Impact of human and environmental interactions on flooding incident in the Jeneberang River South Sulawesi

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Abstract. Human interaction with the environment due to negative impacts. This can be seen, among others, in the interaction of the community with the environment in the Jeneberang watershed area, South Sulawesi Province, which has an impact in the form of flood events. This paper aims to determine the extent of the impact of human and environmental interactions on flooding in the area. The study was carried out through several studies and studies on human interactions and the natural environment in the Jeneberang watershed, literature studies, reviewing and concluding various journals, as well as collecting data through analysis of maps and secondary data from relevant agencies and primary data from the community as the main actors. The results of the study indicate that human interaction with the environment in the Jeneberang watershed has an impact in the form of flooding because the Jeneberang watershed management activities have not been optimally integrated, which are indicated by: 1. Watershed characteristics are not taken into account in infrastructure development. 2. There is still limited understanding of land-use communities about the characteristics of rainfall and surface runoff, as well as their relation to landslides and sedimentation, 3. The influence of mining activities on river flow narrowing and dam silting is not taken into account, and 4. The occurrence of vegetation degradation in downstream. In order to optimize flood control efforts in the Jeneberang river, it is necessary to carry out integrated management of the Jeneberang watershed by integrating all activities in all sectors. Planning for flood control and environmental conservation in general needs to really consider physical factors in the form of climate, hydrology, geology, tectonics, in addition to vegetation, management, technology, and socio-economic and cultural factors. Communities need to be motivated to continue trying to increase their income and welfare, accompanied by efforts to increase understanding and awareness of the importance of maintaining and preserving the environment, through diversifying livelihoods and utilizing natural resources and land that always prioritizes conservation aspects.

1. Introduction
Humans interact with the natural environment through various patterns of interaction such as land management, agriculture, plantations, mining, fisheries, infrastructure development, settlements, conservation, rehabilitation and so on. Humans always want to benefit from changes in their environment, but these changes can have a negative impact if the principle of environmental sustainability is not considered.
Conditions such as the latter above are what occur in the interaction of people living in the Jeneberang watershed and their environment. One of the negative impacts arising from this interaction is the occurrence of flooding in the downstream watershed. Flooding is a condition of rainwater runoff that exceeds the capacity of the channel and river system, as a result of changes in land use by humans [1]. High surface runoff is influenced by high rainfall intensity, geology, land use (vegetation type and density), topography, slope, slope, area of catchment area or watershed [2].

In 2019 there was a flood downstream of the Jeneberang watershed, namely the cities of Makassar and Sungguminasa (the capital city of Gowa Regency). The flood was caused by high rainfall with intensity > 500 mm that occurred in Gowa and Makassar Districts and an increase in sea level from 1.85 m to 5.73 m within a day, as well as landslides in 6 sub-districts within the Gowa Regency area (BBWS Pompengan 2019).

2. Jeneberang river profile
Along the Jeneberang watershed stretches the Jeneberang River with a length of 90 km [3] stretches from upstream in the West with Mount Bawakaraeng located in Gowa Regency and downstream in the East with Makassar City and parts of Gowa Regency, namely Sungguminasa, the capital city of Gowa Regency. The area of the Jeneberang watershed is 75,494.14 ha (SK.304/MENLHK/PDASHL/DAS.0/7/2018) and dominated by APL 48,949.93 ha (Other Designated area or non-forest area) or around 65% and the rest is forest area [4]. In the middle of this watershed there is the Bili Bili dam which functions primarily as a Jeneberang river flood control, raw water supplier for irrigation, electricity, and agriculture and fisheries, as well as a tourism facility [5]. The Jeneberang watershed is not only fed by the Jeneberang River, but also by one supporting river, namely the Jenelata River. In this watershed there are several cities, namely the City of Malino, Bili Bili, Sungguminasa and Makassar. The topography of the Jeneberang watershed is dominated by an altitude of 100 m to 1000 m (58% of the watershed area), with a slope of 0% to 8% (about 32% of the watershed area), 15% to 25% about 25.54% and 25% to 45% about 22.93% of the watershed area [4].

In the lower part of the Jeneberang River, namely Makassar City, it empties into 3 (three) quite large rivers namely Jeneberang, Tallo and Pampang which are reservoirs for surface water flow originating from the Gowa and Maros Regencies [6]. The condition and existence of the city of Makassar as a coastal area requires that it always prioritizes flood management considerations in every city development plan and activity.

Based on the daily maximum rainfall data that occurred during the period 1976 to 2001 in the Jeneberang watershed, there is an estimate of the possibility of repeated extreme rain events several times. High rainfall results in high surface runoff [3,7]. The Jeneberang watershed has an active tectonic character, so disaster vulnerability needs to be monitored, especially in infrastructure development including the Bili Bili dam which is located in the middle of the watershed, because it can cause flash floods in the Sungguminasa and Makassar areas if it collapses [8].

In the upstream part of the Jeneberang watershed, especially in Malino City and its surroundings, there are residential developments, infrastructure, mining (upstream of the Bili Bili dam) as well as processing of agricultural land and plantations, which are carried out by the community and the private sector. This is supported by the status of the city of Malino as a tourist city, with a number of tourist objects that are crowded with domestic and foreign tourists, which makes the city of Malino as one of the centers of economic growth in Gowa Regency.

3. Methods
The study was conducted through a review of several studies and studies on the interaction of humans and the natural environment in the Jeneberang watershed, literature studies, reviewing, analyzing and concluding various journals, as well as collecting data through map analysis and secondary data from relevant agencies, and primary data from the community as actors. main.
4. Literature Review

4.1. Infrastructure development in the Jeneberang watershed

The road in the Malino area (Gowa Regency) to Manipi (Sinjai Regency) is built across and cuts the northeastern slope of Mount Lompobattang, above Lompobattang volcanic rock which is weathered so that it is prone to erosions every rainy season [3]. The Jeneberang watershed has tectonic conditions active so that infrastructure development needs to pay attention to tectonic conditions, including dams, [8].

Watertight areas such as the construction of physical structures have a major impact on water balance and flooding because they increase runoff. Construction activities damage the topsoil so that the soil is unhealthy, and cannot restore water resources [1].

4.2. Land use in the Jeneberang River Basin

The type of land use and vegetation upstream of the watershed determines the amount of runoff water that goes downstream. The high rainfall which increases runoff can be slowed by upstream vegetation [1]. The upstream Jeneberang watershed has a fine soil texture which can lead to high runoff and erosion [9]. According to Asdak (2010) [2] vegetation can slow down runoff and increase the amount of water retained above the ground surface, thereby reducing the runoff rate and reducing the peak runoff discharge.

4.3. Mining in Jeneberang River Basin

In addition to positive impacts, sand mining also causes negative impacts according to Isa (2020), for the surrounding community it can result in land damage, disruption of flora and fauna, disruption of population health and safety, landslide-prone land and potential flooding, air pollution, dust, water contamination, and road damage due to sand transport.

Sustainable mining management must consider socio-economic, environmental and institutional dimensions by integrating economic and environmental elements in the preparation of a plan or policy [10].

4.4. Vegetation in downstream of the Jeneberang river

Coastal plants are useful as resources, protection and aesthetics, their functions and benefits are fundamental for environmental, social, economic and cultural interests that as a whole support sustainable development in coastal areas. The downstream of the Jeneberang river is the lower part of the Jeneberang watershed. Makassar City is located at the downstream of the Jeneberang River and the Tallo River. Before experiencing rapid development, the natural vegetation at the downstream of the Jeneberang river was the pes-caprae type of sandy beach vegetation, resistant to periodic droughts. Management should be based on the concept that mangroves are part of a wetland system that needs to be maintained because of their hydrological and ecological functions [3].

5. Results

Sustainability of life in the Jeneberang watershed includes various types of activities, Humans as stakeholders interact with the natural environment, will influence and benefit each other, including the community, government and private sector. The community is an actor who directly interacts with nature. The government interacts with the environment indirectly through the preparation of plans, implementing policies, programs, and rehabilitation and conservation activities, while the private sector can directly or indirectly.

The number of settlements in the upstream area of the Jeneberang watershed, especially in forest areas that do not consider biophysical factors, can affect the occurrence of flooding in the downstream area, especially in topography and high slopes, which are prone to landslides when the intensity of rain is high or on soft soil types. This can be seen in the area of vegetation in the Jeneberang watershed which is forest vegetation ranging from 15 % and non-forest vegetation ranging from 85 % (rice fields, agriculture, settlements, dams, and others). Deforestation increased in the Jeneberang watershed from
1990 to 2010, although from 2010 to 2017 there was a decrease, which can be seen from the percentage of land cover from 17.65% (1990) to 16.63% (2020) [4].

The amount of sand and soil mining in the upstream of the Bili Bili dam between the sabo dams without supervision and monitoring, can result in the erosion of topsoil thereby reducing soil fertility, open and hollow soils so that they easily collapse when it rains, community land is damaged when it rains and water overflows, rivers become shallow, soil that is uncovered erodes when the intensity is high, high rainfall and cause sedimentation in the reservoir. Some of the mining is upstream of the Bili Bili dam between the sabo dams.

The use of land in the upstream watershed by local communities, regardless of the climate aspect and the needs and suitability of the land, can result in high surface water runoff when it rains, landslides and ultimately floods. The large number of people who have agricultural and plantation land in the upstream Jeneberang watershed can be seen from the number of villages in the Jeneberang watershed, most of which are in the highlands [11] as well as increasing residential areas, dry land, rice fields and open land in the upstream part of the watershed and decreasing forest area (Map of Jeneberang watershed land cover 2016 and 2019 KLHK). In Gowa Regency and Makassar City, rainfall data recorded at several nearby rain stations show depths exceeding 300 mm/hr. This indicates that the rainfall has been very extreme [4].

The maintenance of the river estuary ecosystem is also important in managing flood, tidal and abrasion events in Makassar City as a downstream area of the Jeneberang watershed. The number of developments in the city of Makassar can be seen from the area of Makassar City of 15,577 Ha with a built area of 11,432.55 Ha or 65% of the area of Makassar City, and the area of green open space is 9.1% [11]. According to the 2014 Makassar City Regulation concerning Green Open Spaces, there are at least 30% of public green open spaces aimed at ecological balance and improving environmental quality. The flood disaster that occurred on the coast of the Jeneberang watershed in 2019 had damaged houses in Makassar City, 477 houses were submerged and In Sungguminasa 604 houses were submerged [11].

| No. | Human Interaction | Expected environmental conditions | Unexpected environmental condition | Impact on Flood incident |
|-----|-------------------|----------------------------------|-----------------------------------|--------------------------|
| 1   | Development of estuary areas | Ecosystem and biodiversity sustainability, protection and security of the coastal environment, community welfare | Loss of natural coastal vegetation with ecological and hydrological functions, as protection and resources for the coastal and estuary environment | Damage to mangrove vegetation that prevents coastal abrasion, as well as reduced wetlands that function as water pockets during the rainy season, making them vulnerable to flooding. |
| 2   | Mining (sand) | River ecosystems and watershed environments are sustainable, biodiversity and soil fertility are maintained, mining results are optimal, and the economy is improving & developing areas | Damage to river ecosystems, silting of rivers, disruption of hydrological functions, damage to community land, | Uncontrolled and unsupervised mining can cause erosion and sedimentation, shallow drainage / rivers / reservoirs, hollow soil and prone to landslides so that when it rains flooding can occur, |
| 3   | Land use (agriculture/plantation) | Sustainability of watershed hydrological function | The hydrological function of the watershed is maintained | Types of plants that are not in accordance with the land can... |
4. Infrastructure and settlement development

Regional development, watershed ecosystem sustainability, watershed hydrological functions, community welfare

Development of infrastructure and settlements is not in accordance with the biophysical condition of the watershed, the destruction of the ecosystem and biodiversity of the watershed, the hydrological function of the watershed is disturbed, prone to disasters.

Development that does not take into account the biophysical characteristics of the watershed can lead to landslides, decreased rainwater infiltration, and increased surface runoff, which has the potential to cause flooding.

6. Conclusion

Based on the explanation above, it can be concluded that human interaction with the environment has the potential to cause an impact in the form of flooding in the Jeneberang River, which is caused by several factors, including:

1. The Jeneberang Watershed Characteristics are not taken into account in infrastructure development,
2. There is still limited understanding of land-use communities about the characteristics of rainfall and surface runoff and their relation to landslides and sedimentation
3. The effect of mining activities on the narrowing of river channels and silting of reservoirs is not taken into account, and
4. The occurrence of vegetation degradation in the downstream of the river.

In order to optimize flood control efforts in the Jeneberang river, it is necessary to implement an integrated Jeneberang watershed management, which integrates all activities in all sectors, and develops synergy between stakeholders in the formulation and implementation of watershed management policies. Planning for flood control and environmental conservation in general, needs to really consider physical factors in the form of climate, hydrology, geology, and tectonics, as well as vegetation factors, management, technology, and socio-economic and cultural factors so as to create a watershed ecosystem diversity, components that are in a state of balance and harmony.

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