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Sustainability Status Of Ambang Subwatershed Management and Flood Vulnerability in Greater Malang, Indonesia

Aptu Andy Kurniawan * , Sunardi Sunardi , Hendarmawan Hendarmawan , Iwan Ridwansyah

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Article

Ecological Status of Ambang Subwatershed Management in Greater Malang

Aptu Andy Kurniawan [1,*], Soenardi [1], Hendarmawan [1] and Iwan Ridwansyah [2]

[1] School Of Graduate Study, Doctor of Environmental Science. Universitas Padjadjaran, Sumedang Regency, West Java, Indonesia

[2] National Research and Innovation (BRIN) Limnology and Water Resources Cibinong Regency, West Java, Indonesia

* Correspondence: aptu22001@mail.unpad.ac.id

Abstract

The Ambang River Basin is very important for the people of Greater Malang in East Java as they face the threat of flooding. To support the government to achieve the Sustainable Development Goals (SDGs), it is essential that the Ambang River Watershed (DAS) management has to consider environmental, economic, social, institutional and technological aspects. The purpose of this study is to evaluate the Ambang Sub-watershed sustainability and identify the factors that significantly determine the Ambang Sub-watershed management's sustainability. This research uses method of observation, interview, documentation study, and literature study. Malang rapflood is based on a descriptive analytic method and MDS (Multidimensional Scaling) as the tool. The result show that the susceptibility of ecological watershed management at the upstream and middle Ambang sub-watersheds is categorized as sustained. The result reveals that sustainability status of the Ambang sub-watershed management is categorized as unsustainable. There are 5 parameters that should be considered to enhance sustainable management of the Ambang sub-watershed.

Subjects: earth science; natural hazard and risk; environmental policy; hazard and disaster

Keywords: watershed management; flood vulnerable; Monte Carlo multidimensional scale; Greater Malang

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1. Introduction

Floods, droughts, land subsidence, and landslides are all water-related disasters that can impact people and their health [1–3]. Water, especially through floods, can be very destructive because natural and human processes interact in complex ways. For example, natural processes are things such as rainfall, landform, and sediment transport. Human activities are such as deforestation and urbanization [4,5]. If these natural mechanisms of erosion and deposition are ignored, they can impede the river in storing water.

When water, wind, and gravity remove soil and deposit it elsewhere, it is deposition [6]. The following factors influence this process precipitation, wind strength, surface runoff, soil type, land gradient, vegetation cover, and conservation measures. Intense precipitation, as an example, enhances surface runoff by detaching and transporting more soil particles, therefore accelerating soil loss. The sandy topsoil is also easily blown away by the wind, particularly in dry areas. But gravity causes rocks and soil to fall down hills, too [7]. There is going to be flooding if the above problems don't improve.

During rainfall, higher precipitation amounts can accelerate surface water flow. This accelerates processes of erosion and sedimentation causing narrowing of river channels. When sediment lodges in a river and obstructs water flow, it leads to floods. Flooding is a common occurrence when rain is heavy and the runoff flowing over the land surface is more than the river can accommodate. This is

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exacerbated by the accumulation of sediment in the channel, which reduces its width [8,9]. Prevention measures include biophysical, socio-institutional, and economic interventions aiming at decreasing susceptibility to these disasters [10,11]. A watershed (DAS) is an area where the rain falls and runs off into rivers, lakes, or reservoirs that ultimately lead to the ocean. Watersheds are ecosystems that connect people with nature. Alterations in a single portion of a watershed influence the entire system [12]. In this sense, effective watershed management is crucial to promote fish and wildlife good watershed management is very important in this respect to preserve healthy ecosystems and prevent natural disasters, such as floods.

A watershed is made up of three sections: the upper, mid, and lower sections of a river [13,14]. Headwaters are the source of streams In a watershed, the upper watershed's ecosystems are instrumental in maintaining the health of the entire watershed Treatmann's research shows that the Biodiversity and Ecosystem Services of this region can enable it to be more resistant to environmental change and facilitate water flow in ways that benefit downstream areas; for example, as buffers against flooding [15].

The Ambang Sub-Watershed is easily flooded in Malang Raya area. The three administrative regions that form part of it include Batu City (upstream), Malang City (middle) and Malang Regency (downstream). The elevation range in the Ambang Sub-Watershed is the lowest, between 305 m.a.s.l. Onze jarenlange kennis van stroomgebieden waters drehen de peuter van de wereld in Pakijs alweer om? 2 November, the following happened: a flash flood occurred in the villages of Sumber Brantas and Bulukerto, in Batu City, East Java. This flash flood, which destroyed homes and displaced people, also claimed lives. The flood was triggered by heavy rain and landslides that occurred at the upper slopes of the river valley. These can really advocate us why letting watersheds be safe from stuff failures, such as this incident, matters. This study is intended to evaluate the sustainability of Ambang Watershed management in terms of ecological, social, economic, institutional, and technological aspects.

Watershed management has been talked about plenty in Indonesia before especially collaborating with people from other fields and having them work together. However, these two aspects have not been integrated in any particular framework for watershed management [16]. The study reveals gaps in prior research namely, disconnect between sectors and regions, and insufficient participation by the community. As a result, this research is concerned with the application of Multidimensional Scaling (MDS) in evaluating the sustainability of Ambang Watershed management in a holistic sense and in identifying the determinants of this sustaining in a multidimensional framework.

From an institutional point of view, natural resource management at the watershed level requires balancing the competing interests of various stakeholders [17]. In order to achieve effective watershed management, coordination among holders of land-use rights, landholders, and government agencies needs to be enhanced. This research indicates that the overall performance of watershed management is determined by numerous influential individuals with strong interests and high authority in the process [18]. The resources and the influence an institution can leverage are dependent on its purpose and function. And so it means that in order to accomplish their goals, the government agencies that oversee the watersheds have to consider what the people want and how they can assist.

The following are key provisions of Government Regulations 37/2012 concerning watershed management in Indonesia: Firstly, is it all part of watershed managementa comprehensive effort of watershed management planning implementation community monitoring evaluation and education and regulation [19,20]. Secondly, effective and integrated watershed management is undertaken in conjunction with spatial planning and water resources management [16]. Finally, "there is a lot of work that is being done to coordinate more between agencies, sectors, levels of government in the region with community support" [17]. People at different levels of government work collectively to manage watersheds, and each one has its own role and responsibility [21]. It is difficult for governance to synchronize management, flow and stakeholder participation when watersheds and political borders are not linear [22].

All people play a role in IWM, which is the process of managing the watershed. It enables superior coordination between all actors, in a way that benefits everyone, from the upper stream to the lower stream [23]. However, IWM is plagued with multiple problems such as poor interregional and intersectoral cooperation, insufficient community participation, multiple, and overlapping regulations and management jurisdictions and uneven information among those working on watershed management [16]. As a result, the watershed has not improved sufficiently. But on the long side of things, climate change is damaging to watersheds, too. So, Indonesia has the opportunity to enhance the IWM for climate change mitigation and adaptation by adopting a transformative path. This implies that coordination, participation and collaboration [24] should be prioritized as well as ensuring transparency and accountability in the execution phase [25], that roles are clearly defined, and that mechanisms for sustainable funding from multiple sources are established [26].

The ideas of coordination, participation, and collaboration related to watershed management in Indonesia even date back to the 1980s and 1990s. Yet these principles have not been put into practice effectively [27]. This is because each stakeholder has their own vested interests and does not care about the project, and there are no regulations that bind them to employ the Integrated Watershed Management (IWM) methodology [28]. Comprehensive legal system like the law, the government regulation, or the regional order is vital in making the watershed management plan incorporated into the regional spatial planning [29].

In watershed management, the influence of upstream-to-downstream areas is crucial for the implementation of SWC measures [30]. Full water management and disaster reduction program at the upstream area might be a solution for water scarcity at the downstream areas [31,32]. Early downstream watershed management, especially in metropolitan areas, was primarily concerned with disaster mitigations from floods, flash floods, droughts, and environmental degradation [33]. This approach has been abandoned in favour of full From Problem Solving to IWRM: Implications for Water Management in Upstream–Downstream relations thinking since it deals exclusively with problems rather than the causes of major problems in upstream areas. The IWRM approach provides a strategy for building on the downstream watershed management activities [34,35]. Integrated Water Resources Management (IWRM) is the conceptual framework within which hydrometeorological disaster mitigation is pursued. It starts at the top and works its way down.

Also, the IWRM approach can be applied to the management of climate change impact and natural disasters such as floods and droughts [36,37]. To control the flood in the downstream area, the first priority is to control them in the watershed area at the upstream by implementing Soil and Water Conservation (SWC) measures. This is done to reduce the risk of runoff, which could result in flooding down the road. Cities and downstream areas are also hustling to retrofit infrastructure to make flood damage less severe. This involves digging biopores, ponds to store water, and wells to receive water. The main purpose of these water conservation structures is to increase groundwater recharge and reduce surface runoff [38]. The technical integration results from the harmonization of two-scale environmental focus: vegetative cover on watersheds scales under the ideas of natural restoration and adaptive civil engineering structures on hillslopes under the aspect of soil/water conservation (SWC) as a response to climate event [17].

The National Disaster Management Authority of Indonesia The agency revealed that the most frequent and deadliest disaster of floods has been oscillating increasingly after steady and significant rises in the last 200 years, especially since the country entered the new century [39]. This study is natural to limit flood vulnerability and increase the realization of Sustainable Development Goals (SDGs), specifically those concerning clean water and sanitation management (SDG 6), climate action (SDG 13), and terrestrial ecosystems (SDG 15). Good Watershed management is critical to protecting the environment, community health, and mitigating disasters. This study was focused on the sustainability of Ambang Watershed management based on flood disaster vulnerability and to provide policy implications for improving runoff-based flood disaster resilience of the watershed.

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This study is aimed to analyze the status of sustainable management of Ambang Watershed based on its flood vulnerability in Malang City. The questions addressed in this study are: How sustainable is Ambang Watershed management in the ecological, economic, social, institutional, and technological aspects? What are the driving forces of Ambang Watershed management in its sustainability to flood? This study investigates to present novel findings for improved and sustainable watersheds management in Ambang through a complete analytical framework and utilizing Multidimensional Scaling (MDS) Method, at the same time, as a benchmark to formulate better policies in handling water related disaster in Indonesia.

2. Material and Method

The research was conducted in Greter Malang District, East Java, Indonesia, from August 2022 to November 2023. This study is a, in addition to write p itself researcher carried on researching on papers before performing research. The idea of 'index evaluation, which is applied to evaluate the situation of sustainable development, has broadened to five aspects: ecological, economic, social, institutional and technological [40].

This study separates the Ambang Sub-watershed area into three zones:

a. Batu City area belongs to the Upper Sub-Watershed,

b. The Area of Malang City belongs to the Middle Sub-Watershed.

c. The Malang District is a part of Hilir sub-watershed.

The division was motivated by the distinctive characteristics of each sub-watershed region and its population, as well as opinions expressed in conversations with experts. The concept of index measurement to assess the state of sustainable development has been extended to cover five dimensions: ecological, economic, social, institutional, and technological [40]. The attribute data that has been collected represents five sustainability facets for the Ambang watershed to include ecological, social, institutional and technological. 3.4 Data collection Expert interviews and literature reviews related information on the characteristics of each attribute within each dimension. What constitutes original data are a) the institutional data, collected at the local level, c) the information on the conditions of land cover, and d) the use of technology, specifically farming's in the way of conservation. This information is the result of interviews with a wide range of stakeholders, including community leaders, farmer associations, non governmental extension agents and government officials, regional government representatives, academics, researchers, and experts. This data is also collected by conducting field work.

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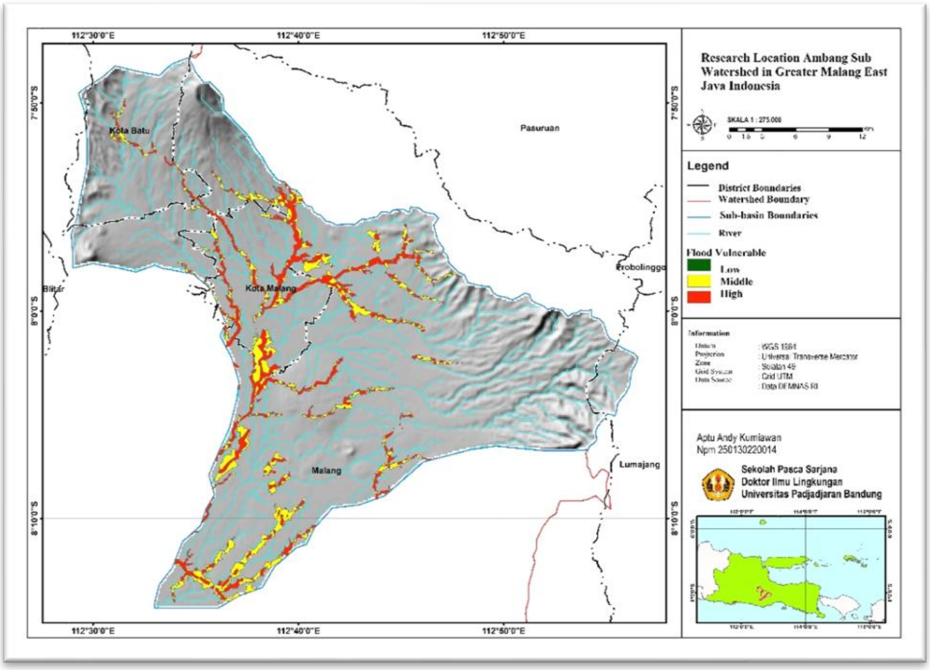

Figure 1. The study area in Greater Malang, East Java, Indonesia.

Data collection was carried out by a number of methods, including participant observation, in-depth and structured interviews, document analysis, and review of the literature. The informants were from the central government, the regional government and community leaders, academicians, non-government counselors, environmentalists, and the community. We selected the expert respondents through purposive sampling based on their experience, knowledge and expertise regarding the Ambang Sub-watershed. Secondary data refers to ecological, economic, and social institutional (which includes rules and organizations), and other relevant information.

3. Results

The level of sustainability of Ambang Sub-watershed management was measured using indicators gathered from literature investigations, interviews, and discussions with expert respondents for each facet of sustainable development. There are a total of 8 indicators in each of the ecological, economic, social, institutional, and technological dimensions. Further analysis is required to determine the key characteristics that have the greatest impact on the sustainability of Ambang Sub-watershed management. These factors are known as indicators and need closer examination.

Table 1. Categorization of the Sustainability Status of Sub watershed Ambang.

No	Indeks Value	Category
1	Not Sustainable	0-25
2	Less Sustainable	26 > index value ≤ 50
3	Sustained	51 > index value ≤ 75
4	Highly sustainable	76 > index value ≤100

Source: Kavanagh, 2001.

Ecological Dimension

The ecological dimension was assessed based on the findings of the literature review, interviews, and discussions with expert respondents. Eight indicators were identified: rainfall, land criticality,

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flood events, landslides, expansion of perennial plantation areas, maintenance of water sources, conversion of land to built-up land, and area planning for settlements.

The ecological dimension of sustainable management in the Ambang River Watershed Sub-District has a value of 53.18 in the upstream area, 63.33 in the middle part, and 54.02 in the downstream area (Figure 2). The three regions are classified as fairly sustainable.

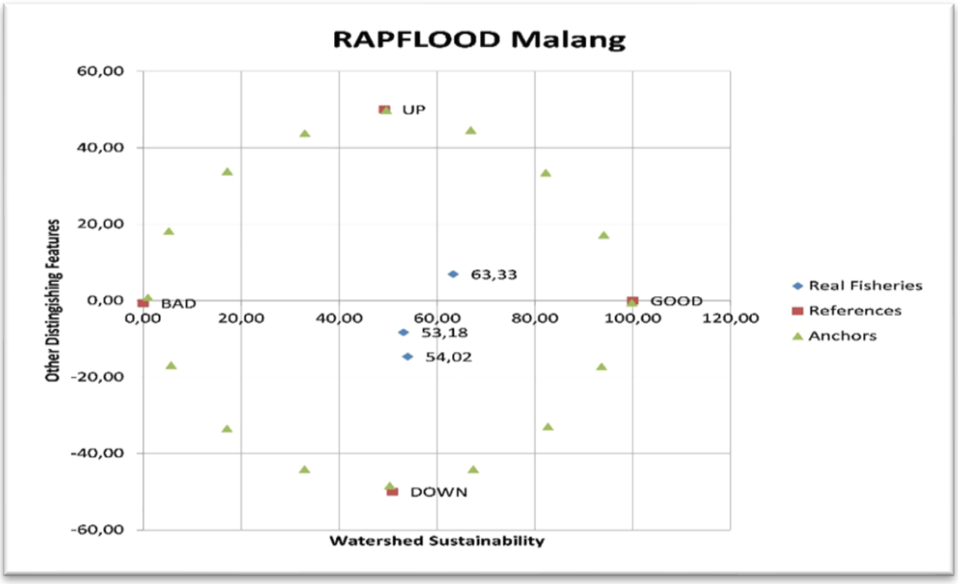

Figure 2. Evaluation of the Ecological Sustainability of Ambang Subwatershed Management.

According to the leverage analysis, the sustainability index value of the Ambang sub-watershed management in the ecological dimension is influenced by three leverage attributes: the possibility for landslides, land cover, and the availability of clean water sources (Figure 3).

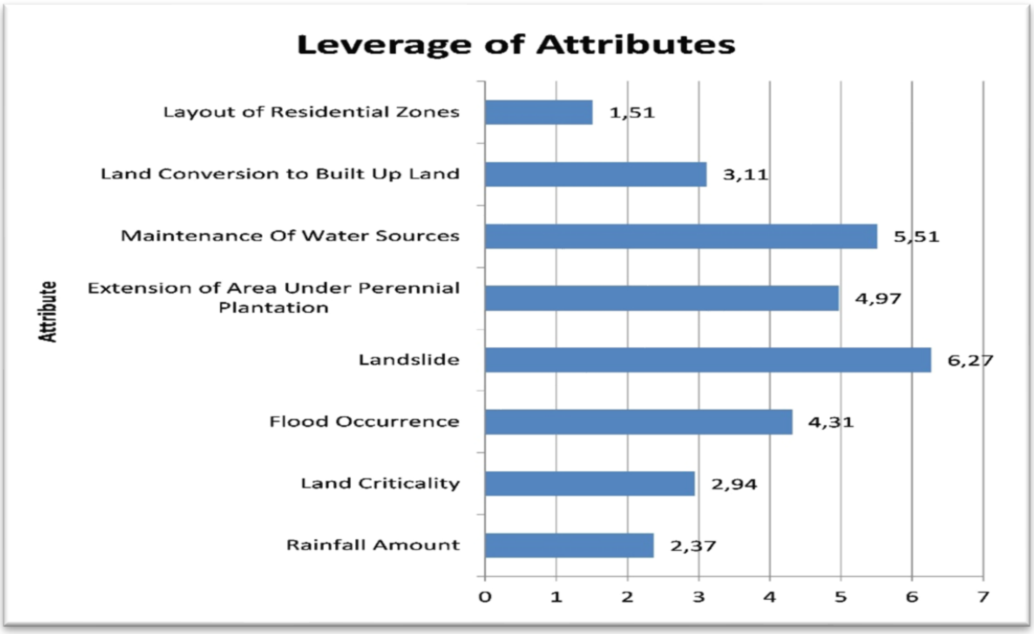

Figure 3. Illustrates the several factors that influence the Ecological Dimension.

4. Discussion

The findings of a preliminary investigation on the correlation between the systems approach to sustainability and the 17 sustainable development goals (SDGs) indicate that this approach defines sustainable development as a convergence of objectives connected to various interconnected systems, specifically environmental (ecological), economic, social, institutional, and technological systems [41]. Research findings of this nature can assist in formulating suitable policy responses to effectively accomplish targeted Sustainable Development Goals (SDGs) [42]. This approach requires cross-disciplinary collaboration, where stakeholders come together to formulate problems and solutions [43]. Cooperation by understanding how systems interact with each other will make policymakers able to design solutions that are more targeted [44,45]. By adopting a more holistic perspective, stakeholders will be able to manage sustainable development challenges more effectively, resulting in more innovative and impactful solutions [46].

In addition to biophysical issues, watershed problems arise as a consequence of disruptions in biophysical, economic, social, political, and institutional aspects [47]. Similar to the results for each dimension mentioned before, a total of 5 parameters were determined to be the most influential levers affecting the value of the multidimensional sustainability index for Mandar watershed management (Table 2). The results of the Monte Carlo analysis and MDS analysis, conducted at a confidence level of 95%, suggest that the discrepancy in value between the two analyses is negligible, or less than 1 (Table 3).

Table 2. Factors affecting the sustainability of Ambang Watershed Management.

No	Leverage Factors	RMS
1	Landslide	6,27
2	Maintenance Of Water Resources	5,51
3	Extension of Area under Perennial Plantation	4,97
4	Flood Occurence	4,31
5	Land Conversion to Build Up Land	3,11

Table 3. Sustainability value (MDS and Monte Carlo).

Dimension	Sub Watershed	Value of Sustainability Index		MDS-MC
		MDS	**Monte Carlo**	
Ecology	Upstream	53,18	53,24	0,06
	Middlestream	63,33	62,48	0,85
	Downstream	54,02	53,37	0,65

This indicates that the MDS analysis methodology employed is “sufficient” for assessing the sustainability level of the Ambang sub-watershed management. The Monte Carlo method can assess the impact of random mistakes on a process and provide an estimation of the actual value of the statistic being studied [48,49]. Table 3 displays the validation estimation outcomes for the five dimensions that exhibit a significant amount of validity, ranging from 0.06% to 0.93%. These results are classified as valid. The analysis output can be deemed a reliable estimating model. The mean sustainability index value for the management of the Ambang sub-watershed is 56.905, indicating consistent performance. This necessitates the requirement for earnest endeavors from all parties or stakeholders in facilitating the administration of the Ambang Sub-watershed.

The results of the multidimensional sustainability analysis of the management of the Ambang sub-watershed indicate that the index values for the upstream, middle, and downstream areas of the Ambang sub-watershed varied across the five dimensions, as shown in Table 3. Enhancing the sustainability of Ambang Sub-Watershed management can be achieved by intervening in Table 2 (21 factors) [29,50,51].

5. Conclusions

Status of sustainability of watershed management on ecological dimension, watershed management included in sustained category. In multidimensional terms, the status of watershed management Ambang is currently at sufficient status sustainable. There are 5 factors at most influence on sustainability management of the Ambang watershed. Improved sustainability status Ambang watershed management can be carried out including through policy interventions and implementation of relevant programs with the 5 most influential factors in sustainable management of the Ambang watershed.

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Authors' contributions: AAK: Conceptualization, Methodology, Software, Investigation, Formal analysis, Funding, Writing—Original Draft; **S, H, IR:** Conceptualization, Methodology, Resources, Supervision; Validation, Writing—Review and Editing.

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