https://doi.org/10.22146/jml.23065>
- Asif, Z., Chen, Z., An, C., & Dong, J. (2022). Environmental Impacts and Challenges Associated with Oil Spills on Shorelines. In *Journal of Marine Science and Engineering* (Vol. 10, Issue 6). <https://doi.org/10.3390/jmse10060762>
- Basu, R. I., & Sharman, K. T. (2021). The path to the blue economy - Lessons from the oil and gas industry. *SNAME Maritime Convention 2021, SMC 2021*. <https://doi.org/10.5957/SMC-2021-077>
- Bayraktarov, E., Brisbane, S., Hagger, V., Smith, C. S., Wilson, K. A., Lovelock, C. E., Gillies, C., Steven, A. D. L., & Saunders, M. I. (2020). Priorities and Motivations of Marine Coastal Restoration Research. *Frontiers in Marine Science*, 7. <https://doi.org/10.3389/fmars.2020.00484>
- Beyer, J., Goksøyr, A., Hjermann, D. Ø., & Klungsøyr, J. (2020). Environmental effects of offshore produced water discharges: A review focused on the Norwegian continental shelf. In *Marine Environmental Research* (Vol. 162). <https://doi.org/10.1016/j.marenvres.2020.105155>
- Binet, F., Saunier, F., & Margni, M. (2021). Assessing the Mitigation Potential of Environmental Impacts From Circular Economy Strategies on an Industrial Sector and Its Value Chain: A Case Study on the Steel Value Chain in Quebec. *Frontiers in Sustainability*, 2. <https://doi.org/10.3389/frsus.2021.738890>



- Blue Economy Policy of India. (2022). *Oceans Conference Record (IEEE)*. <https://doi.org/10.1109/OCEANSCennai45887.2022.9775217>
- Bonoli, A., Zanni, S., & Serrano-Bernardo, F. (2021). Sustainability in building and construction within the framework of circular cities and european new green deal. The contribution of concrete recycling. In *Sustainability (Switzerland)* (Vol. 13, Issue 4). <https://doi.org/10.3390/su13042139>
- Borowski, P. F. (2021). Digitization, Digital Twins, Blockchain, and Industry 4.0 as Elements of Management Process in Enterprises in the Energy Sector. *Energies*, 14(7). <https://doi.org/10.3390/en14071885>
- Carpenter, C. (2022). Legacy Gulf of Mexico Oil and Gas Facilities Hold Promise for Role in Blue Economy. *Journal of Petroleum Technology*, 74(09). <https://doi.org/10.2118/0922-0083-jpt>
- Cresswell, T., Brown, S., Wong, H., & Apte, S. (2021). Assessing the impacts of scale residues from offshore oil and gas decommissioning on marine organisms. *The APPEA Journal*, 61(2). <https://doi.org/10.1071/aj20024>
- Danovaro, R., Aronson, J., Cimino, R., Gambi, C., Snelgrove, P. V. R., & Van Dover, C. (2021). Marine ecosystem restoration in a changing ocean. *Restoration Ecology*, 29(S2). <https://doi.org/10.1111/rec.13432>
- Djoric, Z. (2022a). Blue economy: Concept research and review of the European Union. *Zbornik Matice Srpske Za Drustvene Nauke*, 182, 233–256. <https://doi.org/10.2298/ZMSDN2282233D>
- Djoric, Z. (2022b). Blue economy: Concept research and review of the European Union. *Zbornik Matice Srpske Za Drustvene Nauke*, 182. <https://doi.org/10.2298/zmsdn2282233d>
- Ehlig-Economides, C., & Hatzignatiou, D. G. (2021). Blue hydrogen economy - A new look at an old idea. *Proceedings - SPE Annual Technical Conference and Exhibition, 2021-September*. <https://doi.org/10.2118/206282-MS>
- Emad, G. R., Shahbakhsh, M., Abdussamie, N., & Rabiul Islam, T. M. (2023). Implementation of industry 4.0 and its effect on human element and sustainable development in the blue economy. *Proceedings of the International Conference on Offshore Mechanics and Arctic Engineering - OMAE*, 10. <https://doi.org/10.1115/OMAE2023-101806>
- Engen, S., Hausner, V. H., Gurney, G. G., Broderstad, E. G., Keller, R., Lundberg, A. K., Murguzur, F. J. A., Salminen, E., Raymond, C. M., Falk-Andersson, J., & Fauchald, P. (2021). Blue justice: A survey for eliciting perceptions of environmental justice among coastal planners' and small-scale fishers in Northern-Norway. *PLoS ONE*, 16(5 May). <https://doi.org/10.1371/journal.pone.0251467>
- Evans, L. S., Buchan, P. M., Fortnam, M., Honig, M., & Heaps, L. (2023). Corrigendum: Putting coastal communities at the center of a sustainable blue economy: A review of risks, opportunities, and strategies (Frontiers in Political Science,

- (2023), 4, (1032204), 10.3389/fpos.2022.1032204). In *Frontiers in Political Science* (Vol. 5). <https://doi.org/10.3389/fpos.2023.1182415>
- Evseeva, O., Shymchenko, A., Miller, A., & Davidenko, L. (2023). Technological challenges in the economy of the oil and gas sector. *E3S Web of Conferences*, 419. <https://doi.org/10.1051/e3sconf/202341901020>
- Fazayanti, Q. N., Wahyuni, E. S., & Nurdinawati, D. (2020). Analisis Sosial Ekonomi dan Ekologi Program Pengelolaan Hutan Bersama Masyarakat (PHBM). *Jurnal Sains Komunikasi Dan Pengembangan Masyarakat [JSKPM]*, 4(3). <https://doi.org/10.29244/jskpm.4.3.377-392>
- Friederichs, C. H. (2023). Path to a Green and Circular Decommissioning. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/216338-MS>
- Fu, P., Pudjianto, D., Zhang, X., & Strbac, G. (2020). Integration of hydrogen into multi-energy systems optimisation. *Energies*, 13(7). <https://doi.org/10.3390/en13071606>
- Fusco, L. M., Schutter, M. S., & Cisneros-Montemayor, A. M. (2022). Oil, Transitions, and the Blue Economy in Canada. *Sustainability (Switzerland)*, 14(13). <https://doi.org/10.3390/su14138132>
- Gammage, L. C., & Jarre, A. (2021). Scenario-Based Approaches to Change Management in Fisheries Can Address Challenges With Scale and Support the Implementation of an Ecosystem Approach to Fisheries Management. *Frontiers in Marine Science*, 8. <https://doi.org/10.3389/fmars.2021.600150>
- Ginga, C. P., Ongpeng, J. M. C., & Daly, M. K. M. (2020). Circular economy on construction and demolition waste: A literature review on material recovery and production. In *Materials* (Vol. 13, Issue 13). <https://doi.org/10.3390/ma13132970>
- Halsey, T., Agrawal, G., Bailey, J. R., Balhoff, M., Borglum, S., Mohanty, K. K., & Traver, M. T. (2023). Grand Challenges for the Oil and Gas Industry for the Next Decade and Beyond. *Journal of Petroleum Technology*, 75(07). <https://doi.org/10.2118/0723-0052-jpt>
- Hansen, H. S., & Bonnevie, I. M. (2020). A Toolset to Estimate the Effects of Human Activities in Maritime Spatial Planning. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 12252 LNCS. [https://doi.org/10.1007/978-3-030-58811-3\\_38](https://doi.org/10.1007/978-3-030-58811-3_38)
- Harris, J. L., & Thompson, B. S. (2023). Supporting places left to the sea: A place-based research agenda for regional coastal transformations in the blue economy. *Progress in Environmental Geography*, 2(4). <https://doi.org/10.1177/27539687231212672>

- Hidayati, E. (2020). Dinamika Kelompok dalam Resiliensi Komunitas Nelayan Menghadapi Kerusakan Ekosistem Laut. *Jurnal Sains Komunikasi Dan Pengembangan Masyarakat [JSKPM]*, 4(6). <https://doi.org/10.29244/jskpm.v4i6.748>
- Howell, D., Schueller, A. M., Bentley, J. W., Buchheister, A., Chagaris, D., Cieri, M., Drew, K., Lundy, M. G., Pedreschi, D., Reid, D. G., & Townsend, H. (2021). Combining Ecosystem and Single-Species Modeling to Provide Ecosystem-Based Fisheries Management Advice Within Current Management Systems. *Frontiers in Marine Science*, 7. <https://doi.org/10.3389/fmars.2020.607831>
- Hughes, E., & Zabala, A. (2023). Net zero by choice? Oil and gas industry motivations for the energy transition and public policy in Scotland. *Climate Policy*, 23(9). <https://doi.org/10.1080/14693062.2023.2262439>
- Ji, L., Huang, G. H., Niu, D. X., Cai, Y. P., & Yin, J. G. (2020). A stochastic optimization model for carbon-emission reduction investment and sustainable energy planning under cost-risk control. *Journal of Environmental Informatics*, 36(2). <https://doi.org/10.3808/jei.202000428>
- Kapoor, A., Fraser, G. S., & Carter, A. (2021). Marine conservation versus offshore oil and gas extraction: Reconciling an intensifying dilemma in Atlantic Canada. *Extractive Industries and Society*, 8(4). <https://doi.org/10.1016/j.exis.2021.100978>
- Khairunnisa, F. (2022). Blue Economic Concept on Protecting Marine Ecosystem in Indonesia and China. *The Lawpreneurship Journal*, 2(1), 43–60. <https://doi.org/10.21632/tlj.2.1.43-60>
- Kislyakova, Yu. G., & Usatova, I. Y. (2022). ENVIRONMENTAL IMPACT ASSESSMENT IN THE OIL AND GAS SECTOR. *Social'no-Ekonomiceskoe Upravlenie: Teoria i Praktika*, 18(1). <https://doi.org/10.22213/2618-9763-2022-1-36-41>
- Krawchenko, T. A., & Gordon, M. (2022). Just Transitions for Oil and Gas Regions and the Role of Regional Development Policies. *Energies*, 15(13). <https://doi.org/10.3390/en15134834>
- Kurniawan, A., Darmawan, ., & Oktariza, W. (2021). PENYUSUNAN TOLOK UKUR PENGELOLAAN PERIKANAN BERKELANJUTAN UNTUK KEARIFAN LOKAL DI DESA ADAT KEDONGANAN PROVINSI BALI. *Jurnal Kebijakan Sosial Ekonomi Kelautan Dan Perikanan*, 11(1). <https://doi.org/10.15578/jksekp.v11i1.9103>
- Kyriazos, T., & Poga, M. (2023). Dealing with Multicollinearity in Factor Analysis: The Problem, Detections, and Solutions. *Open Journal of Statistics*, 13(03), 404–424. <https://doi.org/10.4236/ojs.2023.133020>
- Lee, K. H., Noh, J., & Khim, J. S. (2020). The Blue Economy and the United Nations' sustainable development goals: Challenges and opportunities. In *Environment International* (Vol. 137). <https://doi.org/10.1016/j.envint.2020.105528>

- Lee, K. H., Noh, J., Lee, J., & Khim, J. S. (2021). Blue economy and the total environment: Mapping the interface. *Environment International*, 157. <https://doi.org/10.1016/j.envint.2021.106796>
- Lester, S. E., Dubel, A. K., Hernán, G., McHenry, J., & Rassweiler, A. (2020). Spatial Planning Principles for Marine Ecosystem Restoration. In *Frontiers in Marine Science* (Vol. 7). <https://doi.org/10.3389/fmars.2020.00328>
- Lindauere, D., Martinez, E., Fernández-Casatejada, R., & Santamaria, C. (2020). A global push for circular economy projects. *Society of Petroleum Engineers - SPE International Conference and Exhibition on Health, Safety, Environment, and Sustainability 2020, HSE and Sustainability 2020*. <https://doi.org/10.2118/199522-ms>
- Liu, Y., Lu, H., Li, Y., Xu, H., Pan, Z., Dai, P., Wang, H., & Yang, Q. (2021). A review of treatment technologies for produced water in offshore oil and gas fields. In *Science of the Total Environment* (Vol. 775). <https://doi.org/10.1016/j.scitotenv.2021.145485>
- Malau, M., Sihite, I. F., Sumanti, I. H., Desrianty, R. M., & Hutahaeon, Y. S. R. (2024). Perkembangan Artificial Intelligence dan Tantangan Generasi Muda di Era Super Digitalized. *IKRA-ITH ABDIMAS*, 8(1). <https://doi.org/10.37817/ikra-ithabdimas.v8i1.3198>
- Marlisa, S. D., & Wijaya, R. (2021). Kesadaran Hukum Masyarakat Desa Jabontegal Pungging Mojokerto Dalam Memiliki Kartu Identitas Anak. *Kajian Moral Dan Kewarganegaraan*, 10(2). <https://doi.org/10.26740/kmkn.v10n2.p382-396>
- Mathur, G. (2023). Communication: A Basic Skill of Medical Practice. *Bangladesh Journal of Medicine*. <https://doi.org/10.3329/bjm.v34i20.66096>
- McAfee, D., McLeod, I. M., Alleway, H. K., Bishop, M. J., Branigan, S., Connell, S. D., Copeland, C., Crawford, C. M., Diggles, B. K., Fitzsimons, J. A., Gilby, B. L., Hamer, P., Hancock, B., Pearce, R., Russell, K., & Gillies, C. L. (2022). Turning a lost reef ecosystem into a national restoration program. *Conservation Biology*, 36(6). <https://doi.org/10.1111/cobi.13958>
- McDonald, H., Hoffman, H., Ressurreição, A., Röschel, L., Gerdes, H., Lago, M., Boteler, B., McFarland, K., & Teixeira, H. (2020). Ecosystem-Based Management for More Effective and Equitable Marine Protected Areas: A Case Study on the Faial-Pico Channel Marine Protected Area, Azores. In *Ecosystem-Based Management, Ecosystem Services and Aquatic Biodiversity*. [https://doi.org/10.1007/978-3-030-45843-0\\_25](https://doi.org/10.1007/978-3-030-45843-0_25)
- McLean, D., Cure, K., Abdul Wahab, M. A., Galaiduk, R., Birt, M., Vaughan, B., Colquhoun, J., Case, M., Radford, B., Stowar, M., Harries, S., Heyward, A., & Miller, K. (2021). A comparison of marine communities along a subsea pipeline with those in surrounding seabed areas. *Continental Shelf Research*, 219. <https://doi.org/10.1016/j.csr.2021.104394>

- McLean, D. L., Bond, T., Partridge, J. C., Rouse, S., & Love, M. (2020). The impact of oil and gas infrastructure in marine ecosystems: a global vision for informing decommissioning decisions. *The APPEA Journal*, 60(2). <https://doi.org/10.1071/aj19153>
- McLean, D. L., Ferreira, L. C., Benthuyssen, J. A., Miller, K. J., Schläppy, M. L., Ajemian, M. J., Berry, O., Birchenough, S. N. R., Bond, T., Boschetti, F., Bull, A. S., Claisse, J. T., Condie, S. A., Consoli, P., Coolen, J. W. P., Elliott, M., Fortune, I. S., Fowler, A. M., Gillanders, B. M., ... Thums, M. (2022). Influence of offshore oil and gas structures on seascape ecological connectivity. In *Global Change Biology* (Vol. 28, Issue 11). <https://doi.org/10.1111/gcb.16134>
- Minunno, R., O'Grady, T., Morrison, G. M., & Gruner, R. L. (2020). Exploring environmental benefits of reuse and recycle practices: A circular economy case study of a modular building. *Resources, Conservation and Recycling*, 160. <https://doi.org/10.1016/j.resconrec.2020.104855>
- Nafisa, A., & Teguh Wibowo, D. (2020). PENGGUNAAN CAPITAL ASSET PRICING MODEL DALAM MENENTUKAN REQUIRED RETURN DAN SYSTEMATIC RISK SAHAM INDIVIDUAL. *DIALEKTIKA: Jurnal Ekonomi Dan Ilmu Sosial*, 5(1). <https://doi.org/10.36636/dialektika.v5i1.418>
- Oruwari, H. O. (2023). Green Technological Approach for Sustainable Operations of Oil and Gas Industry. *Society of Petroleum Engineers - SPE Nigeria Annual International Conference and Exhibition, NAIC 2023*. <https://doi.org/10.2118/217178-MS>
- Pajarianto, H., Amri, S. R., & Umrah, A. S. (2023). PENGUATAN KAWASAN LIFE STYLE WITHOUT TOBACCO: EDUKASI MULTIDISIPLIN PENDIDIKAN, KESEHATAN, DAN HUKUM. *SELAPARANG: Jurnal Pengabdian Masyarakat Berkemajuan*, 7(1). <https://doi.org/10.31764/jpmb.v7i1.12597>
- Pereira, E. G., Omotuyi, O., Koenck, A., Obani, P., Gopaulsingh, M., & Mohammed, S. (2023). DECOMMISSIONING OFFSHORE OIL AND GAS PLATFORMS: IS THE RIGS-TO-REEFS PROGRAM A MORE SUSTAINABLE ALTERNATIVE? *Journal of Sustainable Development Law and Policy*, 14(1). <https://doi.org/10.4314/jsdlp.v14i1.2s>
- Pires, D. R., & Lima, A. A. de. (2022). The logistical challenges to implement the environmental management system in a natural gas company in the North Region. *International Journal of Advanced Engineering Research and Science*, 9(9). <https://doi.org/10.22161/ijaers.99.16>
- Pires Manso, J. R., Martínez Vázquez, R. M., Milán García, J., & de Pablo Valenciano, J. (2023). Renewable Energies and Blue Economy: New Trends in Global Research. *Energies*, 16(10). <https://doi.org/10.3390/en16104210>
- Podda, C., & Porporato, E. M. D. (2023). Marine spatial planning for connectivity and conservation through ecological corridors between marine protected areas

- and other effective area-based conservation measures. In *Frontiers in Marine Science* (Vol. 10). <https://doi.org/10.3389/fmars.2023.1271397>
- Poranek, N., Łaźniewska-Piekarczyk, B., Czajkowski, A., & Pikoń, K. (2021). Possibilities of Management of Fly Ash from Municipal Solid Waste Incineration Plant in Building Industry in the Circular Economy. *IOP Conference Series: Materials Science and Engineering*, 1203(3). <https://doi.org/10.1088/1757-899x/1203/3/032087>
- Pratama, M. N., Perdanakusuma, A. R., & Rachmadi, A. (2023). Evaluasi Maturitas Teknologi Informasi Pada Proses Problem Management PT. XYZ Menggunakan Kerangka Kerja COBIT 5. *Jurnal Teknologi Informasi Dan Ilmu Komputer*, 10(2). <https://doi.org/10.25126/jtiik.20231026406>
- Rahardi, R. K. (2022). PERSEPSI URGENSI INKLUSI ASPEK-ASPEK MULTIMODALITAS DALAM DESAIN MODEL PEMBELAJARAN PRAGMATIK EDUKASIONAL. *LOA: Jurnal Ketatabahasaan Dan Kesusastraan*, 17(2). <https://doi.org/10.26499/loa.v17i2.4641>
- Rianti Kartika, W., Sukarsih, I., & Kurniati, E. (2023). Pembentukan Portofolio Optimal dengan Metode Markowitz pada Saham Syariah IDX-MES BUMN 17. *Bandung Conference Series: Mathematics*, 3(1). <https://doi.org/10.29313/bcsm.v3i1.6342>
- Ririh, K. R., Wicaksono, A., Berliandaldo, M., & Ajie, F. T. (2021). KAJIAN EFEKTIVITAS PROGRAM CORPORATE SOCIAL RESPONSIBILITY (CSR): STUDI KASUS PERUSAHAAN PEMBANGKIT ENERGI "Y." *J@ti Undip: Jurnal Teknik Industri*, 16(1). <https://doi.org/10.14710/jati.16.1.29-41>
- Rodriguez-Perez, A., Tsikliras, A. C., Gal, G., Steenbeek, J., Falk-Andersson, J., & Heymans, J. J. (2023). Using ecosystem models to inform ecosystem-based fisheries management in Europe: a review of the policy landscape and related stakeholder needs. In *Frontiers in Marine Science* (Vol. 10). <https://doi.org/10.3389/fmars.2023.1196329>
- Rosa, J. C. S., Morrison-Saunders, A., Hughes, M., & Sánchez, L. E. (2020). Planning mine restoration through ecosystem services to enhance community engagement and deliver social benefits. *Restoration Ecology*, 28(4). <https://doi.org/10.1111/rec.13162>
- Rybski, R. (2023). Energy in the European Green Deal: impacts and recommendations for MENA countries. *Journal of World Energy Law and Business*, 16(2). <https://doi.org/10.1093/jwelb/jwac033>
- Safari, A., Roy, J., & Assadi, M. (2021). Petroleum sector-driven roadmap for future hydrogen economy. *Applied Sciences (Switzerland)*, 11(21). <https://doi.org/10.3390/app112110389>
- Saunders, M. I., Doropoulos, C., Bayraktarov, E., Babcock, R. C., Gorman, D., Eger, A. M., Vozzo, M. L., Gillies, C. L., Vanderklift, M. A., Steven, A. D. L., Bustamante, R. H., &

- Silliman, B. R. (2020). Bright Spots in Coastal Marine Ecosystem Restoration. In *Current Biology* (Vol. 30, Issue 24). <https://doi.org/10.1016/j.cub.2020.10.056>
- Schutter, M. S., Hicks, C. C., Phelps, J., & Waterton, C. (2021). The blue economy as a boundary object for hegemony across scales. *Marine Policy*, 132. <https://doi.org/10.1016/j.marpol.2021.104673>
- Sheaves, M., Waltham, N. J., Benham, C., Bradley, M., Mattone, C., Diedrich, A., Sheaves, J., Sheaves, A., Hernandez, S., Dale, P., Banhalimi-Zakar, Z., & Newlands, M. (2021). Restoration of marine ecosystems: Understanding possible futures for optimal outcomes. In *Science of the Total Environment* (Vol. 796). <https://doi.org/10.1016/j.scitotenv.2021.148845>
- Sidiq, Rd. S. S., Sugiyanto, S., & Firmansyah, Y. (2023). Pemberdayaan Berbasis Kolaborasi dalam Penataan Fisik dan Sumber Daya Manusia di Bendungan Sungai Paku. *Lumbung Inovasi: Jurnal Pengabdian Kepada Masyarakat*, 8(3). <https://doi.org/10.36312/linov.v8i3.1430>
- Slater, A. M., Irvine, K. N., Byg, A. A., Davies, I. M., Gubbins, M., Kafas, A., Kenter, J., MacDonald, A., O'Hara Murray, R., Potts, T., Tweddle, J. F., Wright, K., & Scott, B. E. (2020). Integrating stakeholder knowledge through modular cooperative participatory processes for marine spatial planning outcomes (CORPORATES). *Ecosystem Services*, 44. <https://doi.org/10.1016/j.ecoser.2020.101126>
- Sunarto, S., & Ansori, T. (2020). PELATIHAN KETRAMPILAN SEBAGAI UPAYA MEMBERDAYAKAN MASYARAKAT (Studi Kegiatan Pelatihan Ketrampilan Pembuatan Kue dan Keripik di Jama'ah Muslimat NU Desa Serangan Kecamatan Sukorejo Tahun 2019). *Journal of Community Development and Disaster Management*, 2(1). <https://doi.org/10.37680/jcd.v2i1.988>
- Tablada, J., Geange, S., & Lundquist, C. J. (2022). Evaluation of biodiversity benefits of proposed marine protected areas from the Sea Change—Tai Timu Tai Pari Hauraki Gulf Marine Spatial Plan. *Conservation Science and Practice*, 4(10). <https://doi.org/10.1111/csp2.12803>
- Talaei, A., Ahiduzzaman, M., Davis, M., Gemechu, E., & Kumar, A. (2020). Potential for energy efficiency improvement and greenhouse gas mitigation in Canada's iron and steel industry. *Energy Efficiency*, 13(6). <https://doi.org/10.1007/s12053-020-09878-0>
- Temizel, C., Yegin, C., Bahar Hosgor, F., Aydin, H., & Kabir, S. (2022). Exploring Green Energy Applications in the Oil and Gas Industry. *Society of Petroleum Engineers - SPE Canadian Energy Technology Conference, CET 2022*. <https://doi.org/10.2118/208900-MS>
- Thufailah, N., Azib, & Setiyawan, S. (2022). Analisis Perbandingan Pembentukan Portofolio Optimal Saham Menggunakan Metode Markowitz Model dan Indeks Tunggal Model pada Perusahaan Sektor Teknologi yang Terdaftar di Bursa Efek Indonesia Periode 2020.2 & 2021.2. *Bandung Conference Series: Business and Management*, 2(1). <https://doi.org/10.29313/bcsbm.v2i1.2399>

- Triguswinri, K., & Afrizal, T. (2021). Eksklusi Sosial dalam Kapital Digital dan Kebijakan Virtual (Studi Filantropi Platform KitaBisa.com). *Ideas: Jurnal Pendidikan, Sosial, Dan Budaya*, 7(3). <https://doi.org/10.32884/ideas.v7i3.394>
- Tsai, W. T. (2021). Trend analysis of taiwan's greenhouse gas emissions from the energy sector and its mitigation strategies and promotion actions. *Atmosphere*, 12(7). <https://doi.org/10.3390/atmos12070859>
- van Elden, S., Meeuwig, J. J., & Hobbs, R. J. (2022). Offshore platforms as novel ecosystems: A case study from Australia's Northwest Shelf. *Ecology and Evolution*, 12(2). <https://doi.org/10.1002/ece3.8496>
- Vazhenina, L., Magaril, E., & Mayburov, I. (2023). Digital Management of Resource Efficiency of Fuel and Energy Companies in a Circular Economy. *Energies*, 16(8). <https://doi.org/10.3390/en16083498>
- Velarde, S. A. R. (2021). Challenges and Opportunities for Green Hydrogen Power Supply in Oil and Gas Remote Facilities. *SPE Middle East Oil and Gas Show and Conference, MEOS, Proceedings, 2021-November*. <https://doi.org/10.2118/204551-MS>
- Voyer, M., Quirk, G., Farmery, A. K., Kajlich, L., & Warner, R. (2021). Launching a Blue Economy: crucial first steps in designing a contextually sensitive and coherent approach. *Journal of Environmental Policy and Planning*, 23(3). <https://doi.org/10.1080/1523908X.2020.1856054>
- Waly, M. M., Mickovski, S. B., & Thomson, C. (2023). Application of Circular Economy in Oil and Gas Produced Water Treatment. *Sustainability (Switzerland)*, 15(3). <https://doi.org/10.3390/su15032132>
- Walz, Y., Nick, F., Higuera Roa, O., Nehren, U., & Sebesvari, Z. (2021). *Coherence and Alignment among Sustainable Land Management, Ecosystem-based Adaptation, Ecosystem-based Disaster Risk Reduction and Nature-based Solutions*. <https://doi.org/10.53324/MWGP9896>
- Watson, S., McLean, D., Balcom, B., Birchenough, S. N. R., Brand, A. M., Camprasse, E. C. M., Claisse, J. T., Joop, C. J. W., Cresswell, T., Fokkema, B., Susan, G., Lea-Anne, H., Chad, H. L., Love, M. S., MacIntosh, A., Marnane, M., McKinley, E., Micallef, S., Morgan, D., ... Macreadie, P. I. (2023). *Offshore Decommissioning Horizon Scan: Research Priorities to Support Decision-Making Activities for Oil and Gas Infrastructure*. <https://doi.org/10.2139/ssrn.4367432>
- Wilmink, R. P. J., Oostenbrink, N. A., & Kersten, R. T. C. (2023). A Revolutionary Environmental Solution in Subsea Engineering and Installations: Ai-Driven Ecosystem Insights. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/217021-MS>
- Woods, P. J. (2022). Aligning integrated ecosystem assessment with adaptation planning in support of ecosystem-based management. *ICES Journal of Marine Science*, 79(2). <https://doi.org/10.1093/icesjms/fsab124>



- Yan, Y., Thanganadar, D., Clough, P. T., Mukherjee, S., Patchigolla, K., Manovic, V., & Anthony, E. J. (2020). Process simulations of blue hydrogen production by upgraded sorption enhanced steam methane reforming (SE-SMR) processes. *Energy Conversion and Management*, 222. <https://doi.org/10.1016/j.enconman.2020.113144>
- Yu, M., Wang, K., & Vredenburg, H. (2021). Insights into low-carbon hydrogen production methods: Green, blue and aqua hydrogen. *International Journal of Hydrogen Energy*, 46(41). <https://doi.org/10.1016/j.ijhydene.2021.04.016>
- Zheliezna, T. A. (2021). EUROPEAN GREEN DEAL AND NEW OPPORTUNITIES FOR THE DEVELOPMENT OF RENEWABLE ENERGY. *Thermophysics and Thermal Power Engineering*, 43(1). <https://doi.org/10.31472/ttpe.1.2021.9>



## Multisectoral Collaboration for Environmental Sustainability and Health

Miftahul Jannah Nasution, Novid Gumelar

The importance of multisectoral collaboration between the government, the private sector, academics, the media and the public to maintain environmental sustainability and health, especially in the oil and gas sector. This cross-sectoral approach emphasizes technological innovation, ESG-based regulation, and public participation supported by strategic policies to achieve a sustainable energy transition.

### **13.1. The Role of the Government in Environmental and Health Management in the Oil and Gas Sector**

The government plays a central role in maintaining environmental sustainability and health in the oil and gas sector through regulations, policies, and supervision. Government regulations can provide a framework for environmental and health responsibility in the oil and gas sector. For illustration, research shows that local government participation as a 10% stakeholder in oil and gas projects increases compliance with environmental standards (Hasiholan et al., 2023). Strengthened sustainability policies, such as the UNEP-endorsed Environmental Management in the Oil & Gas industry guide, highlight the importance of a holistic framework for environmental management throughout the oil and gas project lifecycle (Brown et al., 2020). The Action study in Brazil highlights the importance of stable public administration in environmental management in the offshore oil and gas sector. The success of this management depends on the autonomy of government bodies to enforce the regulations that have been established (Oliveira Bredariol & Vinha, 2020). In a global context, the application of a risk-based assessment matrix to measure environmental impacts also helps governments identify areas that need increased oversight (Guerrero-Martin et al., 2023). The government has a role in encouraging sustainable investment in the oil and gas sector through Environmental, Social, and Governance (ESG)-based policies. This helps to improve the environmental performance of companies and attract investment for green technologies (Nazarova & Tikhomirov, 2022). Collaboration with international institutions is also important. A prominent illustration is the adoption of AI-based technologies to support more efficient environmental management (Chutcheva et al., 2022). Research shows that weaknesses in the integration of public health into environmental impact

assessments are still an obstacle. This reduces the effectiveness of policies in ensuring the well-being of local communities (Viliani & Harris, 2020). Endeavors to ensure sustainability in this sector require strengthening the role of governments in energy transition planning, including policy support for clean energy and better environmental impact mitigation (Krawchenko & Gordon, 2022). The government has the primary responsibility in creating effective policies and supervision to ensure the sustainability of the oil and gas sector. Through regulation, cross-sector collaboration, and the adoption of modern technology, governments can mitigate environmental and health impacts while supporting sustainable development. Illustration in the form of a figure 13.1. is a conceptual diagram that describes a framework for multisectoral collaboration to support environmental and health sustainability, especially in the context of the oil and gas sector. This diagram shows the roles and interrelationships between five main actors: government, private sector, academia, community, and the media. Each actor has specific responsibilities that complement each other in creating a transparent, innovative, and sustainable system.

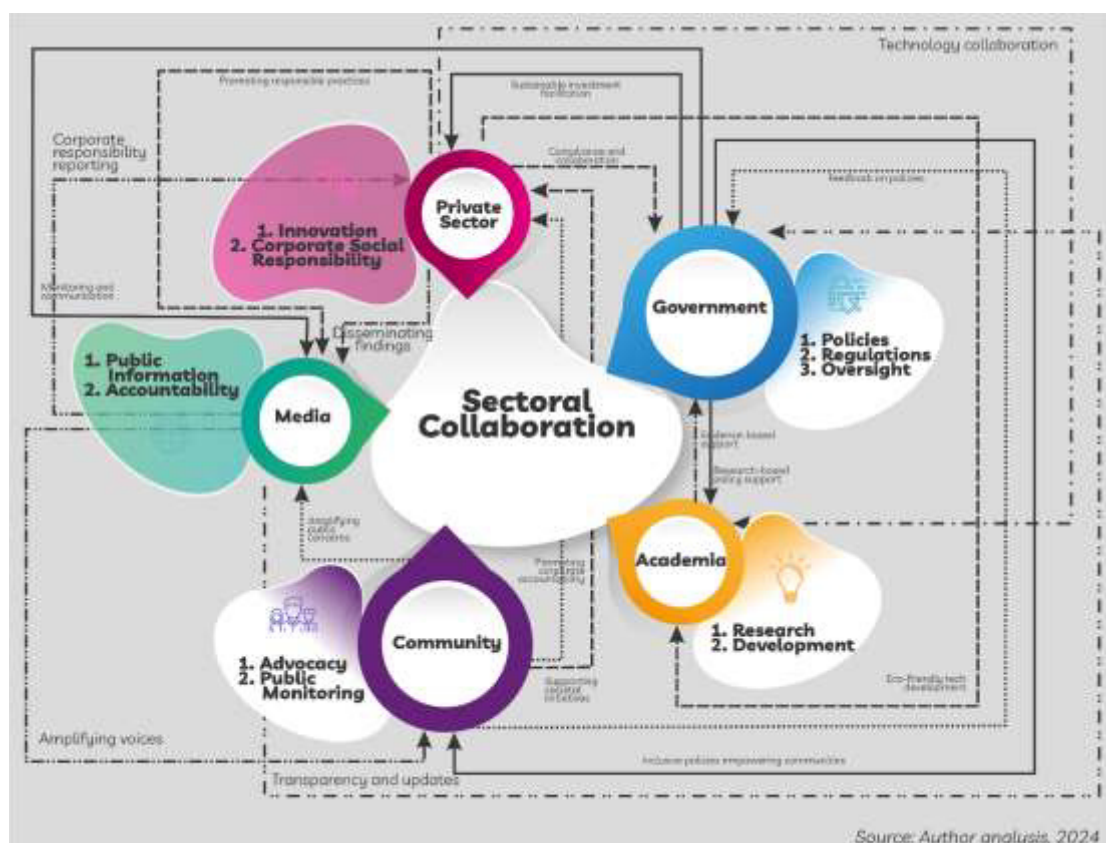


Figure 13.1. Connectivity between actors in Environmental and Health Management of the Oil and Gas Sector

Governments play a central role by establishing policies, regulations, and oversight to ensure sustainable practices. Academics support the government by providing evidence-based research that underpins policymaking, while encouraging

the private sector to innovate through environmentally friendly technologies. The private sector contributes through technological innovation and the implementation of corporate social responsibility (CSR), which aims to minimize environmental impact and support community welfare. Communities have a role to play in public advocacy and monitoring, ensuring that oil and gas sector activities remain transparent and meet the interests of the community. The media acts as a liaison, disseminating information, raising public awareness, and monitoring the accountability of other actors. Relationships between actors are depicted with a connecting line, emphasizing the importance of synergies between them, such as technological collaboration between the private sector and academia, as well as feedback from the community and the media to the government. Figure 13.1. showing how each actor can work collectively in an effort to create a more responsible and sustainable oil and gas system. This synergy is key in addressing complex environmental and health challenges, while maintaining a balance between industrial needs and ecosystem sustainability.

Table 13.1. presenting examples of policies, regulations, and the role of government supervision in environmental and health management of the oil and gas sector based on the latest scientific studies. Each entry outlines the policy focus, implementation steps, and outcomes achieved. The data used was taken from scientific studies and international publications since 2020.

Table 13.1. Government Policies and Regulations in Environmental and Health Management of the Oil and Gas Sector

| No. | Policy/Regulation                                                | Focus                                                            | Implementation                                                                                            | Results Achieved                                                                   |
|-----|------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| 1   | Local Participation as Stakeholders (Hasiholan et al, 2023)      | Increasing the environmental responsibility of local governments | Holder of 10% Participating Interest to monitor the Corporation's compliance with environmental standards | Higher environmental compliance; Better local collaboration                        |
| 2   | UNEP Guidelines for Environmental Management (Brown et al, 2020) | Integrating environmental management best practices              | Preparation of guidelines with UNEP and IPIECA, followed by training workshops                            | Better environmental risk management in the oil and gas project cycle              |
| 3   | Offshore Regulation in Brazil (Oliveira Bredariol & Vinha, 2020) | Ensuring the stability of public administration                  | Involve stakeholders in policy making; Giving Full Autonomy to Supervisory Bodies                         | Stability of offshore management increases, rules are more effective               |
| 4   | Risk-Based Assessment Matrix (Guerrero-Martin et al, 2023)       | Measuring the environmental impact of a project                  | Assessment matrixes are used to evaluate impacts on water, soil, and air                                  | Identify more accurate mitigation priorities; More effective decision-making tools |

| No. | Policy/Regulation                                                                               | Focus                                                                | Implementation                                                                                       | Results Achieved                                                                                       |
|-----|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| 5   | ESG Policies in Oil and Gas Companies (Nazarova & Tikhomirov, 2022)                             | Improve the Corporation's environmental performance                  | ESG-based policies are implemented in companies to attract investors who care about sustainability   | Environmental performance improves, investment attractiveness increases                                |
| 6   | Adoption of AI Technology for Environmental Management (Chutcheva et al., 2022)                 | Improve environmental management efficiency                          | Use of AI to monitor and analyze environmental data in real-time                                     | Increased management efficiency, faster environmental impact mitigation                                |
| 7   | Health Impact Assessment (HIA) (Viliani & Harris, 2020)                                         | Integration of public health in oil and gas projects                 | Incorporating public health parameters in project impact assessments                                 | Improving the welfare of local communities, reducing social conflicts                                  |
| 8   | Just Transition Policy for Clean Energy (Krawchenko & Gordon, 2022)                             | A just energy transition                                             | Policy development to shift oil and gas sector workers to the clean energy sector                    | Reducing the social impact of the energy transition; Improving the sustainability of the local economy |
| 9   | IoT Monitoring Program in Oil and Gas Management (Wanasinghe et al., 2020)                      | Use of technology to minimize environmental risks                    | Use of IoT to monitor real-time data related to gas leaks, air pollution, and operational efficiency | Reducing environmental risks; Increased operational efficiency                                         |
| 10  | Increased Supervision of Unlawful Oil Fields (Kalalo et al., 2024; Marpaung et al., 2023)       | Addressing social and environmental impacts                          | Creation of a cluster system for mine management, training of local communities                      | Reduce pollution incidence; improving community governance toward the environment                      |
| 11  | The Application of ESG to Attract Green Investment (Whitaker, 2022)                             | Improving environmental and social performance                       | Development of liquefied natural gas (LNG) infrastructure and carbon capture                         | Increase investor interest; reduce carbon emissions                                                    |
| 12  | Risk Assessment Strategies for the Safety of Oil and Gas Workers (Nayanov & Khamidullina, 2020) | Improve work safety                                                  | Using retrospective analysis and statistical control methods to evaluate work accidents              | Reduction of work accidents; More efficient safety management system                                   |
| 13  | Nova Scotia Offshore Management Policy (Kapoor et al., 2021)                                    | Strengthening the role of strategic assessment for offshore projects | Implementation of marine space-based management to map project impacts on health and the environment | Increasing the credibility of the environmental assessment process; improve stakeholder engagement     |

| No. | Policy/Regulation                                                                        | Focus                                                | Implementation                                                                                      | Results Achieved                                                         |
|-----|------------------------------------------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| 14  | Public Health Integration in the Impact of Oil and Gas Projects (Viliani & Harris, 2020) | Incorporating public health aspects into the project | Adjustment of environmental impact assessment (EIA) to accommodate public health as a key indicator | The welfare of local communities has increased; Reduced social conflicts |

Source : Author's Search, 2024

Table 13.1. It shows that the government has various approaches in managing the environmental impact and health of the oil and gas sector. Locally-based regulations such as local community participation (No. 1) and guidance from international bodies such as UNEP (No. 2) are important in building a more effective monitoring system. Technological innovations such as the use of AI (No. 6) provide modern solutions that improve management efficiency. However, there are still challenges in integrating the overall public health impact (No. 7), which requires a cross-sectoral and collaborative approach. The application of IoT (No. 9) shows the importance of technology in improving the efficiency of environmental management. In addition, the integration of public health aspects (No. 14) shows endeavors to create more inclusive and sustainable oil and gas projects. The just energy transition policy (No. 8) shows a focus on managing the social impact of the energy transformation, while ESG-based initiatives (No. 11) emphasize the importance of attracting sustainability-conscious investors. A more comprehensive approach will require strengthening policies that focus on long-term sustainability, while ensuring adequate oversight for each stage of oil and gas projects. This table highlights the variety of policies and innovations that the government has implemented to maintain sustainability in the oil and gas sector, illustrating the importance of a holistic approach to oil and gas sector management, involving technology, policies, and community participation.

Research on effective regulatory implementation strategies in the oil and gas sector highlights various approaches such as law enforcement and incentivization. (Irawati et al., 2021) reviewed the implementation of supervision in the downstream oil and gas sector in Indonesia through the Job Creation Law, which, although strengthening supervision, requires regulatory improvement to address shortcomings in LNG and CNG management. In Nigeria, weaknesses in law enforcement against gas flaring have been identified as a major obstacle. This study suggests fiscal incentives and gas market restructuring to improve compliance with anti-flaring policies (Olujobi, 2020). (Valishvili, 2020) emphasizes the importance of a combination of legal and economic mechanisms such as fines and incentives to encourage companies to switch to the green path in environmental management. In addition, research by (Mas'ud et al., 2020) highlights environmental tax compliance models in the oil and gas industry in Nigeria which show that strict regulatory enforcement and the use of legal force can improve tax compliance, thereby reducing negative impacts

on the environment. An more study by (Tsybka, 2023) illustrates administrative and legal measures in Ukraine to address threats to energy Stock in the oil and gas sector during emergencies, such as export restrictions and domestic incentives. Various strategies ranging from risk-based approaches, economic incentives, to strengthened compliance models have shown their effectiveness in the implementation of oil and gas sector regulations. The combination of strong enforcement measures with incentives provides an opportunity to improve compliance and support the sustainability of the industry.

Several international policy implementations have succeeded in reducing the negative impact of the oil and gas sector. This table includes policies from different countries that have been successfully implemented, followed by relevant literature sources.

Table 13.2. Successful International Policies in Mitigating the Negative Impact of the Oil and Gas Sector

| It | Country/<br>Organization                                           | Policy                                                                             | Description                                                                                                                                                                                                                                                                                      |
|----|--------------------------------------------------------------------|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Brasil (Morais et al, 2023)                                        | Operational Safety Management System (SGSO) system                                 | Brazil implements SGSO to improve operational safety management at offshore oil and gas installations. The system includes 17 management practices that are regularly audited to ensure compliance with international standards and improve operational efficiency and environmental protection. |
| 2  | Jepang (Chutcheva et al, 2022)                                     | Renewable Energy Policy in the Oil and Gas Sector                                  | The use of renewable energy in oil and gas operations to reduce dependence on fossil fuels and reduce carbon emissions.                                                                                                                                                                          |
| 3  | Kanada (Dong et al, 2020; Hannouf et al, 2020; Mas'ud et al, 2020) | Carbon Pricing Mechanism                                                           | Canada has adopted a carbon pricing mechanism for the energy sector, including oil and gas. This policy motivates companies to reduce emissions through carbon taxes or cap-and-trade systems. This approach has succeeded in reducing emissions and driving the adoption of clean energy.       |
| 4  |                                                                    | Oil and Gas Technology Social Impact Assessment                                    | Policy-based analysis to prioritize the social aspects of the development of green oil and gas technologies in Alberta, which contributes to the successful implementation of new technologies.                                                                                                  |
| 5  |                                                                    | The Influence of Environmental Policy on Oil and Gas Sector Investment Performance | An analysis of the impact of environmental policies on investment efficiency in Canada's oil and gas sector shows that flexible policies improve efficiency but can reduce pressure for emission reductions.                                                                                     |
| 6  | Kazakhstan (Vihristyuk & Dimitrova, 2022)                          | Implementation of ESG in Oil and Gas Sector Policy                                 | Compliance with ESG principles in Kazakh oil and gas companies improves financial stability and investment attractiveness by reducing environmental and social risks.                                                                                                                            |

| It | Country/<br>Organization                                                    | Policy                                                                                              | Description                                                                                                                                                                                                                                                                                                                                   |
|----|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7  | Nigeria<br>(Olujobi,<br>2020)                                               | Strengthened<br>Anti-Flaring<br>Policy                                                              | The Nigerian government is updating its anti-flaring laws with a combination of heavy sanctions and economic incentives. This policy aims to encourage companies to invest in gas use technology, reduce gas waste, and mitigate climate change.                                                                                              |
| 8  | Norway<br>(Olujobi,<br>2020)                                                | Anti-Flaring<br>Regulations                                                                         | Norway implements strict regulations to reduce gas flaring by integrating economic incentives and the use of advanced technology. As a result, the flaring rate in Norway is among the lowest in the world. This regulation also improves energy efficiency and state revenue through gas exports.                                            |
| 9  | Rusia (Heim et<br>al., 2023)                                                | Flaring Gas<br>Policy with a<br>Triple Bottom<br>Line Approach                                      | Integration of social, economic, and environmental policies in the management of flare gas in oil-producing areas, with a focus on the adoption of new technologies to reduce environmental impacts.                                                                                                                                          |
| 10 | Tiongkok<br>(Sheng et al.,<br>2020)                                         | Incentive-Based<br>Environmental<br>Regulation                                                      | China implements incentive policies to increase companies' compliance with environmental regulations, including in the oil and gas sector. These regulations include subsidies for green technologies and penalties for violations. This approach improves the quality of the environment and the efficiency of the Corporation's operations. |
| 11 | Uni Emirat<br>Arab<br>(Chutcheva et<br>al., 2022)                           | AI-Based<br>Environmental<br>Management                                                             | Implementation of artificial intelligence in the environmental management of the oil and gas sector to support sustainability, improve operational efficiency, and protect the environment through in-depth data analysis.                                                                                                                    |
| 12 | Uni Eropa<br>(Brown et al.,<br>2020; Peeters<br>&<br>Athanasiadou,<br>2020) | Effort Sharing<br>Regulation<br>(ESR)                                                               | The ESR policy provides individual emission reduction targets for EU member states. This regulation emphasizes a flexible but binding approach in meeting emission reduction targets, including in the oil and gas sector. Strict monitoring ensures the effectiveness of policies in reducing environmental impacts.                         |
| 13 |                                                                             | Guidelines for<br>Environmental<br>Management<br>Practices in the<br>Upstream Oil<br>and Gas Sector | This guide brings together best practices in environmental management throughout the life cycle of oil and gas projects, covering aspects of technology, environmental impacts, and international regulations.                                                                                                                                |

Source : Author's Search, 2024

Table 13.2. shows that a combination of economic incentives, strong law enforcement, and technology-based approaches can have a positive impact in reducing the negative impact of the oil and gas sector. Countries such as Norway and Canada have successfully adopted mechanisms that integrate environmental policies with economic needs. Meanwhile, the European Union and Brazil emphasized the importance of transparency and audits in regulations. This kind of policy proves that the management of the oil and gas sector can run sustainably if a holistic approach is implemented. Various strategies and policies are implemented in various



countries to reduce the negative impact of the oil and gas sector. Technology-based approaches such as artificial intelligence, the integration of social aspects in technology, and the implementation of ESG principles show that policy success depends on a combination of technological innovation and strict regulations. This provides a basis for cross-country learning in designing effective and sustainable environmental policies.

### **13.2. Community Participation in Safeguarding the Environment and Health**

Community participation in protecting the environment and health due to oil and gas (oil and gas) activities include various aspects, ranging from problem identification, advocacy, to direct involvement in decision-making. Local governments, as holders of the right to participate in oil and gas operations, have a great responsibility to ensure compliance with environmental regulations and support sustainable development. This is outlined in research that shows the importance of a legal framework to encourage the sustainability of the oil and gas sector (Hasiholan et al., 2023). In addition, oil and gas activities often have a negative impact on public health, such as an increase in respiratory diseases, cardiovascular, and a decrease in life expectancy, especially in communities located close to the location of unconventional oil and gas activities (Apergis et al., 2021). Communities can also participate through legal mechanisms such as class action, which gives them the right to ensure the fulfillment of their right to a healthy environment (TJAHJANI, 2021). In Uganda, equal collaboration between communities and decision-makers in the oil and gas sector has been shown to promote sustainable development as well as improve the relationship between local actors and the government (Coleman et al., 2023). However, the health impact of oil and gas operations remains a concern. A study in Los Angeles revealed that living close to oil and gas facilities is associated with decreased lung function and increased health symptoms such as eye and nose irritation (Johnston et al., 2021). On the other hand, in Nigeria, gas flaring triggers negative impacts on the environment and public health. The study shows the importance of prevention programs and increasing public awareness of these health risks, as well as the need to strengthen community capacity to dialogue with the government (Obi et al., 2021). Awareness, education, and stronger collaboration between communities, governments, and the private sector are important steps to reduce negative impacts and promote social and environmental sustainability in oil and gas-affected areas.

The ideal concept of community empowerment for independent oversight of oil and gas industry activities includes a supportive legal framework, education, multi-stakeholder collaboration, technology use, sustainable funding, and advocacy strategies. Community education and training are also very important to increase awareness about environmental and health risks, as well as equip communities with

technical skills to monitor environmental quality, as implemented in community-based training programs in Indonesia (Kwarto et al., 2021). Collaboration between the community, the government, and companies is a key opponent, with the establishment of local monitoring committees to assess the impact of oil and gas activities transparently and encourage appropriate mitigation actions. For illustration, in Uganda, direct community involvement in collaborative governance has succeeded in increasing trust and equitable outcomes (Coleman et al., 2023). The use of digital technologies such as environmental sensors, smartphone-based reporting applications, and open data can also support accountability. Sustainable funding through community funds sourced from oil and gas company contributions, as well as grants from governments or international donors, can ensure the implementation of these monitoring programs. Advocacy strategies are also important to involve communities in fighting for their rights, through accessible complaints mechanisms and legal help in cases of violations. The implementation of this model begins with stakeholder mapping, the implementation of trials at locations affected by oil and gas, and continuous evaluation to ensure its effectiveness. With this approach, independent supervision based on community empowerment can protect the environment, improve welfare, and create sustainability in the management of the oil and gas industry. One of the interesting case studies related to community involvement in ecosystem restoration projects is the initiative carried out by Repsol in Peru. This project involves indigenous peoples, governments, and companies to restore ecosystem functions at drilling sites that have completed their operational period. Restoration was carried out in the area of the Tsoroja indigenous community and the buffer area of the Ashaninka Communal Reserve. Similar initiatives have also been found in the restoration of soil affected by gas drilling in Arkansas, United States. Research shows that abandoned land can be restored through reclamation, resulting in ecosystem benefits such as increased agricultural value, carbon sequestration, and biodiversity restoration. This reclamation has the potential to provide economic benefits of up to \$2 million USD per year through improved ecosystem services (Nallur et al., 2020). On the other hand, community involvement in ecosystem restoration often faces challenges in integrating social dimensions. Studies in Mexico show that forest restoration projects often only involve communities as temporary workers, without actually empowering them to play an active role in the long-term. To ensure the success of restoration, community participation needs to be designed to address the long-term needs of local communities, such as providing training and creating new economic opportunities (Ceccon et al., 2020). Another interesting approach is peatland ecosystem restoration in Canada, which prioritizes carbon recovery and ecosystem function through revegetation. Here, community involvement in planting peat-specific plant species helps restore the hydrological function and soil carbon. Restoration involving the removal of ex-mining materials

with management involving the community shows results that are closer to the conditions of natural ecosystems (Lemmer et al., 2020). These studies show that the success of ecosystem restoration around oil and gas areas is highly dependent on meaningful community involvement, integration of ecosystem and social needs, and collaborative approaches between communities, companies, and governments. With the right strategy, restoration projects not only restore ecosystem function but also improve the welfare of local communities.

### **13.3. Private Sector Contribution to Sustainability**

The private sector plays a crucial role in realizing sustainability through various initiatives that include technological innovation, green policies, and collaboration with governments and civil society. One of the significant contributions is the implementation of sustainable business practices, such as energy efficiency, waste reduction, and the use of renewable resources. Studies show that companies that integrate sustainability in their core strategies not only improve reputation, but also long-term economic performance. For example, collaboration for sustainability innovation, the study highlights the role of the private sector in creating and disseminating sustainability innovations through the evolution of circular business models and cross-sector partnerships. This collaboration not only strengthens the social and environmental dimensions, but also spreads the culture of sustainability to other sectors (Cantele et al., 2020). The role of the private sector in the circular economy: this article explores how the private sector contributes to the implementation of the circular economy, overcoming financial and regulatory constraints, and supporting sustainability through resource reduction and environmentally friendly infrastructure adaptation (Owojori & Okoro, 2022). Public-private partnerships for the SDGs: this study reviews a global network of public-private partnerships to support the SDGs. Research shows that these partnerships strengthen inter-stakeholder relationships, increase role clarity, and maximize sustainability impacts (Choi et al., 2020). The role of the private sector in achieving the SDGs: this article discusses the responsibility of the private sector in supporting the SDGs through CSR, green initiatives, and the circular economy. The study also highlights implementation challenges such as lack of investment and measurable evaluation tools (Rashed & Shah, 2021). Public-private green partnerships for sustainable development: this study examines the contribution of public-private green partnerships to the global sustainable development agenda, focusing on innovative mechanisms to financially support green projects (VASSILEVA, 2022). Thus, the private sector is not only a key driver of innovation, but also an agent of change that supports the implementation of global sustainability policies. The private sector has a great responsibility and capacity to drive global sustainability through environmentally oriented strategies, technological innovation, and inclusive

partnerships. Their increased role will be crucial in achieving a broader vision of sustainability.

Oil and gas (oil and gas) companies play an important role in the global economy, but they also face significant challenges in minimizing the environmental and social impacts of their operations. Therefore, CSR and sustainability initiatives have become crucial strategic components. In this sector, CSR functions to reduce carbon emissions, improve energy efficiency, support local communities, and promote ethical and transparent business practices. Based on the latest research, many oil and gas companies are actively implementing innovative approaches to improve the sustainability of their operations. For Illustration, the role of CSR in the sustainability strategy of oil and gas companies: this study analyzes the various CSR approaches used by oil and gas companies in Russia and Western countries. Research shows that strong CSR integration improves a company's long-term sustainability through cross-sector partnerships and low-carbon technologies (Gusov et al., 2022). Low-carbon technological innovations: this article discusses technological innovations to address the carbon impact of heavy oil exploitation. Technologies such as CO<sub>2</sub> injection and solvent-based thermal recovery help reduce emissions by up to 80% and improve crude oil recovery rates (H. Li et al., 2023). Implementation of CCUS: this study highlights CCUS technology that integrates CO<sub>2</sub> injection with oil recovery to increase production and store large amounts of carbon in oil reservoirs, providing environmental and economic benefits (Weixiang & Chunpeng, 2023). Shared value in CSR of oil and gas companies in Indonesia: a case study at PT Pertamina EP Tarakan Field revealed that the implementation of CSV (Creating Shared Value) through CSR not only supports sustainability goals but also produces shared value for the company and local communities (Kurniawan & Arief, 2023). Overall, CSR in the oil and gas industry is not only an effort to fulfill legal or social obligations, but also serves as a business strategy that provides added value for the Corporation. Through effective CSR implementation, companies can improve their reputation, build stakeholder trust, and create more sustainable operating conditions. This proves that sustainability and profitability can go hand in hand, although operational challenges remain significant. Case studies related to collaboration between oil and gas (oil and gas) companies and the community in health and environmental projects. Information in table 13.3. It is compiled based on the results of scientific studies from several articles that have been published since 2020.

Table 13.3. It shows how a collaborative approach between oil and gas companies, governments, and local communities can yield significant results in addressing health and environmental challenges. These projects not only generate immediate benefits, such as health risk reduction and environmental improvements, but also strengthen relationships between stakeholders through collaborative governance.

Table 13.3. Case Study of Collaboration between Oil and Gas Companies and the Community in Health and Environment Projects

| No. | Case Studies                                                                                                          | Collaborative Approach                                                                             | Key Results                                                                                                                                         |
|-----|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Oil and Gas Impact Mitigation in Ghana (Arthur, 2020)                                                                 | Community education and worker capacity building in environmental impact mitigation                | Reducing environmental impacts due to oil and gas exploitation and strengthening community relationships with companies                             |
| 2   | Project on Psychophysical Impact Management in Kazakhstan's Oil and Gas Region (Bashbaeva et al, 2020)                | Study on the impact of psychophysical health due to the oil and gas work environment               | Identify physical fatigue, low motivation, and mental disorders due to the work environment, with recommendations for specific health interventions |
| 3   | Community and Government Collaboration in Uganda in the Oil and Gas Sector (Coleman et al, 2023)                      | Equal community participation in collaborative governance                                          | Increased fairness in decision-making, improved public relations with governments, and better environmental outcomes                                |
| 4   | Clean Air Project in Boston for Public Health (Hersey & Gordon, 2021)                                                 | Multi-stakeholder planning for air quality management                                              | Reducing health risks related to air pollution and strengthening community-based collaborative governance                                           |
| 5   | Public Awareness of the Impact of Flaring Gas in the Oil and Gas Industry Community (Obi et al, 2021)                 | Collaboration between oil companies, communities, and governments for health intervention programs | Increasing public awareness of health risks due to gas flaring and the implementation of preventive and treatment programs                          |
| 6   | University-Community Research for Clean Water Resources Management (Oliveira Bredariol & Vinha, 2020)                 | Evaluation of water quality at oil extraction sites with community participation                   | Increasing community awareness of sanitation and implementing water quality improvement measures to prevent health risks                            |
| 7   | Interdisciplinary Collaboration for Environmental Health Management in Appalachian Virginia (Satterwhite et al, 2020) | Joint research with universities, local governments, and the community                             | Evidence-based strategic recommendations that strengthen the environmental health of communities around munitions factories                         |

Source : Author's Search, 2024

An evidence-based and participatory approach is key to the success of every initiative. The addition of cases shows a wider scope of collaboration between oil and gas companies and the community in health and environmental projects. These studies underscore the importance of a multidisciplinary approach and cultural sensitivity in addressing challenges unique to each region. Examples such as projects in Latin America and Ghana show the benefits of community-based risk management, while research in Kazakhstan highlights the need to pay attention to the psychophysical aspects of workers in the oil and gas industry.

#### **13.4. The Role of Academics in Improving Innovation and Advocacy**

Academics have a significant role in encouraging innovation and advocacy in various fields, both in social, economic, and technological contexts. Through scientific research and publications, academics provide empirical evidence and critical insights that form the basis for strategic decision-making and public policy. They also serve as a link between theory and practice, creating innovative solutions based on societal needs as well as global trends. Various studies support the importance of this role. For illustration, academic freedom and innovation, this study highlights how academic freedom affects the quantity and quality of innovation. The findings show that an increase in academic freedom by one standard deviation increases patent applications by 41% and patent citations by 29% (Audretsch et al., 2023). Advocacy, activism, and lobbying in academia, this article explores faculty and policymakers' perceptions of academic involvement in advocacy and lobbying. The findings suggest that institutions need to align rhetoric with reality to support more effective academic engagement in public policy (Jessani et al., 2022). Role of universities in promoting innovation policy in Southeast Asia, this study discusses how universities in Southeast Asia, such as Thailand, Malaysia, and Indonesia, contribute to innovation policy through special research and education in the field of innovation policy (Asmara, 2023). In the context of advocacy, academics are often critical voices highlighting issues such as social inequality, climate change, and human rights through their scientific work and participation in international forums. Academics are the driving force of innovation and advocacy that rests on the strength of research and science. Through their contributions, whether in the form of publications, collaborations with stakeholders, or involvement in public policy, academics build the foundation for better and sustainable development of society.

Academic research has an important role to play in developing innovative solutions to manage the environmental and health impacts of the oil and gas sector. Environmentally friendly technologies have been designed to reduce adverse impacts during the life cycle of oil and gas operations, such as environmentally efficient technologies in handling emergencies at drilling sites (Weixiang & Chunpeng, 2023). In addition, the implementation of the Internet of Things (IoT) further strengthens digital transformation in this industry by minimizing health, safety, and environmental (HSE) risks, while improving operational efficiency and capital productivity (Wanasinghe et al., 2020). The implementation of the circular economy is also starting to become a trend in oil and gas industry innovation, which aims to improve the sustainability of operations, especially in underdeveloped countries (Dua & Jain, 2024). In the Niger Delta, research shows the impact of oil exploration on public health such as respiratory distress, due to greenhouse gas emissions and environmental contamination (Jumbo et al., 2023).

Table 13.4. Academic Studies on Environmental Management and Higher Education Involvement in the Oil and Gas Sector

| No. | Research Title                                                                                           | Focus                                                                                                                            |
|-----|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| 1   | The IoT in the Oil and Gas industry                                                                      | The use of IoT to improve operational efficiency and reduce environmental risks (Wanasinghe et al., 2020)                        |
| 2   | Toward an Innovative Green Strategic Formulation Methodology                                             | HSE-based green strategy in the management of oil and gas companies (Padash & Ghatari, 2020)                                     |
| 3   | Energy Transitions: An Academia Take on Shaping the Future Professionals of Oil and Gas                  | Interdisciplinary education to meet the workforce needs of the future energy sector (Passalacqua & Turki I Alsaba, 2020)         |
| 4   | Exploring the Impact of Green Human Resource Management on Environmental Performance                     | Green HR management practices to improve the environmental performance of oil and gas companies (Bhatti et al, 2022)             |
| 5   | Sustainable Environmental Management and Preservation in Old Well Oil and Gas Traditional Mining Sites   | Environmental management at old traditional oil and gas mining sites in Indonesia (Subadi, 2023)                                 |
| 6   | Measurement Development for Eco-Innovation Capabilities of Malaysian Oil and Gas Firms                   | Development of a scale to measure eco-innovation capabilities in Malaysian oil and gas companies (Munodawafa & Johl, 2022)       |
| 7   | Development of Methodological Approaches of Value-Based Management at Oil and Gas Extraction Enterprises | Value-based management to improve the sustainability and performance of oil and gas extraction companies (Dmytruk, 2023)         |
| 8   | Lack of Integration Between Academia and industry                                                        | Innovative strategies to improve connectivity between universities and the oil and gas industry (Hegazy et al, 2023)             |
| 9   | Advancing Technology in Oil and Gas: Collaboration and Comparison with the Space Sector                  | Cross-sector innovation between oil and gas and space to improve remote management (Crusan, 2020)                                |
| 10  | An Integrated Digital Collaborative Work Environment for Drilling                                        | A digital work environment for the integration of business processes in the oil and gas sector (Amer et al, 2022)                |
| 11  | Research on the Mechanism of Government–industry–University–Institute Collaborative Innovation           | An evolutionary game model for stabilizing green technology collaboration between universities and industry (T. Li & Zhou, 2022) |
| 12  | The Influence of Shared R&D-Project Innovativeness Perceptions on University-industry Collaboration      | The impact of shared perception on the performance of research and development collaboration projects (Schultz et al, 2021)      |
| 13  | Institutionalizing University-Business Innovation Systems in an Innovation Economy                       | Transforming the university into a collaborative ecosystem-based innovation center. (Magumba, 2023)                              |
| 14  | Collaborations Involving Malaysia Upstream Regulator to Enhance Decommissioning                          | Collaboration with Malaysian regulators for eco-friendly decommissioning solutions (Rahman et al, 2021)                          |
| 15  | Digital Transformation in Oil and Gas industry                                                           | Digital transformation in the oil and gas sector for operational efficiency and risk mitigation (Haouel & Nemeslaki, 2023)       |

Source : Author's Search, 2024.

Other innovative solutions include the use of submarines equipped with drilling technology for offshore oil exploration, which is capable of reducing the risk of

extreme weather and improving operational efficiency (Ali et al., 2023). Efficient resource management has also been found to be very influential in improving sustainable performance in the oil and gas sector. This involves product design practices that are integrated with manufacturing planning, which is reinforced by the Corporation's culture of innovation (Wang et al., 2022). All of these approaches demonstrate how academic research supports the oil and gas sector by providing evidence-based solutions to address complex challenges, including environmental and health impact mitigation. Various academic studies that focus on managing environmental and health impacts in the oil and gas sector, as well as the involvement of universities in community education and expert training. Table 13.4. provides insight into innovations that can be made through collaboration between universities, governments, and the private sector to create sustainable solutions.

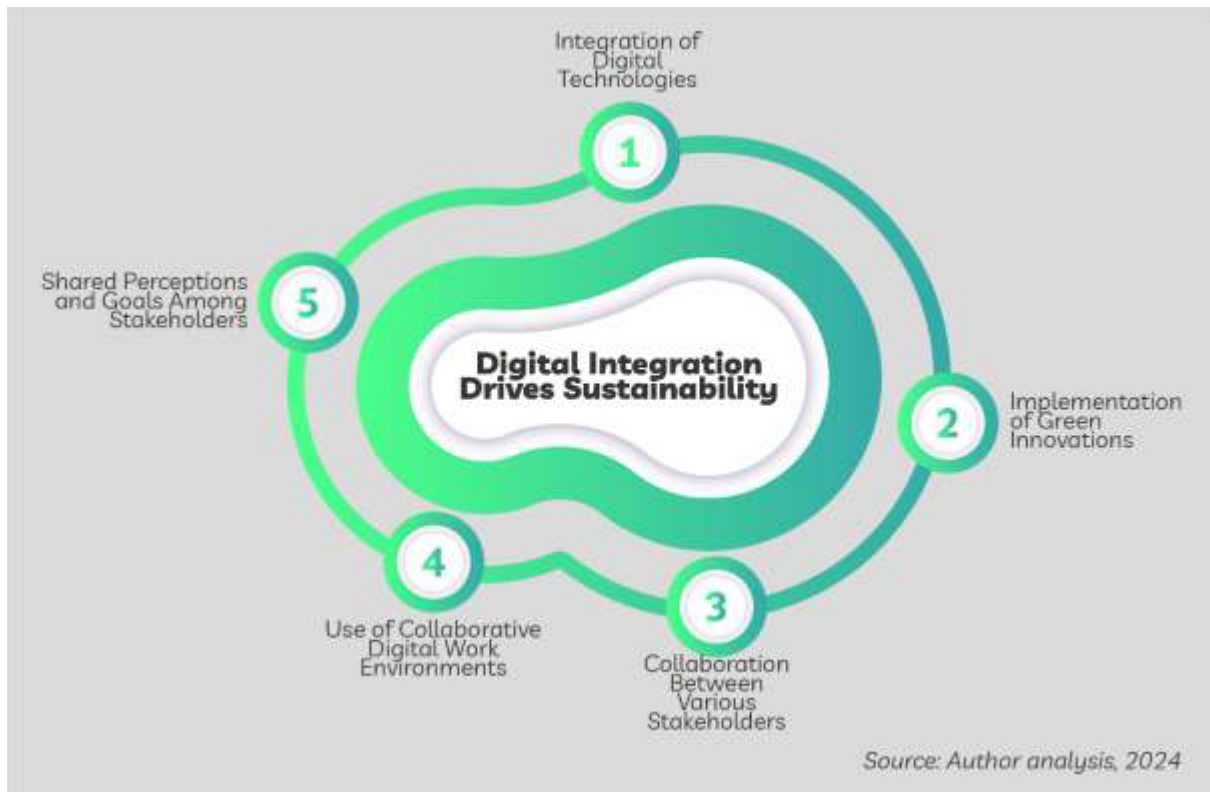
These studies demonstrate the importance of a multidisciplinary approach, collaboration between various stakeholders, and technological innovation in addressing environmental and health challenges in the oil and gas sector. From the use of IoT technology to the development of green strategies and value-based management, each of the studies provides valuable insights that can be adapted in both local and international contexts. Active collaboration between universities, governments, and the private sector will be key to creating sustainable solutions that have a wide impact. Cross-sector collaboration has an important role in advancing innovation, both in environmental management and improving operational efficiency in the energy sector. Several studies, such as the Green Hydrogen Hub collaboration in Denmark, highlight the importance of building flexible collaboration structures to achieve common solutions. On the other hand, digital transformation is the main strategy to increase productivity in the oil and gas sector. Collaboration between universities, governments, and the private sector allows the use of complementary resources and expertise to create innovations that have a positive impact on the environment and the economy.

### **13.5. Case Study: Multisectoral Collaboration in Overcoming the Impact of Oil and Gas Activities**

The oil and gas sector have a significant impact on the environment and public health, so it requires innovative solutions through collaboration between the government, universities, and the private sector. One interesting case study is the Green Hydrogen Hub project in Denmark, which shows how governments, the private sector, and academic institutions can come together to create large-scale energy storage capacity to support the green energy transition. In the oil and gas sector, the development of a collaborative digital work environment is also an important concern. A study by (Amer et al., 2022) highlights how the integration of digital technology can accelerate the process of planning, design, and monitoring drilling



with up to 100% efficiency. This digital platform-based work environment supports cross-disciplinary collaboration, from reservoir management to drilling well design, resulting in significant time and cost savings. Another study from (T. Li & Zhou, 2022) discusses the importance of the government–industry–university collaboration model in green technology innovation. Through evolutionary game theory and mobile automata approaches, the study highlights that collaboration can be strengthened with government incentives, fair distribution of revenue, as well as penalties for breach of contract. This model is effective for increasing the adoption of environmentally friendly technologies in the energy sector. One illustration of the implementation of regulatory collaboration is the decommissioning program in Malaysia, which is carried out by PETRONAS together with regulatory bodies and the academic sector. The program leverages cross-sector experience to reduce decommissioning costs and protect the environment through innovations such as rig-to-reef programs. This collaboration shows that waste management in the oil and gas sector can be carried out more efficiently by sharing lessons learned from various stakeholders (Rahman et al., 2021). Digital transformation in the oil and gas sector is also an important part of multisectoral collaboration. A study in Norway by (Haouel & Nemeslaki, 2023) shows how digital strategies can improve operational Stock, increase transparency, and create cost efficiencies throughout the energy supply chain. Companies like Equinor have successfully created a collaborative ecosystem that engages suppliers, start-ups, and academics to share data and develop innovative technology solutions. In addition, the importance of shared perception of research projects is also expressed by (Schultz et al., 2021). In university-industry collaboration projects, intensive planning and collaboration in the planning process improve project performance through increased sense of shared ownership among stakeholders. Multisectoral collaboration shows that innovative solutions to reduce environmental impact and improve the sustainability of the oil and gas sector require a holistic approach that combines cross-disciplinary expertise. By supporting digital transformation, redesigning cooperation models, and leveraging green technologies, the oil and gas sector can play an important role in the transition to sustainable energy. The success of cross-sector project analyses aimed at mitigating environmental and health impacts is inseparable from several key factors. First, the integration of digital technology plays a central role in supporting operational efficiency while reducing negative impacts on the environment. For illustration, a study by (Haouel & Nemeslaki, 2023) shows how digital strategies in the Norwegian oil and gas sector enable real-time data collection, improve operational transparency, and create cost-effective solutions for energy supply chains. This digital transformation also helps companies like Equinor in managing environmental risks through data-driven innovation and collaboration with technology start-ups.



Gambar 13.2. Digital Integration Drives Sustainability

Second, success is also influenced by the implementation of green innovations that involve a sustainable technology approach. A study by (T. Li & Zhou, 2022) revealed that collaboration between governments, industry, and universities in green technology innovation can be strengthened through economic incentives, fair distribution of income, and penalties for breach of contract. These factors create a stable and effective collaboration mechanism in driving the adoption of green technologies, such as renewable energy and environmentally friendly production processes. Third, well-designed collaboration between various stakeholders is a key element of success. In a decommissioning project in Malaysia, PETRONAS is working with regulators, oil and gas operators, and academics to convert unused oil rigs into marine habitat. This approach not only reduces waste but also improves marine biodiversity, demonstrating how cross-sector collaboration can create dual benefits for the environment and society (Rahman et al., 2021). Furthermore, the use of a collaborative digital work environment has also been proven to increase efficiency and mitigate health impacts. A study by (Amer et al., 2022) shows how the integration of digital platforms can speed up the drilling process by up to 100%, reduce time and costs, and improve operational oversight.

This technology allows for early detection of potential environmental and health risks, so mitigation can be carried out quickly and effectively. Finally, collaboration involving common perceptions and goals among stakeholders is also an important factor. (Schultz et al., 2021) showed that intensive planning and

collaboration in project design can increase a sense of ownership and commitment between parties, which contributes to the success of environmental mitigation projects.

Table 13.5. Cases and Success Factors of Multisectoral Collaboration in the Oil and Gas Industry

| No. | Country/Region                                    | Case Examples                                                                                            | Key Success Factors                                                                                           |
|-----|---------------------------------------------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| 1   | Australia (Keys & Taylor, 2021)                   | International standardization through multi-stakeholder collaboration in the oil and gas industry        | Involvement of global standards bodies such as ISO and collaboration with industry for project cost reduction |
| 2   | Brazil (Jones, 2020)                              | Deepwater project efficiency with innovative technology                                                  | Use of new technologies to lower operating costs and improve exploration outcomes                             |
| 3   | Global (Redda & Turner, 2018)                     | Survey on the success of major oil and gas projects                                                      | Competent project leaders, risk management, and connectivity with local resources                             |
| 4   | Global (Masucci et al., 2020)                     | Open innovation initiatives to accelerate the advancement of oil and gas technology                      | Collaboration between companies through open innovation strategies and intellectual Building rights control   |
| 5   | UK (Peacock & Dow, 2019)                          | Energy transition through cross-sector collaboration in the North Sea                                    | Increased efficiency by sharing best practices and innovations in cost management                             |
| 7   | Kanada (Amer et al., 2022)                        | Development of a collaborative digital work environment for drilling operations                          | Business process integration, use of predictive analytics, and unified data management                        |
| 8   | Kanada (Oil Sands) (A. Abbink et al., 2014)       | Collaboration on megascale project for oil sands exploration                                             | Partnership relationships that share risks, adapt to innovative technologies, and support the local economy   |
| 9   | Nigeria (ACHEBELEMA & ACHEBELEMA, 2021)           | Collaborative strategy between the government and the private sector for oil and gas resource management | Collaborative management and leadership that supports organizational resilience                               |
| 10  | Scotland (Aberdeen) (Adams & Mueller-Hirth, 2021) | Sub-sea engineering collaboration under market uncertainty                                               | Flexibility and transparency of relationships between organizations                                           |

Source : Author's Search, 2024

This factor allows each actor to work within a framework of common goals, thereby reducing the potential for conflict and inefficiencies. Overall, the success of cross-sector projects in mitigating environmental and health impacts requires the integration of digital technologies, the implementation of green innovations, and well-planned collaboration. This approach not only provides long-term solutions to environmental challenges but also creates significant social, economic, and ecological

benefits for all parties. Multisectoral collaboration in the oil and gas (oil and gas) industry has shown effectiveness in solving complex challenges and improving project efficiency. The main success factors in this collaboration vary from inter-organizational relationships, supporting technology, to risk management. The following is a table that summarizes real examples of certain regions that have succeeded through collaboration and the key factors for the success of multisectoral collaboration in the oil and gas sector.

From various studies (table 13.5), it can be seen that the success of multisectoral collaboration in the oil and gas sector is highly dependent on internal factors such as trust, two-way communication, and leadership, as well as external factors such as economic conditions, technological innovation, and regulatory support. Practical guidance to improve the effectiveness of collaboration in oil and gas projects, especially in regions facing similar challenges. For evidence-based decision-making, the use of advanced technology and strategic risk management are also elements that cannot be ignored. The success of multisectoral collaboration in the oil and gas sector depends not only on technical capabilities but also on innovation in managing inter-stakeholder relationships. Initiatives such as international standardization in Australia, digitalization of operations in Canada, and the efficiency of deepwater projects in Brazil are proof that planned collaboration can address industry challenges. With an approach that continues to involve various sectors, the oil and gas industry can move toward better sustainability and efficiency. These sources underscore the importance of the involvement of all stakeholders to realize a significant and sustainable transformation in the energy sector. Relationship management, technological innovation, and resource management are the foundations for the success of multisectoral collaboration in the future.

### **13.6. Strategies to Strengthen Collaboration for the Future**

To ensure environmental sustainability and health in the oil and gas (oil and gas) sector, various collaborative strategies are needed that integrate technological innovation, environmental management, and sustainable business practices. One key approach is the implementation of an Environmental Management System (EMS), which helps companies identify, measure, and manage environmental impacts, including the use of impact evaluation matrixes to mitigate carbon footprints and other pollution (Guerrero-Martin et al., 2023). In addition, decarbonization endeavors through technologies such as carbon capture and storage (CCUS), electrification of operations, and transition to renewable energy are important steps to significantly reduce greenhouse gas emissions (Oruwari, 2023). Technological innovation plays a key role, such as hydrogen use, biomass processing, and nanoparticles, which help companies expand their green energy portfolios while meeting global sustainability targets (Dadd et al., 2023). In addition, cross-sector collaboration in the innovation

ecosystem, involving companies, research centers, universities, and governments, creates synergies to develop low-carbon technologies such as synthetic fuels and electric vehicles (Menéndez et al., 2022). Water resources are also the main focus with the efficiency of water use and recycling of treated water in oil and gas operations, especially in drought-prone areas. This strategy is important to ensure the sustainability of water resources while supporting global energy needs (Scanlon et al., 2020). Finally, improving the sustainability of oil and gas infrastructure with a risk, reliability, and resilience (3R) approach can ensure operational continuity while reducing environmental impact. This step is also important to support the broader energy transition toward renewable energy sources (Y. Mahmood et al., 2023). By adopting these strategies, the oil and gas sector can contribute to a balance between economic development and environmental conservation, support the achievement of the SDGs, and meet energy needs responsibly.

Creating synergies between sectors in the oil and gas (oil and gas) industry presents complex challenges as well as significant opportunities, especially in supporting environmental sustainability, operational efficiency, and energy transition. Key challenges include the divergence of agendas between the traditional and renewable energy sectors, the lack of policy harmonization, and technological barriers in integrating cross-sector solutions. For illustration, cross-sector policy integration is often hampered by regulatory fragmentation and a lack of strategic coordination, which reduces the effectiveness of collaboration between stakeholders (Botah, 2023). However, great opportunities arise through a cross-sectoral collaborative approach. In the oil and gas industry, synergy between the public and private sectors allows the development of low-carbon technologies such as CCUS, as well as the electrification of oil and gas operations. This can significantly reduce the carbon footprint and improve operational efficiency (Oruwari & Itsekor, 2023). In addition, cross-sector collaboration also allows for improved waste management in oil and gas operations, such as the use of flare gas into useful energy through an integrated waste management mechanism (Jotaworn et al., 2021). The era of digitalization and industry 4.0 also brings great opportunities to create synergistic interactions between people, technology, and processes in the oil and gas sector. Regionally, cross-regional synergy in the oil and gas industry can improve energy efficiency and resource management. For illustration, cross-regional industrial synergies in China show great potential in creating economic growth up to 35% higher and reducing energy consumption by up to 32% through the integration of cross-industry management (Chen et al., 2021). The oil and gas sector has unique challenges in creating synergies between sectors. However, by capitalizing on opportunities through strategic collaboration, adoption of advanced technologies, and an inclusive cross-sectoral approach, the industry can overcome barriers, support

the global energy transition, and contribute to environmental and economic sustainability.

Improving the effectiveness of cross-sector collaboration requires strategies that take into account the complexity of inter-organizational relationships, diversity of goals, and resource constraints. One of the main recommendations is to build trust and social relationships between stakeholders, which is the foundation for creating sustainable collaboration results. The use of social capital such as institutions, relationships, and values that govern interactions between individuals has been shown to strengthen the results of cross-sector collaboration ((Graves & Higgins, 2021). Another strategy is the implementation of an integrated collaboration framework. Research shows that collaboration effectiveness increases when there are governance mechanisms that involve shared goals, resource coordination, and inclusive decision-making. In the Action of cross-sectoral health collaboration, strong leadership and collective commitment are essential to achieve the desired outcomes (Calancie et al., 2021). The use of tools and technology to facilitate collaboration is also highly encouraged. For Illustration, self-assessment tools such as the Cross-Sectoral Cooperation Self-Assessment Tool (CroCo SA) help organizations assess their strengths and weaknesses in cross-sectoral cooperation, allowing for strategic steps to improve the collaboration process (Matinheikki & Liinamo, 2022). Additionally, it is important to develop a flexible and adaptive framework to deal with the dynamics of cross-sector collaboration. Studies on public-private sector collaboration show that adaptive approaches and collaborative leadership can mitigate tensions between different organizational interests, allowing for greater shared value creation (Virta & Malmelin, 2022). The final recommendation is to promote collaborative learning through cross-sectoral partnerships. Collaborations that facilitate shared learning, such as in the "collaborative learning" model in the health sector, show that the integration of ideas from different sectors can result in innovative solutions to complex challenges (Day et al., 2022). By implementing these strategies, organizations can increase the effectiveness of cross-sector collaboration to face global challenges with a more innovative, inclusive, and sustainable approach.

In the face of environmental sustainability and health demands, the oil and gas (oil and gas) sector must transform toward more environmentally friendly, efficient, and climate-responsive operational practices. One of the key elements of the long-term vision is the implementation of a risk-based, reliability, and resilience (3R) sustainability framework that enables oil and gas infrastructure to manage environmental and social threats holistically, while supporting the transition to renewable energy (H. Mahmood, 2023). In addition, the implementation of ESG-based strategies is the foundation of sustainability in the oil and gas industry. This strategy includes reducing carbon emissions through energy management, promoting a circular economy, and developing low-carbon solutions to support the

global energy transition (Bandeira et al., 2023). In the social dimension, companies can improve occupational health and safety through technology-based education and training such as virtual reality simulations, ensuring the readiness of the workforce to face sustainable energy needs (Dias & Deegan, 2020). On a global scale, waste and exhaust gas management such as methane is also a major focus, given its significant contribution to climate change. Technologies such as CCUS and collaboration with the renewable energy sector can accelerate the transition to a near-emission-free energy supply chain (Wood, 2020). This vision also emphasizes the importance of local community involvement in the planning and implementation of oil and gas projects. HIA is an integral part of sustainability, ensuring that oil and gas projects not only contribute to economic growth but also to the well-being of local communities (Viliani & Harris, 2020). The long-term vision for the sustainability of the oil and gas sector includes a transformation toward greener, inclusive, and technology-based operational practices, with a commitment to environmental sustainability, social welfare, and technological innovation as the foundation for future sustainability.

### **13.7. Conclusion and Recommendations**

Chapter 13 discusses the issue of multisectoral collaboration for environmental sustainability and health in the oil and gas sector, focusing on the roles of government, society, the private sector, academia, and the media. The main problems identified are the negative impact of oil and gas activities on the environment and public health, as well as the lack of synergy and harmonization between stakeholders. Barriers such as the integration of public health in EIA, weak law enforcement, and the imbalance between industrial needs and ecosystem sustainability are significant challenges. This chapter aims to explore multisectoral collaboration models that can improve environmental and health sustainability through regulatory strategies, technological innovation, and community engagement. Examples include the implementation of green energy, technology-based environmental management systems, and community involvement in ecosystem restoration.

This chapter offers a holistic approach that combines advanced technologies, such as carbon capture and digital twins, with community-based strategies to achieve sustainability. In addition, a data-driven approach to environmental and health impact mitigation emphasizes the importance of innovation in creating a balance between economic and ecological needs in the oil and gas sector. In conclusion, Chapter 13 highlights the need for synergy between technology, regulation, and collaboration between stakeholders to address environmental and health challenges in the oil and gas sector.

## Reference

- A. Abbink, O., W. Faber, D., & H. Marrewijk, A. (2014). Collaboration Dynamics in Megaprojects in the Canadian Oil Sands Industry. *74th EAGE Conference and Exhibition Incorporating EUROPEC 2012*. <https://doi.org/10.3997/2214-4609.20148141>
- ACHEBELEMA, C., & ACHEBELEMA, D. (2021). COLLABORATIVE MANAGEMENT AND ORGANISATIONAL RESILIENCE: EVIDENCE FROM THE OIL AND GAS INDUSTRY OF A DEVELOPING ECONOMY. *African Journal of Business and Economic Development*, 1–15. <https://doi.org/10.46654/AJBED.1502>
- Adams, N. N., & Mueller-Hirth, N. (2021). Collaborate and die! Exploring different understandings of organisational cooperation within Scotland's uncertain North Sea oil and gas industry. *Energy Research and Social Science*, 73. <https://doi.org/10.1016/j.erss.2021.101909>
- Ali, M. G., Hegazy, G. M., Atef, A., & Ali, M. G. (2023). Innovative Submarine Solution for Overcoming Challenges in Offshore Oil and Gas Operations. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/217048-MS>
- Amer, M., Radwhi, A., Ali, A., & Ali, A. (2022). An Integrated Digital Collaborative Work Environment for Drilling. *International Petroleum Technology Conference, IPTC 2022*. <https://doi.org/10.2523/IPTC-22546-EA>
- Apergis, N., Mustafa, G., & Dastidar, S. G. (2021). An analysis of the impact of unconventional oil and gas activities on public health: New evidence across Oklahoma counties. *Energy Economics*, 97. <https://doi.org/10.1016/j.eneco.2021.105223>
- Arthur, J. L. (2020). Mitigating the Environmental Effects of Oil and Gas Exploitation: Issues of Compliance, Cost of Production, and Community Awareness. *Journal of Power and Energy Engineering*, 08(09). <https://doi.org/10.4236/jpee.2020.89005>
- Asmara, A. Y. (2023). Role of Universities in Promoting Innovation Policy in Southeast Asian Countries. *STI Policy and Management Journal*, 8(1). <https://doi.org/10.14203/stipm.2023.354>
- Audretsch, D. B., Fisch, C., Franzoni, C., Momtaz, P. P., & Vismara, S. (2023). Academic Freedom and Innovation: A Research Note. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4384419>
- Bandeira, G. L., Trindade, D. N., Sodario, M., & Ferronato, G. (2023). Creating Sustainable Value: An ESG Framework for the Petroleum Industry. *Offshore Technology Conference Brasil, OTCB 2023*. <https://doi.org/10.4043/32707-MS>



- Bashbaeva, M., Zinalieva, A., Umarova, G., Baspakova, A., & Duisenova, A. (2020). Psychophysical aspects of public health in the oil and gas region. *Open Access Macedonian Journal of Medical Sciences*, 8. <https://doi.org/10.3889/oamjms.2020.4542>
- Bhatti, S. H., Saleem, F., Murtaza, G., & Haq, T. U. (2022). Exploring the impact of green human resource management on environmental performance: the roles of perceived organizational support and innovative environmental behavior. *International Journal of Manpower*, 43(3). <https://doi.org/10.1108/IJM-05-2020-0215>
- Botah, K. Y. (2023). Integration of Sectoral Policies: Potentials and Obstacles in a Complex and Interconnected World. *Journal of Social and Policy Issues*. <https://doi.org/10.58835/jspi.v3i3.210>
- Brown, W., Kostareli, A., & Sealy, I. (2020). Environmental management in the oil & gas industry, a guide to environmental management good practices in the upstream oil & gas industry - Second edition. *Society of Petroleum Engineers - SPE International Conference and Exhibition on Health, Safety, Environment, and Sustainability 2020, HSE and Sustainability 2020*. <https://doi.org/10.2118/199456-ms>
- Calancie, L., Frerichs, L., Davis, M. M., Sullivan, E., White, A. M., Cilenti, D., Corbie-Smith, G., & Lich, K. H. (2021). Consolidated framework for collaboration research derived from a systematic review of theories, models, frameworks and principles for cross-sector collaboration. *PLoS ONE*, 16(1 January). <https://doi.org/10.1371/journal.pone.0244501>
- Cantele, S., Moggi, S., & Campedelli, B. (2020). Spreading sustainability innovation through the co-evolution of sustainable business models and partnerships. *Sustainability (Switzerland)*, 12(3). <https://doi.org/10.3390/su12031190>
- Ceccon, E., Méndez-Toribio, M., & Martínez-Garza, C. (2020). Social Participation in Forest Restoration Projects: Insights from a National Assessment in Mexico. *Human Ecology*, 48(5). <https://doi.org/10.1007/s10745-020-00178-w>
- Chen, Y., Nie, H., Chen, J., & Peng, L. (2021). Regional industrial synergy: Potential and path crossing the “environmental mountain.” *Science of the Total Environment*, 765. <https://doi.org/10.1016/j.scitotenv.2020.142714>
- Choi, G., Jin, T., Jeong, Y., & Lee, S. K. (2020). Evolution of partnerships for sustainable development: The case of P4G. *Sustainability (Switzerland)*, 12(16). <https://doi.org/10.3390/su12166485>
- Chutcheva, Y. V., Kuprianova, L. M., Seregina, A. A., & Kukushkin, S. N. (2022). Environmental management of companies in the oil and gas markets based

- on AI for sustainable development: An international review. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.952102>
- Coleman, E. A., Schultz, B., Rani Parker, A., Manyindo, J., & Mukuru, E. M. (2023). How Communities Benefit from Collaborative Governance: Experimental Evidence in Ugandan Oil and Gas. *Journal of Public Administration Research and Theory*, 33(4). <https://doi.org/10.1093/jopart/muac050>
- Crusan, J. (2020). Advancing technology in oil and gas: collaboration and comparison with the space sector. *The APPEA Journal*, 60(2). <https://doi.org/10.1071/aj19227>
- Dadd, E., Kirou, V., Velasquez, J., Kalhori, S. K., & Galatro, D. (2023). Sustainability and future of the oil and gas industry: a mini-review. *DYNA (Colombia)*, 90(226). <https://doi.org/10.15446/dyna.v90n226.105963>
- Day, S., Couzner, L., Laver, K. E., Withall, A., Draper, B., & Cations, M. (2022). Cross-sector learning collaboratives can improve post-diagnosis care integration for people with young onset dementia. *Health and Social Care in the Community*, 30(6). <https://doi.org/10.1111/hsc.14051>
- Dias, J. M. M., & Deegan, A. (2020). Building the national workforce for a sustainable energy future. *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference 2020, ADIP 2020*. <https://doi.org/10.2118/202986-ms>
- Dmytruk, V. (2023). Development of methodological approaches of value-based management at oil and gas extraction enterprises. *Economic Analysis*, 33(1). <https://doi.org/10.35774/econa2023.01.288>
- Dong, X., Dong, W., & Lv, X. (2020). Impact of environmental policy on investment efficiency: Evidence from the oil and gas sector in Canada. *Journal of Cleaner Production*, 252. <https://doi.org/10.1016/j.jclepro.2019.119758>
- Dua, S., & Jain, N. K. (2024). Circular economy and innovation in oil and gas industry: A systematic literature review and bibliometric analysis. *International Social Science Journal*, 74(252). <https://doi.org/10.1111/issj.12474>
- Graves, E., & Higgins, A. (2021). Do Cross Sector Collaborations Need Social Capital? A Tool for Quantification and Validation. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3725494>
- Guerrero-Martin, C. A., Ortega-Ramírez, A. T., Rodríguez, P. A. P., López, S. J. R., Guerrero-Martin, L. E., Salinas-Silva, R., & Camacho-Galindo, S. (2023). Analysis of Environmental Sustainability through a Weighting Matrix in the Oil and Gas Industry. *Sustainability (Switzerland)*, 15(11). <https://doi.org/10.3390/su15119063>

- Gusov, A. Z., Lylova, E. V., Kolganova, E. V., & Eyeberdiyeva, M. M. (2022). Increasing the social responsibility of oil and gas companies in the context of the green economy formation: Russian and Western experience. *MIR (Modernization. Innovation. Research)*, 13(2). <https://doi.org/10.18184/2079-4665.2022.13.2.304-321>
- Hannouf, M., Assefa, G., & Gates, I. (2020). From social hotspots to policies for successful implementation of environmentally better technologies? The example of social life cycle assessment of oil and gas technologies in Alberta, Canada. *Environmental Science and Policy*, 110. <https://doi.org/10.1016/j.envsci.2020.05.002>
- Haouel, C., & Nemeslaki, A. (2023). Digital Transformation in Oil and Gas Industry. *Periodica Polytechnica Social and Management Sciences*, 32(1). <https://doi.org/10.3311/ppso.20830>
- Hasiholan, A., Murwadi, T., & Sukarsa, D. E. (2023). Environmental Responsibilities of Local Governments as PI Holders in Upstream Oil and Gas Operations. *IOP Conference Series: Earth and Environmental Science*, 1270(1). <https://doi.org/10.1088/1755-1315/1270/1/012006>
- Hegazy, G. M., Ali, M. G., Abdeltawab, B. A., & Ali, M. G. (2023). Lack of Integration Between Academia and the Industry: How to Upscale Experience Through Innovative Guidelines Involving Research Outcomes. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/216092-MS>
- Heim, I., Vigneau, A. C., & Kalyuzhnova, Y. (2023). Environmental and socio-economic policies in oil and gas regions: triple bottom line approach. *Regional Studies*, 57(1). <https://doi.org/10.1080/00343404.2022.2056589>
- Hersey, S., & Gordon, E. (2021). Air Partners: Community-driven air quality monitoring, mitigation, and collaborative governance. *ACM International Conference Proceeding Series*. <https://doi.org/10.1145/3461564.3461592>
- Irawati, I., Prananingtyas, P., Dewi, I., & Disemadi, H. (2021). Effectiveness of Law of the Republic of Indonesia Number 11 of 2020 on Job Creation towards Oil and Gas Downstream Business Supervision Implementation in Indonesia. *Proceedings of the 2nd International Conference on Law, Economic, Governance, ICOLEG 2021, 29-30 June 2021, Semarang, Indonesia*. <https://doi.org/10.4108/eai.29-6-2021.2312619>
- Jessani, N. S., Ling, B., Babcock, C., Valmeekanathan, A., & Holtgrave, D. R. (2022). Advocacy, activism, and lobbying: How variations in interpretation affects ability for academia to engage with public policy. *PLOS Global Public Health*, 2(3 March). <https://doi.org/10.1371/journal.pgph.0000034>

- Johnston, J. E., Enebish, T., Eckel, S. P., Navarro, S., & Shamasunder, B. (2021). Respiratory health, pulmonary function and local engagement in urban communities near oil development. *Environmental Research*, 197. <https://doi.org/10.1016/j.envres.2021.111088>
- Jones, C. M. (2020). Guest Editorial: The South American Deepwater Sector. *Journal of Petroleum Technology*, 72(09). <https://doi.org/10.2118/0920-0010-jpt>
- Jotaworn, S., Nitivattananon, V., Kusakabe, K., & Xue, W. (2021). Partnership towards synergistic municipal solid waste management services in a coastal tourism sub-region. *Sustainability (Switzerland)*, 13(1). <https://doi.org/10.3390/su13010397>
- Jumbo, J. A., Ordinioha, B., Mmom, P., Okokon, E., Teere, M. B., & Tamunomiegbam, A. (2023). Environmental and Health Impacts of Crude Oil Exploration in the Niger Delta. *Journal of Environment*, 3(2). <https://doi.org/10.47941/je.1424>
- Kalalo, J. J. J., Betaubun, R. M. N., Marpaung, D. N., & Badilla, N. W. Y. (2024). Disharmony of policy laws and regulations in the effort to develop beef cattle production in Indonesia. *IOP Conference Series: Earth and Environmental Science*, 1341(1), 012087. <https://doi.org/10.1088/1755-1315/1341/1/012087>
- Kapoor, A., Fraser, G. S., & Carter, A. (2021). Marine conservation versus offshore oil and gas extraction: Reconciling an intensifying dilemma in Atlantic Canada. *Extractive Industries and Society*, 8(4). <https://doi.org/10.1016/j.exis.2021.100978>
- Keys, M., & Taylor, M. (2021). International standardisation driving global competitiveness and sustainability of the oil and gas and future energy industries. *The APPEA Journal*, 61(2). <https://doi.org/10.1071/aj20156>
- Krawchenko, T. A., & Gordon, M. (2022). Just Transitions for Oil and Gas Regions and the Role of Regional Development Policies. *Energies*, 15(13). <https://doi.org/10.3390/en15134834>
- Kurniawan, I., & Arief, N. N. (2023). Creating Shared Value in Upstream Oil and Gas Company and Community: A Case Study of CSR Implementation in PT Pertamina EP Tarakan Field. *European Journal of Business and Management Research*, 8(4). <https://doi.org/10.24018/ejbmr.2023.8.4.2091>
- Kwarto, F., Nurafiah, N., Suharman, H., & Dahlan, M. (2021). *Sustainability Reporting in the Upstream Oil and Gas Industry Between Awards and Violations: A Systematic Literature Review, Evidence From Indonesia*. <https://doi.org/10.20944/preprints202109.0186.v1>
- Lemmer, M., Rochefort, L., & Strack, M. (2020). Greenhouse Gas Emissions Dynamics in Restored Fens After In-Situ Oil Sands Well Pad Disturbances of Canadian

- Boreal Peatlands. *Frontiers in Earth Science*, 8. <https://doi.org/10.3389/feart.2020.557943>
- Li, H., Wang, Q., & Wu, Y. (2023). Current Status and Development Direction of Low-Carbon Exploitation Technology for Heavy Oil. In *Energies* (Vol. 16, Issue 5). <https://doi.org/10.3390/en16052219>
- Li, T., & Zhou, X. (2022). Research on the Mechanism of Government–Industry–University–Institute Collaborative Innovation in Green Technology Based on Game–Based Cellular Automata. *International Journal of Environmental Research and Public Health*, 19(5). <https://doi.org/10.3390/ijerph19053046>
- Magumba, D. (2023). Institutionalizing University-Business Innovation Systems in an Innovation Economy. *European Journal of Business and Management Research*, 8(3). <https://doi.org/10.24018/ejbmr.2023.8.3.1935>
- Mahmood, H. (2023). The Determinants of Carbon Intensities of Different Sources of Carbon Emissions in Saudi Arabia: The Asymmetric Role of Natural Resource Rent. *Economies*, 11(11). <https://doi.org/10.3390/economies11110276>
- Mahmood, Y., Afrin, T., Huang, Y., & Yodo, N. (2023). Sustainable Development for Oil and Gas Infrastructure from Risk, Reliability, and Resilience Perspectives. In *Sustainability (Switzerland)* (Vol. 15, Issue 6). <https://doi.org/10.3390/su15064953>
- Marpaung, Z. S., Khairunnisa, T., Widodo, S., & Imelda, I. (2023). IMPACT OF ILLEGAL OIL MINING: WHAT SHOULD GOVERNMENT DO? *Jurnal Kebijakan Publik*, 14(3). <https://doi.org/10.31258/jkp.v14i3.8279>
- Masucci, M., Brusoni, S., & Cennamo, C. (2020). Removing bottlenecks in business ecosystems: The strategic role of outbound open innovation. *Research Policy*, 49(1). <https://doi.org/10.1016/j.respol.2019.103823>
- Mas'ud, A., Yusuf, R., Udin, N. M., & Al-Dhamari, R. (2020). Enforce environmental tax compliance model for the oil and gas industry. *International Journal of Energy Sector Management*, 14(6). <https://doi.org/10.1108/IJESM-11-2019-0005>
- Matinheikki, K., & Liinamo, A. (2022). Identifying cross-sectoral cooperation for urban health. *European Journal of Public Health*, 32(Supplement\_3). <https://doi.org/10.1093/eurpub/ckac129.565>
- Morais, C. P. M., Almeida, D. P. S., & Alves, V. F. B. (2023). Regulating Human Factors in Brazilian Oil & Gas Offshore Installations. *Offshore Technology Conference Brasil, OTCB 2023*. <https://doi.org/10.4043/32959-MS>
- Munodawafa, R. T., & Johl, S. K. (2022). Measurement development for eco-innovation capabilities of Malaysian oil and gas firms. *International Journal of*

- Productivity and Performance Management*, 71(8).  
<https://doi.org/10.1108/IJPPM-07-2020-0404>
- Nallur, V., McClung, M. R., & Moran, M. D. (2020). Potential for Reclamation of Abandoned Gas Wells to Restore Ecosystem Services in the Fayetteville Shale of Arkansas. *Environmental Management*, 66(2).  
<https://doi.org/10.1007/s00267-020-01307-3>
- Nayanov, P. A., & Khamidullina, E. A. (2020). Statistical risk management analysis for hazardous oil and gas production facilities. *XXI Century. Technosphere Safety*, 5(4), 393–402. <https://doi.org/10.21285/2500-1582-2020-4-393-402>
- Nazarova, V. V., & Tikhomirov, E. D. (2022). The impact of environmental performance of oil and gas companies on their financial performance. *Moscow University Economics Bulletin*, 5. <https://doi.org/10.38050/01300105202258>
- Obi, N. I., Bwititi, P. T., & Nwose, E. U. (2021). Community Awareness of Health Problems Associated with Gas Flaring and Programme to Mitigate. *Journal of Complementary and Alternative Medical Research*.  
<https://doi.org/10.9734/jocamr/2021/v16i230284>
- Oliveira Bredariol, T., & Vinha, V. (2020). The Role of Public Administration in Environmental Governance: a Case Study based on the Institutional Analysis and Development Framework. *Desenvolvimento Em Debate*, 8(2).  
<https://doi.org/10.51861/ded.dmv.2.005>
- Olujobi, O. J. (2020). Analysis of the legal framework governing gas flaring in Nigeria's upstream petroleum sector and the need for overhauling. In *Social Sciences* (Vol. 9, Issue 8). <https://doi.org/10.3390/SOCSCI9080132>
- Oruwari, H. O. (2023). Green Technological Approach for Sustainable Operations of Oil and Gas Industry. *Society of Petroleum Engineers - SPE Nigeria Annual International Conference and Exhibition, NAIC 2023*.  
<https://doi.org/10.2118/217178-MS>
- Oruwari, H. O., & Itsekor, L. (2023). Strategies for Decarbonizing the Oil and Gas Industries. *Society of Petroleum Engineers - SPE Nigeria Annual International Conference and Exhibition, NAIC 2023*. <https://doi.org/10.2118/217179-MS>
- Owojori, O. M., & Okoro, C. (2022). The Private Sector Role as a Key Supporting Stakeholder towards Circular Economy in the Built Environment: A Scientometric and Content Analysis. In *Buildings* (Vol. 12, Issue 5).  
<https://doi.org/10.3390/buildings12050695>
- Padash, A., & Ghatari, A. R. (2020). Toward an Innovative Green Strategic Formulation Methodology: Empowerment of Corporate Social, Health, Safety and Environment. *Journal of Cleaner Production*, 261.  
<https://doi.org/10.1016/j.jclepro.2020.121075>

- Passalacqua, H., & Turki I Alsaba, M. (2020, October 19). Energy Transitions: An Academia Take on Shaping the Future Professionals of Oil and Gas. *SPE Annual Technical Conference and Exhibition*. <https://doi.org/10.2118/201593-MS>
- Peacock, J., & Dow, S. (2019). Opportunities for collaboration in the Australian oil and gas industry: learning lessons from more mature basins and international best practice (North Sea, Norway, Gulf of Mexico, Onshore US). *The APPEA Journal*, 59(2). <https://doi.org/10.1071/aj18145>
- Peeters, M., & Athanasiadou, N. (2020). The continued effort sharing approach in EU climate law: Binding targets, challenging enforcement? *Review of European, Comparative and International Environmental Law*, 29(2). <https://doi.org/10.1111/reel.12356>
- Rahman, S. B. A., Bakar, N. B. M. A., & Zainai, A. I. Bin. (2021). Collaborations Involving Malaysia Upstream Regulator to Enhance Decommissioning. *Society of Petroleum Engineers - SPE Symposium: Decommissioning and Abandonment, SM02 2021*. <https://doi.org/10.2118/208468-MS>
- Rashed, A. H., & Shah, A. (2021). The role of private sector in the implementation of sustainable development goals. In *Environment, Development and Sustainability* (Vol. 23, Issue 3). <https://doi.org/10.1007/s10668-020-00718-w>
- Redda, Y., & Turner, R. (2018). Mapping the success dimensions of large oil and gas projects. *Proceedings - SPE Annual Technical Conference and Exhibition, 2018-September*. <https://doi.org/10.2118/191764-ms>
- Satterwhite, E., Bell, S. E., Marr, L. C., Thompson, C. K., Prussin, A. J., Buttlings, L., Pan, J., & Gohlke, J. M. (2020). Building interdisciplinary partnerships for community-engaged environmental health research in Appalachian Virginia. *International Journal of Environmental Research and Public Health*, 17(5). <https://doi.org/10.3390/ijerph17051695>
- Scanlon, B. R., Ikonnikova, S., Yang, Q., & Reedy, R. C. (2020). Will Water Issues Constrain Oil and Gas Production in the United States? *Environmental Science and Technology*, 54(6). <https://doi.org/10.1021/acs.est.9b06390>
- Schultz, C., Gretsche, O., & Kock, A. (2021). The influence of shared R&D-project innovativeness perceptions on university-industry collaboration performance. *Journal of Technology Transfer*, 46(4). <https://doi.org/10.1007/s10961-020-09818-1>
- Sheng, J., Zhou, W., & Zhu, B. (2020). The coordination of stakeholder interests in environmental regulation: Lessons from China's environmental regulation policies from the perspective of the evolutionary game theory. *Journal of Cleaner Production*, 249. <https://doi.org/10.1016/j.jclepro.2019.119385>

- Subadi, S. (2023). Sustainable Environmental Management and Preservation in Old Well Oil and Gas Traditional Mining Sites Indonesia: Whose Responsibility? *Journal of Law and Sustainable Development*, 11(12). <https://doi.org/10.55908/sdgs.v11i12.2115>
- TJAHJANI, J. (2021). CLASS ACTION AS A FORM OF COMMUNITY PARTICIPATION IN ENVIRONMENTAL LAW ENFORCEMENT. *Jurnal Independent*, 9(2). <https://doi.org/10.30736/ji.v9i2.144>
- Tsybka, A. (2023). Administrative and legal measures to overcome threats to energy security of Ukraine in the oil and gas sector. *Visegrad Journal on Human Rights*, 5. <https://doi.org/10.61345/1339-7915.2023.5.15>
- Valishvili, M. A. (2020). D&R OBLIGATIONS OF OIL PRODUCING COMPANIES: ECONOMIC AND LEGAL MECHANISMS FOR IMPLEMENTATION. *Vestnik Universiteta*, 7. <https://doi.org/10.26425/1816-4277-2020-7-59-67>
- VASSILEVA, A. (2022). Green Public-Private Partnerships (PPPs) as an Instrument for Sustainable Development. *Journal of World Economy: Transformations & Transitions*. <https://doi.org/10.52459/jowett25221122>
- Vihristyuk, O., & Dimitrova, A. (2022). The Study of Social Risks Affecting the Financial Stability of the Oil and Gas Industry and the Ways of Enterprise Management. *International Conference on High Technology for Sustainable Development, HiTech 2022 - Proceedings*. <https://doi.org/10.1109/HiTech56937.2022.10145561>
- Viliani, F., & Harris, P. (2020). Assessment of health impacts on local communities is fundamental for sustainability. *Society of Petroleum Engineers - SPE International Conference and Exhibition on Health, Safety, Environment, and Sustainability 2020, HSE and Sustainability 2020*. <https://doi.org/10.2118/199487-ms>
- Virta, S., & Malmelin, N. (2022). Managing Organisational Tensions in Cross-Sector Collaboration: The Case of Mediapolis. *Media and Communication*, 10(1). <https://doi.org/10.17645/mac.v10i1.4394>
- Wanasinghe, T. R., Gosine, R. G., James, L. A., Mann, G. K. I., De Silva, O., & Warrian, P. J. (2020). The Internet of Things in the Oil and Gas Industry: A Systematic Review. *IEEE Internet of Things Journal*, 7(9). <https://doi.org/10.1109/JIOT.2020.2995617>
- Wang, Y., Zhang, S., & Xu, S. (2022). Impact of Efficient Resource Management Practices on Sustainable Performance: Moderating Role of Innovative Culture- Evidence From Oil and Gas Firms. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.938247>



- Weixiang, C., & Chunpeng, W. (2023). Carbon Capture, Utilization and Storage (CCUS) in Tight Oil Reservoir. *Society of Petroleum Engineers - ADIPEC, ADIP 2023*. <https://doi.org/10.2118/216110-MS>
- Whitaker, S. (2022). *The Role of ESG in Attracting Capital to The Petroleum Industry*. <https://doi.org/10.29118/ipa22-bc-288>
- Wood, D. A. (2020). The natural gas sector needs to be mindful of its sustainability credentials. In *Advances in Geo-Energy Research* (Vol. 4, Issue 3). <https://doi.org/10.46690/ager.2020.03.01>



# Conclusions and Recommendations

## Chapter

## 14

Andjar Prasetyo, Ira Amanda Hirbasari

The importance of managing oil and gas BUMDs to support regional economic development through transparent governance, low-carbon technology, and community involvement. The recommendations focus on balancing economic benefits, environmental conservation, and public health protection for long-term sustainability.

### 14.1. Conclusion

#### 1. Summary of Oil and Gas BUMD Management

Oil and gas BUMDs have an important role in supporting regional and national development strategies, both in economy and social. The existence of oil and gas BUMDs helps increase regional revenues through taxes and other contributions and advises local economic growth. However, oil and gas exploration and production activities also bring challenges in environmental sustainability and impact on public health. Oil and gas BUMD activities need to be balanced among endeavors to achieve economic benefits and commitment to sustainability. For illustration, research in the oil and gas sector in the United States shows that investment in corporate innovation can significantly improve environmental sustainability, especially when supported by appropriate managerial incentives (Tang et al., 2023). Another study highlights that large oil and gas companies, such as ExxonMobil and BP, have shifted their strategies to adapt to the global trend toward low-carbon energy through technological innovation and business model diversification (Sheydai et al., 2021). In Indonesia, research shows that the contribution of the oil and gas sector to local income is significant, but its impact on local employment is often limited. For illustration, in Bojonegoro, only a small part of the local workforce is absorbed compared to other agricultural sectors (Qurbani et al., 2020). In addition, the sustainability of spatial governance in oil and gas areas still faces regulatory challenges that are not aligned among the local and national levels (Chusaini et al., 2023). In the context of global sustainability, strategies that emphasize technology-based environmental management such as artificial intelligence and green innovation have proven to be able to improve operational efficiency and encourage the transition to clean energy

(Chutcheva et al., 2022). A collaborative approach among governments, the private sector, and local communities can amplify these positive impacts, both economically and socially. The success of oil and gas BUMDs is determined not only by their economic performance but also by their ability to integrate sustainability principles into their operations. Strategic steps to achieve this balance involve increased investment in green technologies, alignment of multi-level regulations, and empowerment of local communities.

The feasibility study for the establishment of BUMD in the Riau Islands mainly focuses on the management of a 10% Participating Interest (PI) in the working area of the Mako Gas Field, Duyung Block, Natuna. The establishment of the Perseroda BUMD aims to take advantage of the great potential of natural gas that has been verified to reach a recoverable reserve of 495 billion cubic feet of gas (BCF). The main implications for public policy in the Riau Islands include optimizing regional revenues which are expected to support maritime-based economic development. However, the document shows that the analysis of public and community service needs has not been fully integrated due to its focus on the formation of profit-oriented entities. On the environmental side, natural gas exploration and management requires strict compliance with environmental policies to prevent the degradation of marine ecosystems. Public health can also be affected by exploration activities if chemical leaks or contamination, so risk mitigation needs to be a priority.

The establishment of BUMD in Wajo Regency is planned to manage the 10% PI as well as the agriculture, parking, and market sectors. In the context of oil and gas, the document states that natural gas management in Wajo aims to meet local energy needs and increase PAD. However, there are challenges in the form of reducing regional levies that are managed less professionally, so the establishment of BUMD is expected to be a solution for transparency and increased management efficiency. Policies in Wajo Regency emphasize more equitable socio-economic impacts, comprising gas management for domestic needs and job development. Environmental aspects tend to not be widely discussed in the document, but it is important to consider mitigating the impact of exploration on the surrounding environment. For public health, the efficient supply of energy from natural gas can improve the quality of life, but the risk of environmental pollution must still be anticipated.

The management of Regional-Owned Enterprises (BUMD) in the oil and gas sector is one of the important strategies in supporting local economic development while maintaining a balance of social and environmental sustainability. Based on studies from the Riau Islands Province and Wajo Regency, as well as related literature, the management of oil and gas BUMDs requires a strategic approach that harmonizes various dimensions. In Riau Islands Province, the establishment of Perseroda BUMD to manage the 10% PI in the Mako Gas Block aims to increase PAD.

The document shows that the main focus is on optimizing regional revenues, with the main challenge being the integration of environmental and public health policies. Gas exploration in the region requires mitigating ecological risks, such as preventing marine pollution, as well as ensuring that business operations do not harm local communities (Dmitrieva & Skobelev, 2023). In Wajo Regency, the management of 10% PI in the natural gas area is aimed at meeting domestic energy needs and increasing PAD. However, the challenges faced include inefficient levy management and a decrease in revenue from the parking sector. The plan to establish a BUMD is expected to create a more transparent and integrated system to improve regional revenue governance. Technology-based approaches, such as the digitization of management systems, are considered vital to improve operational efficiency (Qurbani et al., 2020). In addition, international research highlights the importance of sustainability-based governance, comprising in gas waste management and the implementation of low-carbon technologies. Studies show that the adoption of environmentally friendly technologies, such as Carbon Capture and Storage (CCS), can significantly reduce carbon emissions, improving the sustainability of BUMD operations (Heim et al., 2023). Other research underscores the importance of good corporate governance in BUMDs to assure transparency, accountability, and community participation in decision-making. Stakeholder involvement can also strengthen the social dimension of sustainability, for illustration through corporate social responsibility (CSR) programs that are integrated with local needs (Doni et al., 2022). The management of oil and gas BUMDs requires a comprehensive strategy that combines economic achievements with environmental preservation and improvement of community welfare. Innovative technology implementation, sustainability-based governance, and stakeholder engagement are key to achieving long-term success.

Oil and gas activities have major implications for policy, environment, and public health, as shown by studies in Riau Islands Province, Wajo Regency, and related literature. At the policy level, the management of oil and gas BUMDs often faces challenges in integrating economic needs with environmental protection and community welfare. In Riau Islands Province, the policy related to the 10% PI in the Mako Gas Block aims to increase PAD and local competitiveness. However, the success of these policies depends on transparency of governance and cross-stakeholder collaboration. Research shows that policies in the oil and gas sector often do not fully prioritize environmental sustainability, which has an impact on the quality of life of the surrounding community (Kislyakova & Usatova, 2022). The environmental impact of oil and gas activities includes air, water, and soil pollution. In Wajo Regency, gas exploration requires rigorous environmental impact evaluations to reduce the risk of pollution. Research shows that emissions from the oil and gas sector, such as nitrogen dioxide (NO<sub>2</sub>) and fine particulate matter (PM<sub>2.5</sub>), contribute to air

quality degradation and create a significant public health burden. A study in the United States estimates that air pollution from the oil and gas sector causes more than 7,500 deaths per year, emphasizing the need for better emission control (J. Buonocore et al., 2021). The public health implications of oil and gas activities include an increased risk of respiratory diseases, cancer, and psychological disorders. In oil and gas exploration sites, such as in Oklahoma and Irkutsk, Russia, the incidence of cancer, heart disease, and infant mortality rates tend to be higher than in other regions. The study also revealed that people living near oil and gas facilities face a risk of chronic stress due to uncertainty and high exposure to environmental risks (Apergis et al., 2021; Nayanov & Khamidullina, 2020). The management of oil and gas activities must consider their impact on policy, the environment, and public health. An integrated approach involving environmentally friendly technology, sustainability-based governance, and strict regulations is needed to mitigate the negative impact of oil and gas activities.

## 2. Achievements and Challenges in Balanced Management

The management of the oil and gas sector by BUMDs such as in Riau Islands Province and Wajo Regency shows significant achievements in supporting regional economic development, but also faces complex challenges in achieving a balance among economic benefits, environmental protection, and public health. In Riau Islands Province, the success of the establishment of BUMD to manage the 10% PI in the Mako Gas Block is an important achievement in increasing PAD and strengthening the region's position in the strategic energy sector. However, challenges arise in the form of the need for transparent and accountable governance, as well as the integration of environmental sustainability strategies that are not optimal. The same thing can be seen in Wajo Regency, where the plan to establish an oil and gas BUMD aims to improve the efficiency of natural gas sector management, but is hit by limited managerial capacity and regulatory challenges related to cross-sector governance. At the global level, the literature shows that the oil and gas sector often face conflicts of interest among economic growth and its impact on the environment and local communities. For illustration, research in the oil and gas sector in Nigeria reveals that although oil exploration generates a large contribution to GDP, it is often accompanied by environmental degradation and increased public health risks due to air and water pollution (Jumbo et al., 2023). Similar challenges were also observed in a study in the United States, where air pollution resulting from oil and gas activities increased the public health burden, causing respiratory illness and premature Demise in intensively exposed areas (J. Buonocore et al., 2021). In this case, a technology-based approach and sustainability are potential solutions. The use of low-carbon technologies, such as CCS and artificial intelligence-based monitoring, has been proven to be able to reduce the environmental impact of oil and gas operations. For

Illustration, a case study in Russia shows that the adoption of CCS technology in the Irkutsk region significantly reduces carbon emissions and other environmental impacts (Nayanov & Khamidullina, 2020). In addition, the involvement of local communities in decision-making is an important factor to assure balanced management of the oil and gas sector. In Wajo Regency, despite endeavors to increase PAD through oil and gas exploration, community involvement in determining investment priorities and profit allocation still needs to be improved, as identified in the feasibility study document. A cross-stakeholder collaboration-based approach, as outlined in various studies, can reduce the potential for social conflict and increase public acceptance of oil and gas activities (Patimah et al., 2023). The achievements in the management of oil and gas BUMD reflect great potential to improve regional economic welfare. However, challenges in the form of environmental impact management, public health, and governance transparency must be overcome through strategies that integrate environmentally friendly technologies, multi-stakeholder collaboration, and strengthening sustainability-based policies.

The success of oil and gas BUMDs in fulfilling public policy interests is reflected in their contribution to regional economic development, increasing PAD, and supporting domestic energy needs. In Riau Islands Province, BUMD formed to manage the 10% PI in the Mako Gas Block has succeeded in providing a significant source of strategic income for the region. This achievement supports national policies that encourage regional involvement in energy resource management. In addition, the existence of this BUMD strengthens the competitiveness of the Riau Islands in the maritime-based energy sector, in line with the strategic policy of developing border areas (Misni et al., 2023). Wajo Regency also showed similar success, although at the planning stage. The plan to form a BUMD to manage the oil and gas sector aims not only to increase PAD but also to meet local energy needs. This approach supports public policy in ensuring that the management of energy resources can provide direct benefits to local communities, such as improving public services and infrastructure (Andi Tenri Awaru et al., 2020). Globally, the success of oil and gas BUMDs is also in line with international best practices in meeting public policy objectives. Studies in the Russian oil and gas sector show that energy resource management involving local governments through local entities can improve the efficiency of resource distribution while promoting social and economic sustainability (Heim et al., 2023). In addition, experience in Indonesia, such as the study in Bojonegoro, reveals that the contribution of the oil and gas sector to PAD is almost 50%, although the contribution to local employment is still limited. This shows the need for a BUMD management strategy that also pays attention to social impacts holistically (Qurbani et al., 2020). However, the success of oil and gas BUMDs in supporting public policies is not only measured by their economic contribution, but also by their impact on society and the environment. The research emphasizes the importance of transparent and

accountable governance to assure that the economic benefits of the oil and gas sector can be allocated fairly for public needs, such as health, education, and environmental risk mitigation (Rustini, 2022). The success of oil and gas BUMDs in fulfilling public policies can be seen from their contribution to PAD, strengthening regional competitiveness, and meeting local energy needs. However, for sustainability, it is necessary to strengthen governance and collaboration with the community so that economic benefits can be felt equally, in line with sustainable development goals.

Balancing economic, environmental, and public health aspects in the management of the oil and gas sector is the main challenge faced by BUMDs, both at the local level such as in the Riau Islands Province and Wajo Regency, as well as globally. Economic challenges are related to the need to maximize PAD and create jobs, as seen in the Riau Islands through the management of a 10% PI on the Mako Gas Block. However, too much focus on economic benefits often overrides the need to assure environmental sustainability, especially given the potential risk of pollution of marine ecosystems in these natural gas exploration areas (Misni et al., 2023). In Wajo Regency, the main challenge is to assure that natural gas management not only increases PAD but also minimizes negative impacts on local communities. While the oil and gas sector is expected to meet domestic energy needs, risks to public health, such as air and water pollution due to exploration activities, require effective mitigation. This challenge is becoming increasingly complex due to the limitations of human resources and technological capacity at the regional level (Andi Tenri Awaru et al., 2020). Internationally, the literature shows that oil and gas activities often produce negative impacts on public health and the environment. For illustration, a study in Oklahoma, United States, showed that oil and gas exploration activities can increase the incidence of respiratory diseases, cancer, and decreased life expectancy in directly affected areas (Apergis et al., 2021). In addition, emissions of pollutants from the oil and gas sector, such as nitrogen dioxide (NO<sub>2</sub>) and fine particles (PM<sub>2.5</sub>), worsen air quality and create a significant health burden in various communities (J. Buonocore et al., 2021). Another challenge is the lack of integration among economic policies and environmental regulations. In some cases, environmental regulations are not strict enough to mitigate risks from oil and gas exploration and production, as seen in energy governance analyses in developing countries. It is also exacerbated by a lack of transparency and community participation in the decision-making process, which can lead to social conflicts and dissatisfaction of local communities (Watterson & Dinan, 2020). Challenges in balancing economic, environmental, and public health aspects include the need to increase local revenues while minimizing negative impacts on ecosystems and local communities. To overcome this challenge, integrated policies, investment in environmentally friendly technologies, and community involvement in oil and gas resource management are needed.

### 3. Impact on the Environment and Public Health

Oil and gas activities have a significant impact on the environment and public health, as seen in the Riau Islands Province, Wajo Regency, and various other regions in the world. In Riau Islands Province, natural gas exploration in the Mako Gas Block faces the risk of pollution of sensitive marine ecosystems. Handling waste and emissions from oil and gas operations requires strict mitigation policies, given the potential impacts such as degradation of marine habitats and pollution of water sources that can affect coastal communities. In contrast, in Wajo Regency, although the economic benefits of natural gas management are expected to be significant, potential environmental risks such as air and soil pollution remain a major concern. This challenge requires the implementation of strong mitigation measures to protect local communities and the surrounding ecosystem (Andi Tenri Awaru et al., 2020; Misni et al., 2023). Globally, the literature reveals that oil and gas exploration and production often cause air, water, and soil pollution, which has a direct impact on public health. Studies in the United States show that emissions of gases such as nitrogen dioxide (NO<sub>2</sub>) and fine particles (PM<sub>2.5</sub>) from the oil and gas sector have led to an increase in respiratory diseases, cancer, and even premature Demise, especially in communities located close to exploration sites (J. J. Buonocore et al., 2023). In Russia, a study in the Irkutsk oil exploration region found that people living near oil and gas production sites experience twice as high infant mortality rates as other regions, as well as a greater prevalence of chronic diseases due to pollution and exposure to toxic chemicals (Nayanov & Khamidullina, 2020). Environmental impacts also include biodiversity Casualty and ecosystem changes that are difficult to restore. For Illustration, research in Brazil identified that oil and gas extraction in offshore areas has disrupted the balance of marine ecosystems, with some impacts being permanent or difficult to recover from through conventional rehabilitation methods (Mein et al., 2021). In addition, in many oil and gas-producing areas, communities face psychosocial impacts, such as chronic stress and mental health disorders due to exposure to environmental pollution and economic uncertainty caused by oil and gas activities. A study in Colorado, United States, shows that stress levels and depression prevalence are higher in communities close to oil and gas exploration sites, mainly due to a lack of transparency of information related to environmental and health risks (Malin, 2020). Oil and gas activities have a wide range of environmental and public health impacts, comprising pollution, ecosystem disruption, and an increased risk of chronic diseases and mental disorders. Addressing these impacts requires technology-based mitigation measures, strong risk management policies, and community involvement in decision-making.

Oil and gas activities have a significant negative impact on the environment and public health, which has been identified both in local contexts such as in Riau Islands Province and Wajo Regency, as well as globally. In the Riau Islands, natural



gas exploration in the Mako Gas Block faces the risk of damaging the marine ecosystem, comprising the potential for water resource pollution due to exploration waste. Although its contribution to PAD is significant, the lack of environmental mitigation can lead to habitat degradation that supports coastal economies, such as fisheries and tourism (Misni et al., 2023). In Wajo Regency, the main risk from oil and gas management is air and soil pollution that can interfere with the quality of life of the surrounding community, especially if technology and waste management are not carried out optimally (Andi Tenri Awaru et al., 2020). Globally, studies show that oil and gas activities produce emissions of pollutants such as nitrogen dioxide (NO<sub>2</sub>), fine particles (PM<sub>2.5</sub>), and volatile organic compounds, which contribute to environmental damage and respiratory diseases. A study in the United States revealed that oil and gas sector emissions are responsible for increased rates of premature death and chronic diseases in communities located near oil and gas exploration sites, with health impacts estimated at \$77 billion per year (J. J. Buonocore et al., 2023). In addition, oil and gas exploration in Irkutsk, Russia, shows an increase in the incidence of cancer, respiratory disorders, and infant mortality rates that are twice as high as in areas without oil and gas activities. The impact is mainly due to exposure to harmful chemicals and environmental pollution that seeps into soil and water (Nayanov & Khamidullina, 2020). Other environmental impacts are biodiversity loss and permanent ecological change. For illustration, research in Brazil noted that oil and gas extraction in the offshore area of the Santos Basin caused significant damage to marine habitats, most of which are permanent and difficult to restore despite remediation measures being implemented (Mein et al., 2021). Key findings show that oil and gas activities contribute to environmental pollution, increased chronic diseases, and ecosystem degradation, which demands technology-based management policies and sustainability approaches to mitigate their impacts. A combination of strong governance and low-carbon technology is essential to mitigate these risks and protect public health and the environment.

Policy implementation in the oil and gas sector is closely related to the socio-ecological effects felt around its operational areas. In Riau Islands Province, the policy that supports the management of 10% PI through BUMD aims to increase PAD and strengthen regional competitiveness. However, the lack of environmental policy integration can have negative socio-ecological effects, such as the degradation of marine ecosystems due to natural gas exploration, which in turn can harm coastal communities that depend on the fisheries and tourism sectors. This imbalance shows the importance of more targeted policies to mitigate impacts on the environment and involve local communities in the decision-making process (Misni et al., 2023). In Wajo Regency, the policy of establishing oil and gas BUMDs is directed to meet domestic energy needs and improve the economic welfare of the community. However, the socio-ecological effects of oil and gas activities, such as air and water pollution, can

affect public health and environmental quality. Policies that do not fully include environmental impact mitigation and community involvement in governance risk creating social conflicts, such as dissatisfaction with the distribution of economic benefits resulting from oil and gas activities (Andi Tenri Awaru et al., 2020). Globally, studies show that less firm policies in regulating the oil and gas sector often result in negative socio-ecological effects. For illustration, research in the UK revealed that policies that support shale-based oil and gas exploration fail to consider ethical impacts and environmental justice, thereby increasing conflicts among local communities and governments. The study also shows that the lack of community participation in the planning and regulatory process of oil and gas exploration leads to social and environmental injustices (Watterson & Dinan, 2016). The socio-ecological effects of policy implementation are also seen in the case of the United States, where poorly regulated oil and gas activities have an impact on increased health risks, such as respiratory diseases and cancer, as well as deterioration of air and water quality. Policies that do not include comprehensive environmental monitoring have exacerbated the negative impact on communities living close to oil and gas exploration sites (J. J. Buonocore et al., 2023). The relationship among the implementation of oil and gas policies and socio-ecological effects in operational areas shows that policies that are not integrated and lack of community participation tend to exacerbate environmental and health impacts. Therefore, an approach that combines sustainability management, strict supervision and active community participation is essential to minimize negative socio-ecological impacts and assure long-term sustainability.

## **14.2. Recommendations**

### **1. Recommendations for Public Policy Improvement**

The management of the oil and gas sector through BUMD has great potential to increase PAD and support local economic development. However, there are important challenges that need to be overcome to achieve long-term sustainability. In Riau Islands Province, the focus on managing the 10% PI of the Mako Gas Block needs to be equipped with transparent governance that pays attention to environmental impacts, such as pollution of marine ecosystems. Environmental risk mitigation policies must be integrated comprehensively to protect coastal communities and the fisheries sector. Similarly, in Wajo Regency, the establishment of BUMD aims to improve the efficiency of natural gas management and meet local energy needs, but challenges related to the management of regional levies and socio-ecological impacts require special attention. Globally, research shows the importance of adopting low-carbon technologies, such as CCS, and artificial intelligence-based technological innovations to reduce the negative impact of oil and gas exploration on the environment and public health. Policies at the local and national levels need to be

aligned in regulating the management of these energy resources, by ensuring the active participation of the community in planning and decision-making. In addition, strengthening sustainability-based governance through stakeholder involvement and the apply transparency and accountability principles can minimize social conflicts and increase the positive impact of oil and gas activities on the surrounding community. Overall, public policy in the management of oil and gas BUMDs must balance economic, environmental, and social interests through a comprehensive approach that involves investment in environmentally friendly technology, strict regulations, and empowerment of local communities. Thus, the benefits of the oil and gas sector can be felt evenly and support sustainable development goals.

Strategic policies to support the sustainability of oil and gas management by BUMD must focus on balancing economic benefits, environmental protection, and community welfare. In Riau Islands Province, the establishment of a BUMD to manage the 10% PI of the Mako Gas Block provides a significant opportunity to increase PAD and regional competitiveness. However, these policies need to be balanced with strengthening sustainability-oriented governance, comprising mitigating environmental impacts through measures such as the implementation of low-carbon technologies and strict management of exploration waste. In addition, oil and gas management in Wajo Regency also shows the need to integrate digital technology to improve management efficiency and assure transparency in governance. Globally, the adoption of innovative technologies such as CCS and artificial intelligence-based management has been proven to improve operational efficiency as well as reduce negative impacts on the environment. Strategic policies must also include regulatory alignment across government levels to assure that oil and gas resource management is in line with sustainability goals. In addition, strengthening community involvement in the decision-making process through CSR programs and community-based sustainability initiatives can strengthen public acceptance of oil and gas activities. The key to the success of this strategic policy lies in cross-stakeholder collaboration, which includes the government, the private sector, and local communities, to create synergies in energy resource management. With this approach, BUMD is not only able to support local economic development, but also preserve the environment and improve the quality of life of the community. The successful implementation of this strategic policy will strengthen the role of BUMD in achieving sustainable development goals.

Strengthening regulations that prioritize a balance among economic interests and environmental sustainability is a key element in the management of the oil and gas sector by Regionally Owned Enterprises (BUMD). In the Riau Islands Province, regulations supporting the management of the 10% PI of the Mako Gas Block must assure the protection of sensitive marine ecosystems through the implementation of strict environmental standards, comprising pollution risk mitigation and exploration

waste management. This step is important to prevent negative impacts on coastal communities that depend on the fisheries and tourism sectors. Similarly, in Wajo Regency, natural gas management requires regulations that assure environmental sustainability, while optimizing economic potential through transparent and accountable governance. Globally, the literature shows that strict environmental regulations are able to reduce the negative impact of oil and gas activities, such as air and water pollution, which can harm public health. The adoption of low-carbon technologies, such as CCS, as well as artificial intelligence-based monitoring need to be integrated into regulations to improve operational efficiency while reducing greenhouse gas emissions. In addition, effective regulation must include strong oversight mechanisms, cross-government collaboration, and local community participation to assure that oil and gas management not only pursues economic benefits but also preserves the environment. With sustainability-oriented regulations, the oil and gas sector can become a driving force for economic development without sacrificing environmental quality. This balance not only supports long-term economic growth but also assures that natural resources are managed responsibly for future generations.

## 2. Apply Environmentally Friendly Technology

The apply environmentally friendly technology in the management of the oil and gas sector by Regionally Owned Enterprises (BUMD) is a strategic step to achieve sustainability and reduce negative impacts on the environment. In Riau Islands Province, technologies such as innovation-based waste management and artificial intelligence-based monitoring systems can help prevent pollution of sensitive marine ecosystems due to natural gas exploration. Meanwhile, in Wajo Regency, low-carbon technologies, comprising CCS, can be integrated to reduce greenhouse gas emissions from natural gas management activities. Digital technology can also be used to improve operational efficiency and governance transparency. Globally, studies show that the adoption of innovative technologies in the oil and gas sector can provide significant benefits. CCS, for illustration, has proven to be effective in reducing carbon emissions substantially, while artificial intelligence-based technologies enable operational optimization and environmental risk management. The use of this environmentally friendly technology not only supports operational efficiency but also increases public acceptance of oil and gas activities, by demonstrating a commitment to sustainability and social responsibility. The implementation of these technologies requires strong policy support, comprising incentives for investment in green innovation and cross-sectoral regulatory alignment. By prioritizing environmentally friendly technology, BUMD can increase its contribution to regional economic development while maintaining environmental sustainability and the quality of life of the community.

The use of green technology in the oil and gas exploration, production, and distribution process is an important step to support the sustainability of the energy sector. In oil and gas exploration, low-carbon technologies such as CCS can help reduce the greenhouse gas emissions produced, while artificial intelligence-based monitoring systems can assure that the drilling and extraction process does not damage the surrounding ecosystem. On the production side, the adoption of eco-friendly technologies allows for more efficient waste management, minimizing water and soil pollution. For illustration, in the Riau Islands Province, the apply this innovative technology can protect sensitive marine ecosystems from the potential impact of natural gas exploration in the Mako Gas Block. Meanwhile, in Wajo Regency, green technology can be applied in natural gas distribution to support local energy needs in a sustainable manner without sacrificing air quality and the surrounding environment. Globally, experience in developed countries shows that green technologies such as CCS and waste treatment based on modern technology are able to balance the economic benefits of oil and gas activities with environmental protection. This technology not only reduces carbon emissions but also improves operational efficiency, making the production process more environmentally friendly and cost-effective. In addition, the integration of renewable energy in oil and gas distribution, such as the use of wind or solar resources to support the operation of oil and gas facilities, can further strengthen the commitment to sustainability. The use of green technology in oil and gas exploration, production, and distribution requires policy support and incentives to encourage investment in this field. With the consistent apply green technology, the oil and gas sector can not only become an economic driving force but also a model in maintaining a balance among the exploitation of natural resources and environmental sustainability.

The apply environmentally friendly technology in the oil and gas sector has shown significant results in reducing environmental impacts while improving operational efficiency. One of the relevant case studies is the adoption of CCS technology in the Irkutsk region, Russia. This technology has succeeded in significantly reducing carbon emissions from oil and gas exploration and production activities, while protecting the surrounding ecosystem from sustainable pollution. Another illustration comes from the United States, where large oil and gas companies such as ExxonMobil and BP have used artificial intelligence-based innovations to monitor and reduce carbon footprints during the production and distribution process. This technology not only improves efficiency but also minimizes the risk of soil and water pollution. In Indonesia, the apply environmentally friendly technology still has the potential to be further developed, such as in the Riau Islands Province and Wajo Regency. For illustration, in natural gas management in the Mako Gas Block, the implementation of modern technologies for waste treatment and emission monitoring can protect marine ecosystems from damage caused by exploration

activities. In Wajo Regency, the integration of digital-based technology can be used to assure more transparent natural gas management and minimal environmental impact. This international experience and local potential confirms that the adoption of environmentally friendly technologies is the key to sustainability in the oil and gas sector. By integrating green technology, this sector can increase competitiveness while preserving the environment, supporting community welfare, and meeting sustainable development targets.

### 3. Public Health Management in Oil and Gas Areas

Public health management in oil and gas areas is an important aspect that must be considered to minimize the negative impact of exploration and production activities on the welfare of local communities. Oil and gas activities are often associated with the risk of air, water, and soil pollution that can trigger health problems, such as respiratory diseases, cancer, and psychological disorders. In Wajo Regency, for illustration, potential health risks due to air pollution and chemical waste from natural gas management need to be mitigated through strict environmental policies and consistent operational supervision. Similarly, in Riau Islands Province, exploration in the Mako Gas Block requires preventive measures to prevent pollution that can affect the health of coastal communities that depend on marine resources. Globally, research shows that regions with intensive oil and gas activities, such as Oklahoma in the United States and Irkutsk in Russia, have higher incidence rates of chronic diseases and health problems than other regions. Gas emissions such as nitrogen dioxide (NO<sub>2</sub>) and fine particles (PM<sub>2.5</sub>) are the main causes of air quality damage that has a direct impact on public health. In addition, the uncertainty and environmental risks of oil and gas activities often trigger chronic stress in communities living around operational areas. To manage these impacts, an integrated approach is needed that involves the implementation of low-emission technologies, strict pollution control policies, and increased access to health services for the surrounding community. In addition, active community involvement in the decision-making process and the provide transparent information on health risks can reduce the potential for social conflict and increase trust in the management of the oil and gas sector. With these measures, public health management in oil and gas areas can go hand in hand with the sustainable development of the energy sector.

Health impact mitigation programs due to oil and gas activities need to be designed to reduce risks posed by air, water, and soil pollution, as well as exposure to hazardous chemicals in oil and gas operational areas. In Riau Islands Province, the exploration of the Mako Gas Block presents an urgent need to implement mitigation measures, such as toxic waste management and regular air quality monitoring to prevent health disruptions to coastal communities. Similarly, in Wajo Regency, mitigation endeavors can include controlling emissions from the natural gas

production process and providing special health services for communities affected by oil and gas activities. Internationally, successful mitigation programs typically involve low-emission technologies, such as the use of artificial intelligence-based air monitoring systems to detect and control harmful emissions, as well as the apply CCS technology to reduce the impact of air pollution. For Illustration, a study in the United States showed that controlling nitrogen dioxide (NO<sub>2</sub>) and fine PM<sub>2.5</sub>) emissions can significantly reduce the risk of respiratory diseases in communities around oil and gas sites. In addition, the provide transparent information about health risks and increased access to medical services for the surrounding community are important components to reduce psychosocial stress due to environmental risk uncertainty. Mitigation programs should also involve local communities through consultation and involvement in decision-making, so that they can understand and support the protection measures taken. By integrating advanced technology, strict risk control policies, and cross-stakeholder collaboration, health impact mitigation programs can assure that communities around oil and gas regions are protected and benefit from the sector's existence without compromising their health.

Collaboration with local governments and health institutions is a strategic step to improve the welfare of the community around the oil and gas operational area. Local governments have an important role in aligning oil and gas management policies with the needs of local communities, comprising ensuring that the allocation of revenue from the oil and gas sector is used to improve public services such as health facilities, education, and infrastructure. In Riau Islands Province, for Illustration, the management of a 10% PI from the Mako Gas Block can be encouraged to create a comprehensive public health program, such as the procurement of mobile clinics and free health services for coastal communities affected by oil and gas activities. In Wajo Regency, the local government can work with health institutions to provide access to medical care for people affected by air and water pollution from natural gas exploration. This collaboration also requires the active involvement of health institutions to conduct regular health impact monitoring, provide epidemiological data, and develop effective mitigation strategies. Global experience shows that partnerships among the oil and gas sector, local governments, and health institutions can reduce public health risks. For Illustration, public health programs in the oil and gas exploration region of Russia involve regular health checks for local communities, while in the United States, similar cooperation has succeeded in reducing the impact of respiratory diseases through continuous air quality monitoring. To strengthen the positive impact of this collaboration, transparency is needed in fund management and program planning, as well as consultation with local communities so that the policies taken are by the needs of the community. With close collaboration among local governments, health institutions, and the oil and gas sector, community welfare

can be significantly improved, while creating a harmonious relationship among local communities and the oil and gas industry.

#### 4. Strengthening Governance and Transparency

Strengthening governance and transparency is an essential step to assure that the management of the oil and gas sector by Regionally Owned Enterprises (BUMD) provides maximum benefits to the community while maintaining environmental sustainability. In Riau Islands Province, the management of a 10% PI in the Mako Gas Block highlights the importance of transparent governance to maximize PAD and prevent potential conflicts of interest in resource management. Similarly, in Wajo Regency, the planning for the establishment of a BUMD to manage natural gas must be accompanied by an accountable monitoring system to avoid revenue leakage and assure a fair distribution of profits for the local community. On a global scale, good governance practices include the apply Good Corporate Governance (GCG) principles, which involve transparency, accountability, and community participation in decision-making. The use of digital technology such as integrated information systems can improve operational efficiency and provide clear access to information to stakeholders. For illustration, in the international oil and gas sector, the adoption of blockchain technology has been used to record transactions and workflows transparently, thereby minimizing the chances of corruption and increasing public trust. Strengthening governance also requires a strict regulatory framework and cross-level oversight to assure alignment among local and national policies. In addition, community involvement through public consultation programs and the submission of open annual reports will help build trust and support the success of BUMD programs. With strong and transparent governance, the oil and gas sector can optimally contribute to regional economic development while minimizing negative impacts on the environment and society.

#### **14.3. Implications and Steps Foreward**

How the management of BUMD in the oil and gas sector plays a strategic role in supporting regional economic development and environmental sustainability. In Riau Islands Province, the management of a 10% PI in the Mako Gas Block provides a great opportunity to increase PAD and regional competitiveness. However, this success is faced with the challenge of integrating environmental policies and public health protection, such as marine pollution mitigation. In Wajo Regency, the plan to establish a BUMD aims to improve the efficiency of natural gas and PAD management. However, the issue of professionalism in the management of regional levies and the lack of technological capacity are the main obstacles. In the global context, the oil and gas sector are often faced with a conflict among economic growth and its impact on the environment and local communities. Management based on



low-carbon technologies, such as CCS and artificial intelligence-based systems, has proven to be effective in reducing carbon emissions and improving operational efficiency. Transparent governance and involving the community in decision-making, comprising the apply GCG principles, is key in creating sustainability and reducing social conflicts. In addition, the adoption of environmentally friendly technologies provides an opportunity to minimize the negative impact of oil and gas exploration on the environment. The success of oil and gas BUMDs is also influenced by multi-stakeholder involvement, comprising collaboration with the government, local communities, and health institutions. Strategic steps for the future include policy alignment across government levels, strengthening technological capacity, and empowering local communities. With this approach, the management of the oil and gas sector can meet the needs of economic development without sacrificing environmental sustainability and community welfare.

The implementation of the recommendations proposed in Chapter 14 provides significant long-term benefits to the local economy, the environment, and public health. From an economic perspective, the management of the oil and gas sector through BUMD with transparent and technology-based governance can increase PAD in a sustainable manner. For illustration, the management of a 10% PI in the Mako Gas Block in Riau Islands Province has great potential to strengthen regional competitiveness and support economic diversification, especially in the maritime sector. In Wajo Regency, optimizing natural gas management can not only meet domestic energy needs but also create jobs, which contributes to the economic welfare of the local community. Environmentally speaking, the adoption of environmentally friendly technologies such as CCS and artificial intelligence-based monitoring can reduce carbon emissions and the impact of pollution due to oil and gas activities. These mitigation measures help protect sensitive ecosystems, such as marine habitats in the Riau Islands and water resources in Wajo Regency, thereby maintaining an ecological balance that supports the fisheries and tourism sectors. The implementation of strict environmental policies can also minimize the risk of air, soil, and water pollution, which is often a major challenge in oil and gas exploration. From the perspective of public health, the implementation of this recommendation will reduce the risk of health problems due to pollution, such as respiratory diseases and psychological disorders that are often experienced by communities around oil and gas sites. Better toxic waste management and regular air quality monitoring can improve people's quality of life, especially in areas such as Wajo and the Riau Islands. In addition, community involvement in the decision-making process and the provide adequate health services will create trust and harmony among the local community and the industrial sector. The implementation of these recommendations offers a holistic approach to create synergies among economic growth, environmental

conservation, and public health protection, which supports long-term sustainability for regions involved in the oil and gas sector.

To implement the recommendations proposed in Chapter 14, stakeholders need to develop a strategic action plan that includes concrete and integrated steps. Local governments must prioritize strengthening the governance of oil and gas BUMDs through the apply GCG principles, such as transparency, accountability, and public participation. This step can be done by building a digital technology-based surveillance system, comprising the use of blockchain to record workflows and transactions transparently. On the regulatory side, it is necessary to align policies across government levels so that the management of the oil and gas sector supports sustainability goals, such as mitigating environmental impacts and reducing carbon emissions through strict regulations that regulate the use of low-carbon technologies, such as CCS. At the operational level, oil and gas BUMDs need to invest in environmentally friendly technologies that improve operational efficiency and minimize negative impacts on the environment, such as the implementation of artificial intelligence-based monitoring systems to detect potential pollution risks. Empowering local communities is also an important step. Through the CSR program, BUMD can allocate funds for the development of health services, education, and job skills training for communities around oil and gas operational areas. This effort not only improves the welfare of the community but also creates a harmonious relationship among the local community and the industrial sector. Cross-stakeholder collaboration, comprising government, the private sector, and local communities, must be strengthened to assure the effective implementation of this action plan. The government can play a role in providing fiscal incentives for companies investing in green technologies and clean energy. In addition, health institutions and civil society organizations can be involved to monitor the impact of oil and gas activities on health and the environment on a regular basis. With an integrated and collaborative approach, the proposed recommendations can be implemented effectively, supporting regional economic development, preserving the environment, and improving community welfare in a sustainable manner.

## Reference

- Andi Tenri Awaru, Herie Saksono, Imam Radianto Anwar, A. Elvira Fajarwati. P., Muh. Tahir Tajang, Daswinarta, Andi Sahlan, H. Suriadi, Dewi Noviany Kahar, & Abdul Malik. (2020). Studi Kelayakan Bidang Usaha Pembentukan Badan Usaha Milik Daerah (PI 10 %, Pertanian Terpadu, Parkir, dan Pasar). In *Badan Perencanaan Pembangunan, Penelitian Dan Pengembangan Kabupaten Wajo*.
- Apergis, N., Mustafa, G., & Dastidar, S. G. (2021). An analysis of the impact of unconventional oil and gas activities on public health: New evidence across Oklahoma counties. *Energy Economics*, 97. <https://doi.org/10.1016/j.eneco.2021.105223>
- Buonocore, J. J., Reka, S., Yang, D., Chang, C., Roy, A., Thompson, T., Lyon, D., McVay, R., Michanowicz, D., & Arunachalam, S. (2023). Air pollution and health impacts of oil & gas production in the United States. *Environmental Research: Health*, 1(2). <https://doi.org/10.1088/2752-5309/acc886>
- Buonocore, J., Reka, S., Yang, D., Chang, C., Roy, A., Thompson, T., Lyon, D., McVay, R., Michanowicz, D., & Arunachalam, S. (2021). *Air Quality and Health Benefits of Methane Policies in the United States Oil & Gas Sector*. <https://doi.org/10.21203/rs.3.rs-199686/v1>
- Chusaini, H. A., Buchori, I., & Setyono, J. S. (2023). Blindness and illumination of state spatial strategies in producing extended urban space: a case from Cepu oil and gas mining area, Indonesia. *International Planning Studies*, 28(3–4). <https://doi.org/10.1080/13563475.2023.2206541>
- Chutcheva, Y. V., Kuprianova, L. M., Seregina, A. A., & Kukushkin, S. N. (2022). Environmental management of companies in the oil and gas markets based on AI for sustainable development: An international review. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.952102>
- Dmitrieva, D. M., & Skobelev, D. O. (2023). DECARBONIZATION OF THE OIL AND GAS SECTOR IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT: KEY DIRECTIONS AND POSSIBLE SCENARIOS FOR THE ARCTIC REGION. *Sever i Rynok: Formirovanie Ekonomiceskogo Poradka*, 26(2). <https://doi.org/10.37614/2220-802X.2.2023.80.001>
- Doni, F., Corvino, A., & Bianchi Martini, S. (2022). Corporate governance model, stakeholder engagement and social issues evidence from European oil and gas industry. *Social Responsibility Journal*, 18(3). <https://doi.org/10.1108/SRJ-08-2020-0336>

- Heim, I., Vigneau, A. C., & Kalyuzhnova, Y. (2023). Environmental and socio-economic policies in oil and gas regions: triple bottom line approach. *Regional Studies*, 57(1). <https://doi.org/10.1080/00343404.2022.2056589>
- Jumbo, J. A., Ordinioha, B., Mmom, P., Okokon, E., Teere, M. B., & Tamunomiegbam, A. (2023). Environmental and Health Impacts of Crude Oil Exploration in the Niger Delta. *Journal of Environment*, 3(2). <https://doi.org/10.47941/je.1424>
- Kislyakova, Yu. G., & Usatova, I. Y. (2022). ENVIRONMENTAL IMPACT ASSESSMENT IN THE OIL AND GAS SECTOR. *Social'no-Ekonomiceskoe Upravlenie: Teoria i Praktika*, 18(1). <https://doi.org/10.22213/2618-9763-2022-1-36-41>
- Malin, S. A. (2020). Depressed democracy, environmental injustice: Exploring the negative mental health implications of unconventional oil and gas production in the United States. *Energy Research and Social Science*, 70. <https://doi.org/10.1016/j.erss.2020.101720>
- Mein, T. F., Gimenes, A. L. V., Dias, E. M., Rebello Pinho Dias Scoton, M. L., & Udaeta, M. E. M. (2021). Environmental vulnerability in pre-salt oil and gas operations. *Energies*, 14(3). <https://doi.org/10.3390/en14030732>
- Misni, Raymond Rayendra Elven, Sekar Nur Wulandari, Tedy Kardana, Andi Gustomo, Maskur Perkasa, Rina Komala Dewi, Risa Adelina Br Tarigan, Aliffisya Ummu Raihan, Gunarto, Ibnu Hibano, Fajar Hanung Basworo, Haris Muzakky, Budi Santoso, Junjung Sahala Tua Manik, Radja Sugiati, Sheptya Yusnita Putri, & Dahliana. (2023). Studi Kelayakan Pendirian BUMD Energi Provinsi Kepulauan Riau. In *Badan Perencanaan, Penelitian, dan Pengembangan Provinsi Kepulauan Riau*.
- Nayanov, P. A., & Khamidullina, E. A. (2020). Statistical risk management analysis for hazardous oil and gas production facilities. *XXI Century. Technosphere Safety*, 5(4), 393–402. <https://doi.org/10.21285/2500-1582-2020-4-393-402>
- Patimah, A. S., Murti, S. H., & Prasetya, A. (2023). Study of Socio-Economic-Cultural Impacts and Community Health Due to Oil and Natural Gas Exploration Activities in the Tuban Oil and Gas Field. *Indonesian Journal of Geography*, 55(1). <https://doi.org/10.22146/ijg.70639>
- Qurbani, I., Sumarno, T., & Cassy, R. (2020). Regional Economic Development Strategy: Increasing Local Generated Domestic Revenue of the Regional-Owned Enterprises in the Oil and Gas Sector. *Brawijaya Law Journal*, 7(1), 70–81. <https://doi.org/10.21776/ub.blj.2020.007.01.05>
- Rustini, N. K. A. (2022). The Implementation of Good Corporate Governance in BUMD Institutions. *Journal of Economics, Finance And Management Studies*, 05(02). <https://doi.org/10.47191/jefms/v5-i2-22>

- Sheydai, T., Nykyforuk, O., Berezhnytska, U., Melnychuk, I., & Mandryk, I. (2021). Environmental management in small and medium-sized enterprises of oil and gas industry. *IOP Conference Series: Earth and Environmental Science*, 628(1). <https://doi.org/10.1088/1755-1315/628/1/012021>
- Tang, H., Rasool, Z., Sindhu, M. I., Naveed, M., & Babar, S. F. (2023). Implications of corporate innovation investment on environment sustainability with moderating role of managerial stock incentives: A case of the oil and gas sector of the United States of America. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.962258>
- Watterson, A., & Dinan, W. (2016). Health impact assessments, regulation, and the unconventional gas industry in the UK: Exploiting resources, ideology, and expertise? *New Solutions*, 25(4). <https://doi.org/10.1177/1048291115615074>
- Watterson, A., & Dinan, W. (2020). Lagging and flagging: Air pollution, shale gas exploration and the interaction of policy, science, ethics and environmental justice in England. In *International Journal of Environmental Research and Public Health* (Vol. 17, Issue 12). <https://doi.org/10.3390/ijerph17124320>



# Index

## A

accountability.....xv, 10, 376, 377, 385, 388, 389, 390, 391, 392, 393, 395, 396, 397, 402, 403, 412, 388, 373, 390, 391, 393, 394, 381, 384, 382, 395, 381, 385, 375, 383, 343, 351, 357, 359  
air quality .400, 373, 387, 394, 378, 382, 385, 383, 386, 403, 344, 347, 354, 355, 356, 359  
artificial intelligence380, 374, 388, 392, 391, 375, 378, 388, 397, 380, 381, 342, 345, 351, 352, 353, 354, 356, 358, 359

## B

BUMD iii, v, vii, viii, ix, xix, xxvi, 1, 2, 4, 7, 8, 11, 12, 16, 388, 389, 391, 395, 403, 373, 383, 384, 385, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 377, 378, 373, 374, 375, 387, 394, 399, 391, 392, 394, 378, 379, 384, 391, 392, 393, 394, 395, 373, 378, 379, 381, 384, 385, 386, 387, 389, 393, 377, 381, 373, 385, 397, 382, 383, 385, 386, 341, 342, 343, 345, 346, 349, 350, 351, 352, 353, 357, 358, 359, 362

## C

carbon.. iii, 374, 378, 386, 397, 399, 400, 383, 382, 383, 387, 388, 389, 392, 393, 394, 395, 392, 373, 374, 376, 379, 380, 382, 384, 385, 386, 387, 389, 390, 391, 393, 394, 395, 405, 374, 375, 381, 382, 386, 387, 389, 398, 400, 394, 389, 394, 373, 376, 377, 380, 382, 383, 385, 393, 394, 395, 396, 397, 400, 405, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 385, 390, 392, 393, 395, 396, 397, 402, 408, 377, 379, 380, 383, 385, 395, 397, 398, 341, 343, 345, 349, 351, 352, 353, 354, 358, 359

collaborative ...xv, 8, 9, 10, 13, 385, 380, 392, 373, 378, 380, 393, 394, 395, 401, 386, 392, 393, 378, 381, 379, 382, 383, 384, 399, 390, 391, 385, 386, 390, 395, 378, 382, 386, 389, 390, 392, 393, 395, 396, 403, 342, 360  
commitment ... xix, 8, 10, 373, 388, 390, 393, 401, 376, 388, 389, 391, 374, 376, 377, 386, 387, 392, 396, 374, 378, 380, 383, 385, 387, 377, 373, 388, 383, 380, 386, 393, 394, 396, 397, 341, 353, 354  
communities .....iv, viii, xx, 1, 5, 7, 8, 9, 10, 11, 13, 379, 387, 388, 390, 391, 392, 393, 394, 395, 396, 397, 398, 401, 402, 403, 407, 381, 385, 387, 391, 392, 394, 399, 401, 373, 380, 381, 382, 383, 384, 373, 374, 375, 377, 378, 379, 381, 382, 384, 385, 386, 390, 391, 392, 393, 394, 375, 381, 383, 387, 390, 391, 392, 393, 394, 395, 374, 394, 374, 379, 380, 381, 382, 383, 384, 388, 389, 390, 391, 393, 394, 395, 396, 402, 378, 381, 387, 388, 389, 390, 395, 396, 373, 375, 381, 382, 387, 381, 382, 383, 384, 389, 390, 391, 392, 397, 382, 383, 384, 385, 386, 391, 393, 394, 397, 398, 401, 404, 374, 377, 378, 382, 385, 386, 397, 403, 408, 342, 343, 345, 346, 347, 348, 349, 351, 352, 355, 356, 358, 359  
competitiveness..... 375, 378, 380, 381, 382, 386, 388, 390, 396, 383, 387, 392, 399, 381, 388, 382, 388, 389, 373, 382, 383, 384, 385, 386, 393, 378, 388, 379, 384, 385, 403, 344, 346, 349, 351, 354, 358  
cost-effective ..... 381, 383, 388, 392, 391, 354  
CSRiii, xxvi, 8, 9, 374, 378, 387, 388, 401, 392, 380, 381, 382, 383, 386, 380, 395, 387, 400, 373, 378, 379, 386, 397, 391, 393, 378, 395, 396, 381, 391, 392, 405, 375, 384, 385, 404, 343, 352, 359

## D

diseases.....399, 403, 410, 389, 373, 374, 386, 387, 388, 389, 390, 391, 394, 373, 382, 384, 385, 386, 374, 381, 383, 386, 382, 344, 347, 348, 349, 350, 355, 356, 359  
domesticx, 384, 386, 387, 374, 376, 385, 402, 379, 342, 343, 346, 347, 350, 358

## E

education ..... xv, xvi, xviii, 375, 392, 401, 375, 376, 378, 380, 386, 393, 380, 382, 385, 390, 386, 387, 393, 395, 396, 383, 388, 389, 391, 392, 382, 386, 376, 380, 382, 384, 396, 382, 386, 387, 388, 389, 397, 346, 356, 359  
emissions..... 5, 374, 377, 378, 380, 384, 385, 387, 388, 397, 399, 400, 382, 383, 386, 387, 388, 389, 390, 393, 395, 392, 373, 375, 376, 378, 379, 380, 381, 382, 383, 384, 385, 386, 391, 394, 395, 396, 373, 376, 381, 387, 388, 389, 390, 391, 392, 393, 394, 373, 396, 377, 378, 379, 381, 388, 389, 394, 373, 374, 375, 376, 379, 381, 383, 384, 386, 387, 389, 390, 392, 377, 379, 381, 382, 383, 384, 385, 387, 393, 394, 395, 402, 405, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 385, 392, 393, 396, 398, 407, 377, 379, 380, 385, 389, 395, 397, 343, 344, 345, 347, 348, 349, 352, 353, 354, 355, 358, 359  
empowering .....381, 392, 383, 384, 389, 383, 358  
energy..xx, 1, 5, 6, 7, 373, 375, 376, 378, 381, 383, 385, 386, 390, 391, 392, 393, 395, 396, 397, 399, 400, 402, 406, 407, 409, 410, 411, 413, 378, 380, 383, 384, 385, 389, 391, 392, 394, 395, 396, 400, 401, 373, 374, 380, 382, 383, 384, 385, 387, 388, 389, 390, 392, 393, 394, 395, 399, 400, 401, 378, 379, 381, 383, 384, 388, 392, 398, 399, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 396, 401, 373, 375, 376, 386, 387, 389, 390, 391, 392, 394, 397, 377, 378, 384, 390, 400, 378, 379, 382, 386, 388, 389, 391, 381, 384, 385, 387, 392, 396, 373, 374, 375, 376, 377, 378, 379, 380, 384, 385, 393, 394, 395, 396, 397, 398, 399, 401, 403, 404, 373, 374, 375, 377, 378, 379, 380, 381, 382, 383, 384, 385, 388, 390, 392, 393, 395, 396, 397, 398, 401, 402, 407, 373, 374, 377, 378, 379, 380, 384, 385, 388, 390, 392, 394, 395, 397, 398, 401, 404, 407, 341, 342, 343, 345, 346, 347, 350, 351, 352, 353, 355, 358, 360

## F

fiscal.....3, 405, 391, 399, 400, 373, 374, 385, 397, 403, 393, 379, 360  
framework. viii, 376, 384, 412, 384, 391, 392, 399, 373, 384, 385, 386, 395, 396, 400, 376, 380, 382, 392, 394, 375, 377, 379, 380, 384, 392, 393, 395, 400, 382, 384, 391, 394, 397, 375, 380, 384, 387, 402, 373, 381, 383, 385, 374, 385, 387, 391, 395, 396, 400, 373, 382, 394, 396, 397, 400, 406, 357  
friendly.....iv, 1, 3, 4, 11, 12, 13, 374, 380, 381, 383, 384, 398, 403, 388, 400, 401, 373, 380, 382, 383, 385, 387, 388, 389, 390, 391, 394, 395, 374, 379, 380, 381, 392, 393, 394, 376, 377, 378, 381, 385, 386, 387, 389, 392, 393, 394, 378, 387, 389, 373, 377, 382, 385, 387, 389, 378, 384, 394, 395, 374, 376, 378, 379, 380, 382, 383, 384, 388, 398, 375, 384, 388, 389, 390, 392, 397, 343, 344, 345, 347, 351, 353, 354, 358, 359

## G

governance.....x, 10, 381, 402, 408, 385, 373, 374, 376, 380, 383, 385, 390, 391, 392, 393, 395, 396, 397, 398, 399, 401, 382, 403, 390, 391, 397, 382, 394, 395, 396, 377, 382, 386, 387, 396, 403, 341, 342, 343, 344, 345, 346, 347, 349, 350, 351, 352, 353, 357, 358, 359, 361  
green technologies. 381, 388, 394, 387, 389, 394, 390, 382, 397, 375, 381, 374, 380, 391, 392, 342, 354, 360

## H

healthiii, iv, v, vi, vii, viii, ix, xv, xx, xxi, xxviii, 1, 2, 3, 4, 7, 8, 9, 11, 12, 373, 377, 379, 382, 383, 387, 388, 398, 399, 401, 402, 403, 406, 407, 411, 376, 378, 393, 383, 387, 388, 377, 380, 386, 389, 392, 393, 396, 398, 401, 373, 381, 385, 389, 377, 373, 374, 380, 383, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 373, 374, 376, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 394, 395, 397, 398, 399, 402, 373, 374, 378, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 392, 393, 394, 396, 373, 378, 381, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 397, 398, 399, 401, 404, 405, 406, 387, 395, 373, 375, 376, 377, 378, 381, 382, 385, 386, 387, 389, 390, 392, 393, 395, 396, 397, 398, 399, 400, 403, 405, 407, 408, 341, 342, 343, 344, 345, 346, 347, 348, 350, 351, 352, 355, 356, 358, 359, 360, 361

health institutions ..... 356, 358, 360  
 health services. 400, 401, 376, 378, 393, 391, 392,  
 393, 394, 395, 389, 355, 356, 359  
 holistic..... 386, 381, 390, 396, 393, 395, 396, 377,  
 383, 390, 393, 396, 373, 376, 381, 382, 384,  
 385, 395, 385, 392, 388, 373, 378, 381, 391,  
 398, 359

## I

incentives ..... 3, 397, 374, 396, 391, 385, 379, 380,  
 384, 385, 390, 396, 397, 405, 379, 393, 396,  
 379, 380, 381, 390, 392, 341, 353, 354, 360, 362  
 industrial ..... vi, 386, 397, 400, 401, 377, 378, 379,  
 382, 386, 400, 386, 390, 392, 381, 389, 392,  
 401, 402, 404, 373, 374, 375, 376, 377, 385,  
 386, 387, 388, 389, 390, 391, 392, 393, 394,  
 396, 397, 400, 375, 387, 388, 389, 390, 391,  
 379, 380, 385, 386, 376, 390, 394, 405, 377,  
 378, 379, 381, 382, 395, 375, 396, 398, 401,  
 359, 360  
 innovation .....viii, xiv, xv, xvi, xviii, 1, 11, 374, 375,  
 381, 408, 411, 413, 381, 392, 400, 380, 387,  
 392, 396, 388, 404, 373, 378, 379, 380, 382,  
 383, 384, 385, 386, 390, 392, 393, 395, 396,  
 397, 398, 399, 400, 373, 378, 379, 380, 384,  
 397, 398, 402, 405, 375, 377, 378, 379, 381,  
 388, 396, 373, 375, 381, 384, 387, 388, 389,  
 390, 392, 393, 394, 395, 397, 398, 400, 402,  
 405, 341, 353, 362  
 integrated...xvi, 387, 384, 393, 394, 395, 396, 397,  
 399, 373, 381, 383, 398, 388, 401, 378, 379,  
 383, 389, 391, 395, 403, 375, 379, 385, 390,  
 392, 394, 402, 374, 375, 378, 379, 381, 390,  
 391, 396, 377, 381, 383, 389, 395, 397, 383,  
 387, 388, 392, 396, 374, 376, 378, 381, 388,  
 392, 393, 397, 408, 389, 396, 342, 343, 344,  
 347, 350, 351, 352, 353, 355, 357, 359  
 investment .. iii, vi, viii, xix, xxvii, 5, 8, 12, 388, 390,  
 391, 403, 373, 375, 378, 379, 383, 387, 388,  
 389, 391, 392, 394, 399, 400, 401, 373, 390,  
 391, 393, 388, 375, 396, 388, 389, 378, 389,  
 390, 396, 373, 375, 376, 377, 378, 379, 380,  
 383, 384, 385, 390, 394, 395, 396, 397, 399,  
 400, 405, 407, 382, 383, 386, 393, 395, 402,  
 373, 376, 380, 384, 401, 341, 345, 347, 351,  
 353, 354, 362

## J

justice..... 2, 377, 385, 374, 379, 383, 384, 389, 391,  
 393, 394, 395, 396, 398, 399, 402, 391, 392,  
 406, 401, 350, 362

## L

local governments xvi, xix, 2, 4, 8, 9, 10, 388, 389,  
 392, 394, 395, 397, 401, 378, 381, 382, 383,  
 384, 385, 386, 387, 388, 391, 392, 393, 397,  
 398, 399, 401, 381, 383, 394, 395, 396, 379,  
 381, 384, 387, 394, 381, 379, 384, 393, 395,  
 389, 390, 396, 390, 382, 376, 386, 346, 356

## M

management...iii, v, vi, vii, viii, ix, x, xiii, xiv, xv, xvi,  
 xvii, xix, xxviii, 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13,  
 14, 15, 373, 374, 376, 377, 379, 380, 381, 383,  
 384, 386, 387, 388, 389, 390, 391, 393, 394,  
 395, 396, 397, 399, 401, 402, 404, 406, 408,  
 411, 412, 413, 373, 374, 378, 382, 383, 384,  
 385, 387, 388, 389, 390, 391, 392, 394, 395,  
 396, 397, 398, 399, 400, 401, 373, 374, 376,  
 377, 378, 379, 380, 381, 382, 383, 384, 385,  
 386, 387, 388, 389, 391, 392, 393, 394, 395,  
 396, 397, 398, 399, 401, 373, 374, 375, 376,  
 377, 378, 379, 384, 385, 386, 387, 388, 389,  
 390, 391, 392, 393, 394, 395, 396, 397, 373,  
 374, 375, 376, 377, 378, 379, 380, 381, 382,  
 383, 384, 385, 387, 388, 389, 390, 391, 392,  
 393, 396, 398, 399, 401, 402, 373, 375, 380,  
 381, 382, 386, 389, 391, 394, 395, 396, 399,  
 373, 376, 377, 379, 382, 384, 385, 386, 389,  
 391, 392, 394, 396, 400, 373, 374, 375, 376,  
 377, 378, 379, 380, 381, 382, 383, 387, 388,  
 389, 390, 391, 392, 393, 394, 395, 396, 397,  
 398, 399, 400, 401, 402, 373, 374, 375, 376,  
 377, 379, 381, 382, 383, 384, 385, 386, 387,  
 388, 389, 390, 391, 392, 393, 394, 396, 397,  
 373, 374, 376, 377, 378, 379, 380, 381, 383,  
 385, 386, 387, 388, 389, 392, 393, 394, 396,  
 397, 398, 403, 405, 374, 375, 376, 377, 378,  
 380, 381, 382, 383, 386, 387, 389, 390, 391,  
 393, 394, 395, 396, 397, 398, 399, 405, 406,  
 408, 373, 376, 377, 378, 379, 380, 381, 383,  
 386, 387, 388, 389, 390, 393, 394, 395, 396,  
 397, 398, 400, 401, 403, 405, 342, 343, 344,  
 346, 348, 349, 350, 351, 352, 353, 354, 355,  
 356, 357, 358, 359, 361, 362  
 mitigation . iii, viii, xiv, 12, 379, 381, 398, 399, 400,  
 402, 403, 411, 386, 387, 390, 393, 374, 375,  
 377, 379, 387, 389, 390, 392, 393, 394, 395,  
 399, 400, 401, 402, 374, 376, 386, 389, 392,  
 393, 394, 373, 375, 380, 381, 387, 389, 394,  
 373, 375, 378, 379, 380, 381, 387, 388, 389,  
 390, 394, 378, 382, 387, 392, 403, 405, 374,  
 379, 383, 390, 407, 374, 376, 377, 382, 386,



389, 393, 398, 403, 342, 346, 347, 348, 349,  
350, 351, 352, 355, 356, 358, 359

## **N**

natural.....iii, v, vi, vii, viii, xxviii, 1, 4, 5, 6, 8, 10, 12,  
13, 381, 383, 384, 389, 390, 391, 396, 397, 402,  
406, 409, 373, 383, 384, 386, 387, 389, 391,  
401, 373, 374, 375, 377, 380, 381, 382, 384,  
385, 386, 387, 390, 394, 395, 396, 398, 399,  
377, 378, 384, 385, 386, 387, 388, 394, 375,  
376, 390, 391, 392, 393, 394, 395, 402, 374,  
375, 377, 384, 397, 391, 396, 373, 374, 375,  
403, 380, 384, 387, 388, 390, 391, 392, 394,  
399, 405, 377, 383, 408, 342, 343, 345, 347,  
348, 349, 351, 352, 353, 354, 355, 356, 357, 358  
nitrogen dioxide.....344, 347, 348, 349, 355, 356

## **O**

oil and gas. iii, v, vi, vii, ix, xix, xx, xxiii, xxix, 1, 2, 3,  
4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 373, 378, 380,  
381, 382, 384, 385, 386, 387, 388, 389, 390,  
391, 392, 393, 394, 395, 396, 397, 398, 399,  
400, 401, 402, 403, 405, 406, 407, 408, 409,  
411, 412, 373, 383, 384, 385, 387, 388, 389,  
390, 391, 394, 395, 396, 397, 398, 401, 373,  
374, 375, 376, 377, 378, 380, 381, 382, 383,  
386, 387, 388, 389, 390, 391, 392, 393, 394,  
395, 397, 398, 399, 400, 401, 373, 374, 375,  
377, 378, 379, 380, 381, 382, 383, 384, 387,  
390, 394, 395, 396, 398, 373, 374, 376, 391,  
392, 394, 395, 396, 397, 398, 400, 402, 373,  
387, 389, 394, 396, 397, 399, 400, 373, 374,  
375, 384, 386, 387, 388, 389, 390, 391, 392,  
393, 394, 395, 396, 397, 398, 399, 373, 374,  
375, 376, 377, 378, 379, 380, 381, 382, 383,  
384, 385, 386, 387, 388, 389, 391, 393, 394,  
395, 396, 397, 398, 400, 401, 402, 373, 374,  
375, 376, 377, 378, 379, 380, 381, 387, 388,  
389, 390, 392, 393, 394, 395, 396, 373, 374,  
375, 376, 377, 378, 379, 380, 381, 382, 384,  
385, 386, 387, 388, 389, 390, 391, 392, 393,  
394, 395, 396, 397, 398, 399, 400, 401, 402,  
403, 404, 405, 406, 407, 374, 375, 376, 377,  
378, 379, 380, 381, 382, 383, 384, 385, 386,  
387, 388, 389, 390, 391, 392, 395, 396, 397,  
398, 399, 400, 401, 402, 403, 404, 373, 375,  
376, 377, 378, 379, 380, 381, 382, 384, 386,  
388, 389, 390, 392, 393, 394, 395, 397, 398,  
399, 400, 401, 402, 403, 405, 406, 407, 341,  
342, 343, 344, 346, 348, 349, 350, 351, 352,  
353, 354, 355, 356, 357, 358, 359, 360, 361, 362  
organizations.....13, 374, 375, 377, 378, 379, 398,  
383, 375, 379, 382, 392, 393, 375, 377, 379,

381, 390, 393, 394, 380, 381, 384, 393, 382,  
384, 401, 379, 380, 383, 384, 388, 398, 390,  
394, 397, 393, 396, 360

## **P**

PAD.....iii, viii, xxviii, 383, 384, 385, 388, 390, 391,  
393, 394, 395, 397, 399, 401, 402, 373, 374,  
379, 384, 391, 395, 342, 343, 344, 345, 346,  
347, 349, 350, 351, 357, 358  
pollution...xvii, 3, 4, 6, 7, 9, 11, 374, 375, 379, 380,  
381, 382, 383, 397, 399, 406, 407, 412, 385,  
387, 388, 389, 394, 383, 384, 397, 373, 374,  
375, 376, 377, 381, 382, 389, 392, 396, 374,  
387, 389, 390, 373, 374, 375, 380, 382, 387,  
388, 389, 391, 392, 394, 395, 396, 402, 384,  
387, 378, 382, 383, 384, 385, 386, 387, 393,  
376, 381, 382, 383, 384, 387, 391, 393, 394,  
395, 399, 401, 402, 406, 373, 374, 377, 378,  
379, 381, 387, 389, 395, 397, 377, 386, 395,  
343, 344, 345, 347, 349, 350, 352, 353, 354,  
355, 356, 358, 359, 360, 362  
preventive.378, 390, 385, 390, 373, 376, 379, 388,  
386, 355  
psychosocial ..... 392, 348, 356  
public health .iii, v, vi, viii, 3, 4, 9, 11, 12, 373, 398,  
400, 389, 393, 381, 373, 374, 386, 387, 388,  
389, 390, 391, 392, 393, 394, 396, 382, 383,  
384, 391, 374, 378, 382, 389, 398, 344, 345,  
347, 348, 349, 355, 356, 359  
public services..... 392, 395, 396, 394, 346, 356

## **Q**

quality. xx, 5, 10, 11, 382, 386, 390, 398, 399, 401,  
405, 412, 389, 390, 393, 384, 385, 388, 389,  
391, 394, 395, 382, 384, 385, 386, 388, 390,  
397, 403, 375, 376, 377, 373, 378, 381, 382,  
386, 387, 388, 391, 393, 394, 395, 396, 397,  
399, 400, 401, 376, 379, 383, 379, 380, 382,  
384, 385, 386, 389, 393, 398, 378, 381, 384,  
389, 405, 385, 386, 380, 382, 386, 387, 343,  
344, 349, 350, 352, 353, 359

## **R**

regional economic.x, 1, 6, 11, 396, 375, 378, 379,  
386, 392, 393, 394, 396, 399, 401, 373, 374,  
341, 344, 346, 353, 357, 360  
relationship ..4, 373, 375, 412, 383, 377, 381, 387,  
395, 377, 400, 384, 382, 350, 357, 360  
research.....x, xi, xii, xiv, xv, xvi, xvii, xviii, xx, 2, 4, 8,  
10, 378, 385, 386, 387, 388, 390, 391, 400, 412,  
375, 382, 383, 386, 387, 388, 389, 392, 394,  
399, 401, 376, 384, 380, 387, 388, 393, 394,

395, 396, 403, 374, 388, 393, 394, 376, 380,  
389, 398, 401, 398, 374, 377, 380, 386, 390, 375,  
376, 379, 380, 382, 374, 378, 380, 381, 382,  
384, 385, 387, 393, 394, 397, 398, 400, 402,  
373, 375, 379, 382, 385, 386, 387, 389, 391,  
395, 400, 407, 341, 343, 345, 346, 348, 349,  
350, 351, 355

Riau Islands Province .... x, xi, xii, xix, xx, xxiii, 5, 6,  
373, 374, 375, 376, 377, 379, 380, 389, 390,  
393, 401, 374, 392, 384, 391, 377, 381, 388,  
343, 344, 346, 347, 348, 349, 350, 351, 352,  
353, 354, 355, 356, 357, 358

## S

social..... iii, vi, xvi, xvii, xxvi, 4, 7, 8, 9, 10, 14, 375,  
376, 377, 378, 382, 384, 385, 387, 388, 389,  
391, 392, 394, 395, 401, 402, 403, 407, 408,  
412, 378, 384, 390, 393, 401, 380, 381, 382,  
383, 384, 385, 388, 398, 373, 375, 379, 380,  
381, 382, 383, 388, 394, 396, 374, 377, 382, 387,  
388, 389, 391, 392, 396, 403, 373, 378, 379,  
382, 383, 386, 387, 389, 396, 374, 378, 379,  
381, 385, 390, 391, 392, 393, 395, 398, 378,  
381, 383, 386, 387, 390, 395, 396, 400, 378,  
380, 385, 386, 374, 375, 381, 382, 388, 390,  
391, 392, 397, 373, 375, 382, 383, 384, 386,  
387, 388, 394, 395, 397, 398, 406, 375, 377,  
378, 380, 381, 382, 383, 384, 385, 387, 394,  
396, 397, 402, 341, 343, 345, 346, 347, 350,  
351, 353, 355, 358, 361

society .... v, viii, 376, 378, 393, 385, 386, 378, 379,  
382, 393, 381, 389, 382, 383, 390, 387, 394,  
384, 387, 392, 397, 346, 357, 360

stakeholder .. xv, xvi, 374, 377, 387, 399, 376, 379,  
380, 381, 390, 391, 396, 398, 386, 387, 393,  
405, 378, 381, 382, 393, 376, 382, 384, 398,  
406, 373, 378, 382, 384, 385, 386, 393, 394,  
407, 344, 345, 351, 352, 356, 358, 360, 361

sustainable... iv, vi, vii, viii, ix, xvi, xxi, 2, 4, 8, 9, 10,  
11, 12, 13, 15, 374, 376, 380, 381, 383, 386,

387, 390, 393, 400, 401, 402, 403, 404, 411,  
412, 379, 381, 382, 383, 384, 388, 391, 392,  
393, 400, 401, 404, 373, 380, 381, 382, 384,  
385, 386, 388, 389, 390, 391, 393, 395, 396,  
397, 398, 399, 401, 373, 375, 376, 377, 379,  
380, 381, 382, 383, 384, 385, 386, 387, 390,  
391, 392, 394, 395, 401, 374, 380, 381, 386,  
387, 388, 389, 390, 391, 392, 393, 395, 398,  
400, 403, 373, 374, 375, 377, 378, 379, 380,  
382, 383, 385, 386, 387, 389, 390, 391, 392,  
393, 394, 395, 396, 399, 374, 376, 377, 378,  
379, 381, 382, 383, 384, 390, 391, 393, 396,  
375, 384, 385, 387, 389, 394, 395, 396, 398,  
387, 376, 380, 382, 385, 386, 391, 392, 394,  
397, 405, 406, 373, 374, 375, 379, 380, 381,  
382, 383, 384, 387, 390, 392, 393, 394, 395,  
396, 397, 398, 401, 402, 403, 373, 375, 378,  
381, 382, 384, 385, 387, 389, 390, 391, 392,  
394, 395, 396, 397, 400, 401, 406, 346, 351,  
352, 353, 354, 355, 358, 360, 361

## T

tourism.....387, 381, 385, 386, 389, 397, 395, 386,  
394, 403, 349, 352, 359

transparency.....10, 376, 377, 384, 388, 389, 390,  
391, 392, 393, 395, 396, 397, 402, 403, 385,  
400, 373, 381, 383, 388, 373, 377, 379, 380,  
381, 386, 387, 390, 391, 393, 377, 381, 384,  
392, 395, 390, 383, 385, 374, 385, 391, 381,  
391, 393, 342, 343, 344, 345, 347, 348, 351,  
353, 356, 357, 359

## W

Wajo Regency vii, ix, xiii, xix, xx, xxiii, 1, 6, 7, 8, 10,  
11, 380, 381, 382, 383, 384, 385, 386, 387, 388,  
393, 394, 395, 396, 397, 398, 401, 374, 391,  
392, 378, 394, 395, 396, 377, 381, 388, 389,  
390, 342, 343, 344, 346, 347, 348, 350, 351,  
352, 353, 354, 355, 356, 357, 358

