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Model for Land Use Optimisation for Flood Management in Lasolo Watershed, Indonesia

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Abstract. Changes in land use from vegetation to non-vegetation in the Lasolo watershed contribute to an increase in the run-off coefficient caused by inundation during the wet season. Therefore, engineering is required to reduce discharge from surfaces. This study seeks to optimize land use in order to manage flooding. This study employs the paimin (modified) method with three different scenarios: Business as usual (BAU), simultaneous, and discrete. Results indicated that the BAU scenario has throughfall and retention capacity values of 15.55 percent and 19.39 percent of the total watershed area, respectively. scenario-2 (simultaneous) decreased throughfall and increased storage capacity (15.35 and 24.65%, respectively); scenario-3 (discrete) also improved. Comparing throughfall values reveals that the discrete simulation (-0.0020) is greater than the simultaneous scenario (-0.008), whereas the retention capacity has the same value (0.0020). The discrete simulation is superior to the simultaneous simulation in terms of optimizing its use for flood management in the Lasolo catchment.

Keywords. watershed, flood management, land use optimization

Introduction

Climate change, alongside natural calamities, flooding, and landslides, is one of the most significant issues of our time (Kan et al., 2019). Among these natural hazards are floods caused by climate change and rising temperatures as a result of global warming, as well as the sudden and torrential rainfall that cause catastrophic flooding (Gagui et al. 2023; Dharmawan et al. 2023). Floods are natural disasters that frequently occur in a region with a particular magnitude and duration, and they have become a critical problem in watershed management (Herath and Wijesekera, 2020), due to natural factors (rainfall, topography, etc.) and human activities (Firdaus and Koestoer, 2022). Ecosystem damage and economic losses have resulted from flood disasters caused by intense rainfall and impermeable soil (Jawad and Al-Abiadh, 2019) and aided by irresponsible land use. Ecosystem degradation has a significant impact on environmental balance and biodiversity loss (Muhsin et al, 2011), while economic losses are estimated to reach tens of billions of dollars annually and millions of lives are lost (Wang et al, 2022).

Lasolo watershed is one of the watersheds located on Sulawesi Island, with a total area of 601,168.75 hectares (BPDAS, 2022). The average height and duration of flooding in this region are 5,626.3 ha, 1.50 m, and 72 hours, respectively, during the wet season. This is the result of the conversion of forest land to mining. In 2019, the mining area was 809.33 ha (KLHK, 2019), while in 2022, the mining area was 352,934.38 ha (BPDAS). This means that there has been a substantial increase. This condition has an effect on the carrying capacity of the watershed, thereby diminishing its ability to support the livelihoods of the local population. In order to enhance the welfare of farmers, it is necessary to optimize land use through management initiatives.

Materials and Methods

Study Location

This research was carried out in the Lasola Watershed. The entire territory comprises 601.168.75 ha and stretches from 2045'93" to 3031'96" south latitude and 121047'73" to 122008'91" east longitude. Administratively, the studied area consists of three provinces: Southeast of Sulawesi (North Konawe Regency, Konawe Regency, and North Kolaka Regency), Central of Sulawesi (Morowali Regency), and South of Sulawesi (East Luwu Regency). Utilized data included rainfall information and several thematic maps, including land use and topography.

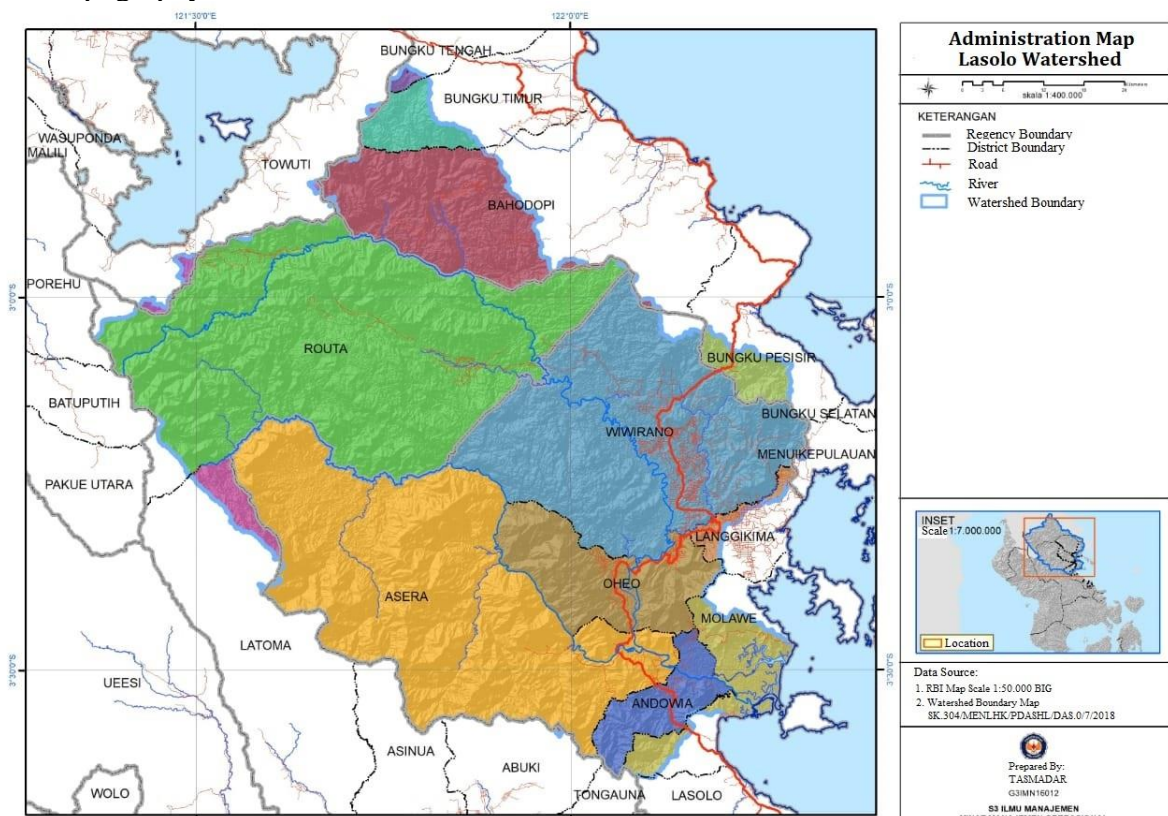


Figure 1. location study

Analysis Data

The flood management model of Lasolo Watershed for Optimum land use is analyzed with the modification Paimin et al. (2012) are throughfall and retention capacity using dual

analysis. (3) the third scenario (discrete), an increase in the area of protected/ conservation forest and a decrease in the area of other land uses. This research uses 3 scenarios in designing the model, (1) the first scenario, business as usual to describe existing conditions; (2) the second scenario (simultaneous), an increase in the area of protected/ conservation forest by 1% and a decrease in the area of other land uses by 0.25%; (3) the third scenario (discrete), an increase in the area of protected/ conservation forest and a decrease in the area of other land uses by 1%.

Results and Discussion

The phenomenon of flood disaster is very complex and difficult to fully understand, therefore, an abstraction is needed in its management. The abstraction in question is placing the phenomenon into a model. The flood management model uses a land use optimization approach. This is because land use contributes to flood water supply by 40% (Paimin et al. 2012). Vegetation land has good infiltration capacity so that the flood water supply is lower than non-vegetation land.

Land use in the Lasolo watershed is classified into 5 types of land use, namely protected forest/conservation forest (311,316.05 ha), production forest/plantation (107,557.06 ha), yard bush (102,910.54), paddy (63,237.30) and Build up (16,147.80) (KLHK, 2019). This shows that this area is still dominated by protected forest/conservation forest which is located in the upstream area, while other types of use are in the middle and downstream areas. Build-up area continues to increase in line with the increase in population (Kete et al, 2019) and mining, along with that, other land uses have decreased. Changes in land use due to continuous exploitation have resulted in infiltration capacity and an increase in settlement flows so there is the potential for flooding. Therefore, efforts are needed to optimize land use by managing throughfall to become surface runoff, then calculating the retention capacity to store rainwater into groundwater.

Table 1 Scenario-1 Existing Condition Lasolo Watershed

Land Use	Area (ha)	Prob. of throughfall	Prob. value of throughfall	Prob. retention capacity	Prob. value of retention capacity
Protected Forest/ Conservation Forest	311.316,0	0,08	0,0414	0,32	0,1657
Production Forest/ Plantation	107.557,0	0,16	0,0286	0,24	0,0429
Yard Bush	102.910,5	0,24	0,0411	0,16	0,0274
Paddy	63.237,30	0,32	0,0337	0,08	0,0084
Build up/ empty land	16.147,80	0,40	0,0107	0,00	0,0000
Σ	601.168,7		0,1555		0,1939

The results of the optimization of land use analysis based on existing conditions (scenario business as usual) show that the throughfall value for protected forest/conservation

forest is 4.14% with a retention capacity of 16.57%, then Production Forest/Plantation (2.86% and 4, 29%), Yard Bush (4.11% and 2.74%), Paddy (3.37% and 0.84%) and Build up/ empty land (1.07% and 0%). The build-up is assumed to have no retention capacity. Overall, land use in the Lasolo watershed in managing flood supply into surface water and infiltration as groundwater is (15.55% and 19.39%). Rainwater that falls into a watershed with vegetated conditions has good infiltration capacity so that the flood water supply is low, on the other hand, non-vegetation land (build-up) is high.

Table 2. Scenario-2 (simultaneous) Optimalisasi Land Use Lasolo Watershed

Land Use	Area (ha)	Prob. value of throughfall	Prob. value of retention capacity	Deviation of Prob. value of throughfall	Deviation of Prob. value of retention capacity
Protected Forest/ Conservation Forest	317.327, 74	0,0422	0,1689	0,0008	0,0032
Production Forest/ Plantation	106.054, 14	0,0282	0,0423	-0,0004	-0,0006
Yard Bush	101.407, 62	0,0405	0,0270	-0,0006	-0,0004
Paddy	61.734,3 8	0,0329	0,0082	-0,0008	-0,0002
Build up/ empty land	14.644,8 8	0,0097	0,0000	-0,0010	0,0000
Σ	601.168, 75	0,1535	0,2465	-0,0020	0,0020

Optimization of land use in scenario-2 is also used in scenario-3, but in this scenario, there is an increase in the area of protected/conservation forest and a decrease in the area of other land uses by 1%. The results of land optimization analysis by intervening in protected/conservation forest and Production Forest/Plantation lands show that there is a decrease in the throughfall value of the existing condition by 15.47% and an increase in retention capacity of 24.53% with a difference of 0.08%. then intervention was carried out on Yard Bush land resulting in throughfall values and retention capacities of 15.39% and 24.61%. This shows that intervention on Yard Bus land in reducing throughfall values and increasing retention capacity is better than Production Forest/Plantation. This condition also occurs in paddy fields, where there is a decrease in throughfall values of 15.31% and an increase in retention capacity of 24.69% with a difference of 0.24%. It can be concluded that changes in forest area affect the behavior of water flow, the wider and denser the vegetation, the lower the potential for flooding and the availability of abundant water resources.

The conversion of vegetation land to non-vegetation in the Lasolo watershed has recently continued to increase so it harms the hydrologist conditions of a watershed. During the rainy season, floods occur because the watershed is unable to absorb, store, and distribute rainwater in the rainy and dry seasons. In addition, there is an increase in the rate of sedimentation and a decrease in the supply of clean water in the upstream area. The conversion

of vegetation land to build-up has an impact on increasing runoff during the rainy season and decreasing base flow during the dry season. Therefore, intervention is needed in land use.

Scenario-3 (discrete) Optimalisasi Land Use Lasolo Watershed

Land Use	Area (ha)	Prob. value of throughfall	Prob. value of retention capacity	Deviation Prob. value of throughfall	Deviation Prob. value of retention capacity
Protected Forest/ Conservation Forest	317.327,74	0,0422	0,1689	0,0008	0,0032
Production Forest/ Plantation	101.545,37	0,0270	0,0405	-0,0016	-0,0024
Yard Bush	102.910,54	0,0411	0,0274		
Paddy	63.237,30	0,0337	0,0084		
Build up/ empty land	16.147,80	0,0107	0,0000		
Σ	601.168,75	0,1547	0,2453	-0,0008	0,0008
Protected Forest/ Conservation Forest	317.327,74	0,0422	0,1689	0,0008	0,0032
Production Forest/ Plantation	107.557,06	0,0286	0,0429		
Yard Bush	96.898,85	0,0387	0,0258	-0,0024	-0,0016
Paddy	63.237,30	0,0337	0,0084		
Build up/ empty land	16.147,80	0,0107	0,0000		
Σ	601.168,75	0,1539	0,2461	-0,0016	0,0016
Protected Forest/ Conservation Forest	317.327,74	0,0422	0,1689	0,0008	0,0032
Production Forest/ Plantation	107.557,06	0,0286	0,0429		
Yard Bush	102.910,54	0,0411	0,0274		
Paddy	57.225,61	0,0305	0,0076	-0,0032	-0,0008
Build up/ empty land	16.147,80	0,0107	0,0000		
Σ	601.168,75	0,1531	0,2469	-0,0024	0,0024
Protected Forest/ Conservation Forest	317.327,74	0,0422	0,1689	0,0008	0,0032
Production Forest/ Plantation	107.557,06	0,0286	0,0429		
Yard Bush	102.910,54	0,0411	0,0274		
Paddy	63.237,30	0,0337	0,0084		

Build up/ empty land	10.136,11	0,0067	0,0000	-0,0040	0,0000
Σ	601.168,75	0,1523	0,2477	-0,0032	0,0032

The results of the build-up/empty land intervention in managing floods showed that there was a decrease in throughfall values and an increase in retention capacity of 15.23% and 24.77%, respectively. This intervention is carried out through re-vegetation on empty land which has recently been increasing as a result of changes in the behavior of people who were formerly farmers, now turning into mining employees. In addition, the existence of mining causes the economic value of the land to be high, to obtain community land rights to tear down forest areas as a result there is an increase in the area of empty land. In the Build up/empty land area, it is carried out To obtain land rights, the community remodeled (tear down forest) the forest area, increasing the area of empty land. In the Build up/empty land area, it is carried out To obtain land rights, the community tear down forest, resulting in an increase in the area of empty land. In the Build up/empty land area, it is carried out vegetation enhancement, tree planting actions, afforestation efforts, and future restoration campaigns (Fazaa et al, 2022), moreover, it is also necessary to engineer repairs to drainage channels and construct infiltration wells to allow rainwater to pass into groundwater and soil stabilizers (Kete et al 2020).

Conclusion

Land use management must regulate spatial patterns and structures in the Lasolo watershed, particularly the link between protected areas and cultivation areas and other forms of land use. This is done to reduce the frequency of frequent flooding in this region. The objective of land optimization is to reduce runoff flows to storage capacity. Existing land use contributes throughfall and retention capacity values of 15.55 percent and 19.39 percent, respectively, of the total area. The land use optimization model indicates that scenario-3 (discrete) has a lower throughfall value than scenario-2 (simultaneous), namely -0.0020 - 0.0008, indicating that the discrete simulation is more effective than the simultaneous simulation at reducing the throughfall value. while the retention capacity of these two techniques is equally effective in increasing storage capacity with a value of 0.0020. Thus, it can be concluded that flood management in the Lasolo catchment makes excellent use of the discrete method.

References

- [1] KAN, C.-Y.L.S.-S.L.Y.-F.L.P.-S., A bootstrap regional model for assessing the long-term impacts of climate change on river discharge. international. Journal of Hydrology Science and Technology, 2019. 9: p. 85. DOI - 10.1504/IJHST.2019.10017442
- [2] BPDAS LASOLO-KONAWEHA INDONESIA: Final Report Review of SW Lasolo-Koaweha Water Resources Management Pattern. Southeast Sulawesi. Kendari. 2022.
- [3] N. A FAZAA, A. B. ALI , A. J. M. AL-JABINAWI, R. FRANCKSEN, M. J. WHITTINGHAM: Land use change in Baghdad City and assessment of the Jadriyah and Umm Al- Khanazeer Island Important Bird Area (IBA) from 1984 to 2020, Baghdad Science Journal, 2022, 19(6):1471-1486, DOI:https://dx.doi.org/10.21123/bsj.2022.7033
- [4] P. FIRDAUS and R. H. KOESTOER: Future Flood Management and Control Policies: A Comparative Study of Europe and Indonesia, Indonesian Journal of Earth Sciences, Vol. 2, No. 2 (2022): 96-109 96, DOI: 10.52562/injoes.v2i2.379
- [5] M.M. HERATH AND N.T.S. WIJESEKERA: Development of a Conceptual Framework

- to Operationalize the Flood Risk Management, IOP Conf. Series: Earth and Environmental Science 563 (2020) 012020, DOI:10.1088/1755-1315/563/1/012020
- [6] A. JAWAD AND H. W. A. W. AL-ABIADH: Valley Drainage Basin Environmental Aspects Extraction Using Quantitatively Morphometric Analyses of Shuttle Radar Topographic Mission Data, Baghdad Science Journal, Vol.16(1) 2019, DOI: <http://dx.doi.org/10.21123/bsj.2019.16.1.0097>
- [7] MINISTRY OF ENVIRONMENT AND FORESTRY INDONESIA: Lasolo Watershed Flood Event Analysis Desk. Jakarta. 2019
- [8] MUHSIN, F. K. MASEHE, R. J. TAWFEEQ: Monitoring the Vegetation and Water Content of Al-Hammar Marsh Using Remote Sensing Techniques, Baghdad Science Journal, Vol.8(2)2011
- [9] PAIMIN, I. B. PRAMONO AND D. R. INDRAWATI: Watershed Management Planning System. Bogor: Center for Research and Development of Conservation and Rehabilitation.
- [10] WANG, S. CUI, L. D. UANZHENG, H. HUANG, B. MANANDHAR, N. E. VILAS, X. FANG, W. HUANG: A review of the flood management: from flood control to flood resilience, Heliyon 8 (2022) e11763, <https://doi.org/10.1016/j.heliyon.2022.e11763>
- [11] S. C. R. KETE, SUPRIHATIN, S. D. TARIGAN, H. EFFENDI: Land use classification based on object and pixel using Landsat 8 OLI in Kendari City, Southeast Sulawesi Province, Indonesia. *IOP Conference Series: Earth and Environmental Science* (Vol. 284, No. 1, p. 012019).
- [12] S. C. R. KETE, SUPRIHATIN, S. D. TARIGAN, H. EFFENDI: Assessment of Land Use Land Cover Changes and their Impact to Groundwater Quality Index in Kendari City - Indonesia. *International Journal of Advanced Science and Technology* 29 (2020), 3441 - 3452