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Study on the Management of the Wanggu River Basin in Southeast Sulawesi: Literature Review

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Abstract

The concept of Integrated Watershed Management essentially involves participatory management by multiple stakeholders, focusing on conservation and sustainable use through an ecological approach that emphasizes the interdependence between humans and nature. The Wanggu Watershed, located in Southeast Sulawesi, is characterized by high dynamics due to various human activities such as agriculture, plantations, forestry, and residential development, all of which influence its performance and carrying capacity. The extent of critical and moderately critical land in the Wanggu Watershed still qualifies it as an area with a high need for critical land rehabilitation. The percentage of vegetation cover, particularly forest cover, remains low and is in poor condition. This study aims to evaluate the watershed management practices implemented in the Wanggu Watershed. The water bodies included in the study comprise lakes, rivers, estuaries, seas, bays, and straits. The results indicate that the condition of vegetation cover—especially forest cover—is still poor, and the erosion index is high. Several soil parameters further reveal that the current watershed management in Wanggu is associated with low land carrying capacity. Therefore, improved land management and conservation efforts are necessary to enhance the watershed's performance and sustainability.

Keyword: Watershed Management, Wanggu Watershed, Carrying Capacity, Watershed Performance

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INTRODUCTION

A river basin (DAS) is an area of land that forms a unified system with a main river and its tributaries, which plays a role in collecting, storing, and naturally draining rainwater into lakes or the sea. The boundaries of a DAS are determined topographically on land, and its marine boundaries are defined by how far the influence of land-based activities still extends (Law No. 17 of 2019). Chay Asdak (2010) explains that a DAS is a land area surrounded by mountain ranges that functions to collect and store rainwater before it is channeled to the sea through the main river. Meanwhile, a sub-watershed is a part of a watershed that receives rainwater and channels it through tributaries to the main river (Regulation of the Minister of Forestry of the Republic of Indonesia No. P.32/MENHUT-II/2009). According to Government Regulation No. 37 of 2012 concerning Watersheds, watershed management encompasses various human efforts to regulate the interaction between natural resources and humans and their activities within the watershed area. The aim is to ensure the sustainability and balance of the ecosystem and to improve the sustainable use of natural resources. The main objectives of watershed management include increasing awareness, capacity, and active participation of relevant agencies and communities; creating productive land that is in line with the carrying capacity and environmental capacity of the watershed; ensuring the availability of water in optimal quantity, quality, and continuity in terms of space and time; and improving community welfare. Community welfare is expected to improve in line with improved land productivity, sustainable water quality and availability, supportive socio-economic conditions, and efficient spatial planning. Efforts to achieve these objectives are carried out through coordination, integration, synchronization, and synergy across sectors and administrative regions, including community involvement in natural resource and environmental management in the watershed area. As stated in Article 18 of Law Number 7 of 2004 concerning Water Resources, some of the central government's authority in managing water resources can be delegated to local governments to support watershed management. Watershed management technology itself has been widely applied in various countries, both developed and developing, due to its ability to adapt to various climatic conditions. This technology is effective in protecting and enhancing soil fertility, particularly in areas with high or low rainfall, and encompasses both technical and non-technical approaches to resource management.

Wanggu is one of the Watershed Areas (DAS) in Southeast Sulawesi that exhibits highly dynamic characteristics due to the intensity of community activities such as agriculture, forestry, plantations, and residential development, which directly impact the performance and carrying capacity of the region. The Wanggu DAS, along with eight micro-DASs in its vicinity, covers an area of approximately ±45,377.3 hectares, serving as a link between the upstream and downstream

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areas and responding to various dynamics occurring in the downstream or outlet areas (Kahirun et al., 2023; Alwi et al., 2011). The extent of critical and moderately critical land in this area still falls under the category of high priority for critical land restoration. The condition of vegetation cover, particularly forest cover, remains poor, with relatively high erosion index values. Several land parameters indicate that the management of the Wanggu watershed is still suboptimal and its land carrying capacity is low, so better land management strategies and conservation efforts are needed to improve the performance and sustainability of the watershed (Kahirun et al., 2023). This journal review aims to examine the watershed management practices applied in the Wanggu watershed.

METHOD

This research is a literature study discussing the topic of watershed management in the Wanggu Watershed in Southeast Sulawesi Province. The study was conducted based on the results of watershed area identification and characterization to gain an understanding of its form and management approach. The areas of focus include the upper reaches of the Wanggu Watershed, the midstream area, the estuary, and the Kendari Bay area. The analysis was conducted on previous studies that had been carried out in the Wanggu watershed area, which covers two administrative areas, namely South Konawe Regency and Kendari City. The selection of this area was based on the differences in flow characteristics and the diversity of human activities along the watershed area, from upstream to downstream. Watershed management is influenced by several factors, including the types of human activities in the surrounding area and the physical characteristics of the watershed. The scientific articles used as sources for the study were taken from national and international journals published between 2010 and 2023.

RESULTS AND DISCUSSION

To support coordination and strengthen communication among stakeholders in addressing various issues related to watershed management, initiatives from relevant parties are needed to create synergy in the implementation of programs, activities, and financing. Additionally, it is necessary to develop a participatory DAS Management Plan involving various stakeholders, including government bureaucrats acting as facilitators, businesses, communities, individuals, academics, and environmentalists. This involvement aims to formulate policy strategies as well as programs and activities that are mutually agreed upon based on the characteristics of natural resources, biodiversity, human resources, formal and informal community institutions (social capital), and artificial resources (artificial capital) (Handayani et al.,

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2014). Watershed management practices have been adopted by communities because they are considered to significantly contribute to improving household livelihoods, preserving ecosystem balance, and responding to the challenges of climate change (Mamo, 2022).

In addition to increasing agricultural productivity, developed watersheds have great potential to minimize land degradation, mitigate the adverse effects of climate change, and generate several ecosystem services (Meena et al., 2022). Considerations for watershed management must encompass various factors, including ecology, sectors, fields of science, and stakeholders (Bismihayati et al., 2023). Studies on watershed management in Indonesia still predominantly focus on scientific perspectives such as the environment, forestry, flood control, disaster management, and climate change (Budiarto et al., 2022). The approach to watershed management must be holistic and integrated, involving hydrology, biophysics, and socio-economic systems. Community participation is a key factor in the effective implementation of programs, which can be achieved by strengthening community awareness of the importance of sustainable watersheds and providing access for communities to be involved in every stage of watershed management, because most watershed management projects fail due to a lack of effective community participation (Reddy et al., 2017: Narendra et al., 2021; Bekele et al., 2023).

Watershed management institutions are integrated with the involvement of village communities, stakeholders, government institutions that cover the watershed area from upstream to downstream, and other regional organizations (Worku and Tripathi, 2015; Reddy et al., 2017; Narendra et al., 2021; Sulistyaningsih et al., 2021). Watershed management faces various complex and interrelated problems. These are characterized by a lack of cross-sectoral, inter-agency, inter-regional integration, and community participation. The increased frequency of hydrometeorological disasters illustrates that watershed management has not been effective in promoting sustainable development. Damage to watersheds in the upstream areas is caused by massive expansion of agricultural land and settlements, leading to erosion and sedimentation that reduce land productivity and increase the frequency of meteorological disasters. The increase in the urban population has a significant impact on spatial pressure, affecting the utilization of river areas. Changes in land use, the complexity of spatial utilization, and community behavior have a negative impact on the quality of the watershed environment (Syafri et al., 2020).

A watershed, understood as a water cycle basin, whose issues are addressed solely through rehabilitation of the upstream watershed, is considered not entirely appropriate. Government policies on watershed management need to be reviewed from scientific, regulatory, and institutional perspectives to highlight contributions and interconnections between sectors. The concept of Integrated Watershed Management fundamentally involves participatory, multi-

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stakeholder management in conservation and utilization through the ecological concept of mutual dependence between nature and humans (Pambudi, 2019).

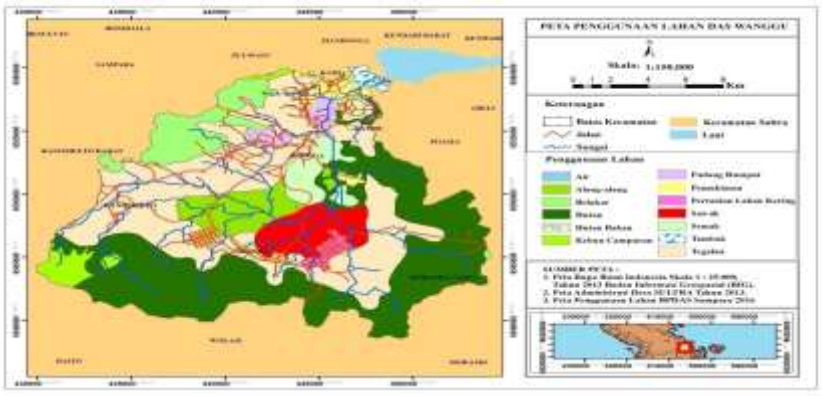


Figure 1. Land use map in the Wanggu watershed in 2016 & GIS analysis results

Table 1. Research on the Wanggu watershed

No.	Research Topic	Source
1	Watershed-based Bay Management Policy (Kendari Bay Case Study)	[Apriyanto, 2007]
2	Study of the Impact of Land Use Dynamics on Erosion and Hydrological Conditions of the Wanggu Watershed	[Alwi et al., 2011]
3	Study of Hydraulic Dynamics of Wanggu River Flow into Kendari Bay and Alternative Control Efforts with Pure Hydraulic and Eco-Hydraulic Integral (Environmentally Friendly)	[Suryawan and Sukri, 2013]
4	Analysis of Water Quality Status and Capacity of Wanggu River Pollution Load in Kendari City	[Sahabuddin et al., 2014]
5	Analysis of the Impact of Land Use Change on Land Degradation and Farmers' Income in Wanggu Watershed, Southeast Sulawesi	[Alwi and Marwah, 2015]
6	Flood Control of Wanggu River in Kendari City, Southeast Sulawesi Province	[Supriadi and Pamungkas, 2016]
7	Study of Flood and Inundation Characteristics (Case Study: Areas Around the Bridges of Jl. MT. Haryono, Jl. Sungai Wanggu and Jl. Boulevard)	[Salihin et al., 2018]
8	Analysis of Wanggu River Flood Inundation Kendari City Southeast	[Deby et al., 2019]

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	Sulawesi Province Using HEC RAS 5.0.6	
9	Drought Analysis to Support Urban Agriculture in Wanggu Catchment Area, Indonesia	[Wicaksono et al., 2019]
10	Resilience of Flood Disasters in the Wanggu Watershed, Kendari City	[Saleh and Setiadi, 2020]
11	Rate and Load of Bed Sediment of the Wanggu River	[Rustan et al., 2020]
12	A Model to Estimate Stored Carbon in the Upland Forests of the Wanggu Watershed	[Kasim et al., 2020]
13	The Impact of Decentralization on Integrated Watershed Management (IWM): A Case Study in the Wanggu Watershed, Southeast Sulawesi,Indonesia	[Alfian, 2020]
14	Community Perceptions of Waste Management on the Wanggu Riverbanks, Lalolara Village, Kambu Subdistrict, Kendari City	[Sarlia and Harudu, 2020]
15	Monitoring Land Use Change Using Sentinel 1 Satellite Imagery in the Wanggu Watershed of Kendari City	[Fadlin et al., 2021]
16	Flood Control Study Using Regulatory Reservoirs	[Maddi et al., 2021]
17	Implementation of the Kendari Regional Disaster Management Agency (BPBD) Function in Flood Disaster Management on the Wanggu River, Indonesia	[Mustafa et al., 2021]
18	Factors Associated with Community Knowledge on Flood Disaster Mitigation around Wanggu River, Lepo-Lepo Village, Baruga Subdistrict,Kendari City	[Ramisa et al., 2021]
19	Spatial analysis of flood-prone areas and harvest failures in the Wanggu Southeast Sulawesi Watershed	[L Alwi et al., 2021]
20	The study of forest land use on land characteristics and soil hydrological characteristics in the Wanggu Watershed, Southeast Sulawesi	[L O Alwi et al., 2021]
21	Analysis of Water Quality with TSS, BOD, Detergent and Phosphate (PO4) Parameters in Wanggu River, Kendari City	[Hema et al., 2021]
22	Spatial Modeling for the Calculation of River Capacity: Case Study Downstream Area of Wanggu River Kendari	[Fadlin et al., 2022]

The implementation of integrated watershed management in Indonesia has not yet reached the expected level. Integration between sectors is influenced by various factors, such as

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the effectiveness of communication, coordination, cooperation, and applicable policies and regulations. The main obstacles in realizing such integration are weak communication and limited coordination and cooperation between sectors. In addition, the implementation of policies strengthened by the existence of regional autonomy laws has also become a barrier to the implementation of sectoral integration in watershed management (Waskitho, 2020).

The watershed governance system that tends to be centralized also faces various problems, including the transfer of authority from the central government to regional and local governments, limited capacity and resources of stakeholders at the local level, institutional conflicts in watershed management, and the need for policies and regulations that support collaborative approaches locally. A number of prerequisites for effective collaborative management are already in place at the provincial level as well as at the watershed level. While there are indications that processes towards collaborative management have been undertaken - particularly through the role of formal watershed interagency forums at the provincial level - tangible evidence of program success and improvements in watershed conditions on the ground is still very limited. Factors hindering such success include political dynamics, leadership changes, and policy changes that do not always support the empowerment of local leaders. In addition, success in decentralizing watershed management is also heavily influenced by the role of international aid organizations, which often contribute to program implementation and participatory processes at the local level (Alfian, 2020).

Kendari City is a service and trade city in Southeast Sulawesi Province that has vulnerability to recurrent floods in urban areas including 10 sub-districts that are still included in the Wanggu River Watershed. This urban area is experiencing the phenomenon of urbanization, namely population growth and high land use change and land ownership transfer. The development of residential areas as a consequence of population growth is also a cumulative factor that triggers flood disasters in the Wanggu River Watershed (Saleh, 2020). Various efforts by the Kendari Regional Government have also been made to reduce the risk of flooding in the Wanggu River by building flood barriers from upstream to downstream, normalizing rivers, improving drainage, and offering relocation of houses in the wilderness which is currently still a wilderness (Mustafa, 2021). One of the infrastructures to reduce flooding in Kendari City is the Boulevard retention pond. The Boulevard retention pond is one of the components of the flood control system in Kendari City, as is also applied in various other regions in Indonesia. Meanwhile, Wanggu Reservoir is located in Lepo Lepo Village, Baruga Sub-district, Kendari City (Maladeni, 2023). The risk of flooding in Kendari City is caused by debit fluctuations or the Wanggu watershed regime coefficient of 96.45 which is classified as high, as well as erosion and surface runoff, namely

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sediment load conditions of 19.73 which are also included in the high category. While the annual flow coefficient value is 0.32, the average annual flood frequency occurs every two years, and the water use index is 0.69. These three parameters are categorized as being in the middle class. From the accumulated weight and score of all parameters of the water system indicator, a value of 111.25 is obtained, including in the poor class category. So that the Wanggu watershed has a poor carrying capacity value of water management indicators (Kahirun et al, 2023b).

The research development map of the Wanggu watershed management study was carried out by making a bibliometric analysis through Vosviewer software. This analysis is complementary and aims to classify the network structure between articles and is presented visually in the form of networks, overlays and density. Cluster identification can be seen based on the size of nodes and words. The larger the size of nodes and words indicates a greater weight. While the distance between nodes describes the strength of the relationship between nodes. The shorter the vulnerable node distance, the stronger the relationship. In this study, four main clusters with large node sizes were found, dominated by the existing river conditions cluster and followed by the drought, erosion and forest clusters (Figure 2). Meanwhile, the distance between nodes tends to be long. This shows that the concentration of researchers is still partial, while the watershed management study is comprehensive, characterized by a network structure that has attachments and linkages between clusters. Therefore, the study of Wanggu watershed management by integrating each cluster is a research gap for researchers to help stakeholders prevent decision-making errors.

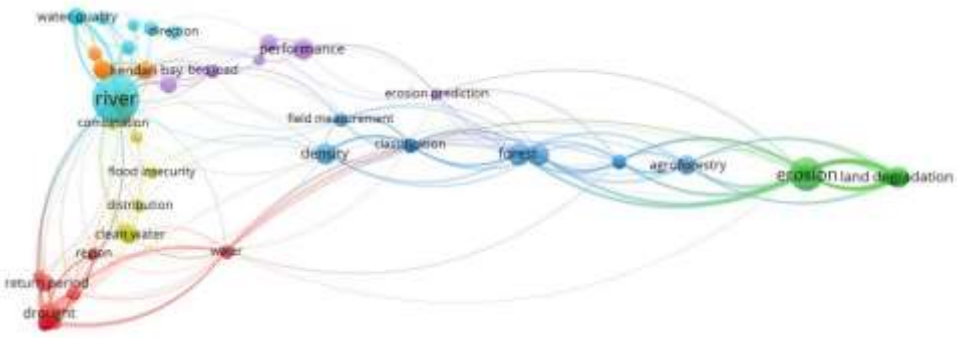


Figure 2. Visualization of the Wanggu watershed management study network

Wanggu watershed management research trends based on the metadata that has been collected are 30 articles. Research trends can be identified through color degradation on the

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barometer (Figure 3). The analysis results show that in 1996-2012, there was a drought in the Wanggu watershed (Wicaksono et al. 2019). Furthermore, in 2012, researchers focused on the existing conditions of the river in the form of water quality, waste, flooding, forest resources, agroforestry and finally in the form of land degradation or erosion. This shows that the condition of the Wanggu watershed has experienced very complex or critical problems. Therefore, it is necessary to have a system approach and involve multi-sectors and multi-factors to restore the ecosystem functions of the Wanggu watershed.

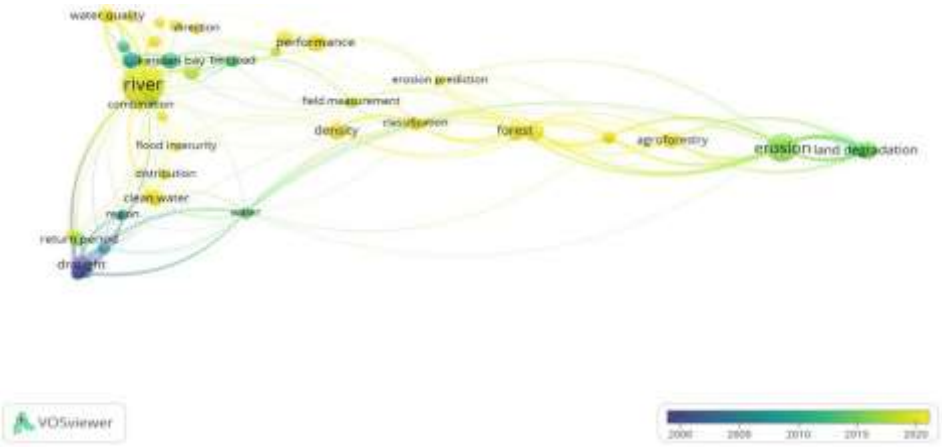


Figure 3. Visualization of research trends in Wanggu watershed management studies

Next, a density visualization analysis was conducted. The denser the node, the more saturated it is, in other words, the topic has been widely researched. In this study, yellow color indicates high density, while dark color indicates low density. The results of the analysis show that the existing conditions of the Wanggu River, land degradation or erosion and drought have been widely researched, while topics on forests and agroforestry are still very few. This is an opportunity for research, for example the keyword existing conditions of the Wanggu River in relation to agroforestry shows a low density and intensity, so research on that topic is still very broad to be researched.

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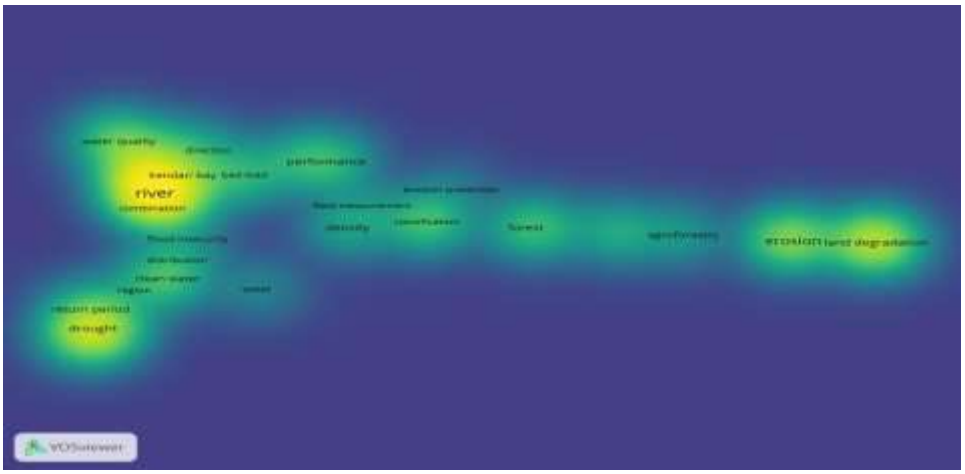


Figure 4. Visualization of research density for Wanggu watershed management study

CONCLUSIONS

The increasing frequency of hydrometeorological disasters illustrates that watershed management has not been effective in promoting sustainable development. Watershed degradation in the upstream part is due to massive expansion of agricultural land and settlements, so that erosion and sedimentation have an impact on decreasing land productivity and increasing the frequency of meteorological disasters. The increase in urban population in the Wanggu watershed has a significant impact on spatial pressure, affecting the utilization of river areas. changes in land use, complexity of space utilization, and community behavior have a negative impact on the quality of the watershed environment, Poor carrying capacity of watersheds can increase the risk of disasters, so in coordination, integration, synchronization and synergy between various parties to realize integrated watershed management.

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