Socioeconomic and Environmental Impact Analysis of Sand Mining in Bone River Flow, Indonesia

ABSTRACT

Referring to the issue of sand mining, this study aims to analyze the social, economic, and environmental impacts of sand mining activities in the Bone River basin with a case study in KelurahanPauwo. This research is expected to provide recommendations for sustainable resource management, community economic diversification, as well as strengthening regulation and supervision This research uses quantitative descriptive statistical methods. The survey research method is data collected using a questionnaire with a total of 50 respondents. Then the data was analyzed using regression analysis and qualitative descriptive. The results of statistical analysis show that the research shows that mining activities greatly affect social aspects classified as moderate (0,59), the impact on economic aspects classified as large (0,69) and the impact on environmental aspects classified as very large (0,78) Sand mining activities greatly affect social aspects in the form of changes in social dynamics in the community. Although sand mining provides short-term economic benefits, such as increased income for local communities, the long-term consequences can hinder sustainable economic growth. In addition, sand mining also causes environmental damage, such as erosion and damaged ecosystems.

Keywords: Sustainable resource management, regulation, community economic diversification, supervision,erosion, damaged ecosystems, sustainable economic growth, Environmental Impact, Socioeconomic Impact, Bone River

1. INTRODUCTION

Indonesia is one of the countries that has abundant natural resources, both biological and non-biological. One of these resources is sand, which is an important material in various development activities, such as building construction, reclamation, and shoreline stabilization. Sand mining activities are significant in supporting these needs, but on the other hand cause various impacts on social, economic and environmental aspects. As a form of natural resource exploitation, sand mining not only provides economic benefits, but also carries the risk of environmental damage and social conflict if not managed wisely.

In Gorontalo Province, especially in the Bone River basin, sand mining activities are intensive. This mining is the main livelihood for some local communities, contributing to income and providing employment opportunities. However, this activity also has an impact on the destruction of riverside vegetation, increased erosion and sedimentation, and air pollution. These environmental impacts affect the stability of Bone's watershed ecosystem, which serves an important function as an air catchment area and habitat for various organisms (Gavriletea, 2017; Dan gavriletea, 2017; Adedeji et al., 2014).
In addition to environmental impacts, sand mining activities also bring changes to the social and economic aspects of the surrounding community. Shifts in employment patterns from the agrarian sector to the mining sector, increased conflict between residents, and changes in patterns of social interaction are issues that must be considered. Economically, while providing short-term benefits, sand mining is often unsustainable, and most activities are carried out without official permits, indicating weak supervision and enforcement of regulations.

Previous research has shown significant impacts of mining activities on the environment and communities. Hulukati& Isa, (2020) revealed that searching for sand along the river can damage air quality and disrupt the balance of the ecosystem. Halim et al. (2019) noted that illegal mining contributes to difficult environmental damage. Another study by the center of Ichsan et al., (2018) highlighted the need for strict regulations in managing this activity to reduce its negative impacts.

Referring to the above issues, this research aims to analyze the social, economic, and environmental impacts of sand mining activities in the Bone River basin with a case study in KelurahanPauwo. This research is expected to provide recommendations for sustainable resource management, community economic diversification, and strengthening

regulation and supervision. Thus, this research is not only relevant for local policy-making, but can also serve as a reference for the management of mining activities in other areas.]

2. MATERIAL AND METHODS

[2.1 Type of Research

This research uses quantitative descriptive statistical methods. Descriptive statistical method is a statistical analysis method used to provide an overview or description of the data that has been collected (Aziza, 2023). This study uses an analytical survey method with a cross sectional approach, namely making observations or measuring variables at one time.

2.2 Location and Time of Research

This research was conducted in the Bone River Watershed, Pauwo Village, Gorontalo Province. The estimated research time is approximately 3 months starting from July to October 2024.

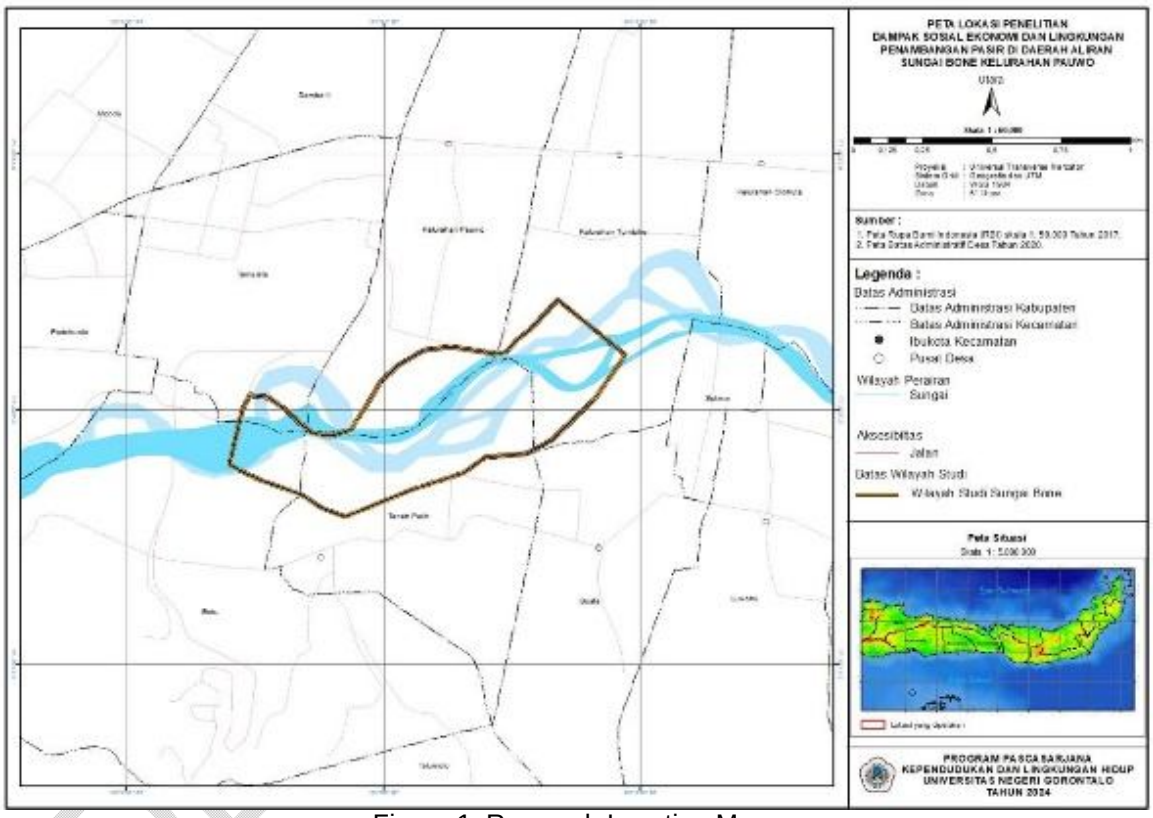

Figure 1: Research Location Map

2.3 Type of Research

This research was conducted in combination with survey methods and qualitative methods. According to Creswell (2023), mixed methods combine two methods in a research activity. However, data collection and analysis are still separated. Data was collected using a cross-sectional approach, where data collection was carried out at one specific time.

2.4 Population and Sample

The population in this study includes all communities affected by sand mining activities in the Bone River Basin, including mining businesses, residents around the mine, and local government officials. The sample was drawn using a simple random sampling technique, which allows each individual in the population to have an equal chance of being selected. This was done so that the sample could represent the entire population well. Researchers divided the sample into several categories, such as mining actors, local residents, and other stakeholders who have involvement or concern about the impact of mining.

2.5 Operational Definition of Research Variables

This study has two research variables, namely the dependent variable and the independent variable. The dependent variables in this research are social, economic and environmental impacts. The independent variable is sand mining activity.

Table1. Operational Definition of Research Variables

No	Variables	Research variables	Definitions and Parameters
1	Independent	Sand mining activities	Excavation below the surface of the land, either on land or under riverbeds, with the aim of extracting non-metallic mineral minerals in the form of sand which has economic significance.
2	Dependent	Social Aspects	Welfare of the sand mining community 1) Job stability 2) Availability of employment
			Social conflict 1) Tensions between local communities and sand miners 2) Criminal incidents related to sand mining
		Economic Aspects	Regional income: 1) Contribution of mining activities 2) Taxes/levies
			Economic diversification
		Environmental Aspects	Erosion and sedimentation
			River Water Quality
			Air Quality
			Noise

2.5 Data Collection and Analysis Techniques

This research uses a combination of survey and qualitative methods. According to Singarimbun and Effendi (2006), the survey method is research that uses a questionnaire instrument to collect data. Respondents were determined by simple randomization with 50 respondents, including sand miners and non-sand miners. In addition, data was also collected through in-depth interviews with key informants. The design and procedures of the quantitative method refer to (Creswell, 2023). The collected survey data were then tabulated and statistically analyzed using SPSS software. The interpretation of the statistical analysis results refers to (Sugiyono, 2009). Moreover, it is also conveyed that before the data is statistically analyzed, it is ensured that it is normally distributed, valid and reliable (Sugiyono, 2009).

3. RESULTS AND DISCUSSION

3.1 Results

This research was conducted in the Bone River Basin, Pauwo Village, Gorontalo Province. Pauwo Village is one of the villages in Kabila District which consists of 4 environments, namely: Environment I, Environment II, Environment III and Environment IV. Based on BPS data in 2023, the population of Pauwo Village is described in the following table.

Table 2. Population of KelurahanPauwo (BPS. 2023)

Environment	family	Soul	
		Male	Female
I	177	264	269
II	199	290	340
III	327	531	521
IV	328	541	532
Total	1031	1626	1684

Sand mining in the Bone River in KelurahanPauwo is carried out through several sand mining processes, namely as follows:

a. Sand excavation process

The process of extracting sand carried out by the community in the Bone River Pauwo Village by using a straw machine. Excavation using a straw machine is done by inserting a hose into the river and directly sucking sand to the riverbank.

Figure 2: Sand excavation process

b. Sand Transportation and Selling ProcessSand is mined using suction equipment and escalators. Then, the sand from the mining is piled up on the riverbank. After a buyer makes a transaction, the sand is sent to the buyer's address using truck transportation. The price of sand is IDR 200,00-Rp 350,000 per dump truck (6.2 cubic meters). The sand is generally used for building materials for housing, offices or government development projects. According to Fridtriyanda et al. (2023), sand mining activities using tools such as those mentioned above impact riverbed changes. It is also conveyed by Xiao et al. (2023) that excessive sand mining changes the landscape, increases carbon emissions, and causes ecological damage, including river flow disruption, erosion, and sedimentation, which negatively affects water quality and flood risk, affecting the environment and biota life.

b. Relationship between sand mining on social impact, economy impact and environmental impact

Table 3 Effects of sand mining on economic, social and environmental aspects

Analysis	Regretion				
	r	R^2	Adjust R^2	F	Sig
The influence of sand mining activities on social impacts	0.590	0.348	0.335	25.65	< 0.001
The influence of sand mining activities on economic impacts	0.659	0.434	0.423	36.85	< 0.001
The influence of sand mining activities on environmental impacts	0.789	0.623	0.615	79,35	< 0.001

Source: Primary data processed, 2024

Based on Table 3 above, sand mining activities have a significant influence on social impacts, economic impacts, and environmental impacts. The explanation of the statistical results is described as follows:

1) The influence of sand mining activities on social impacts
a) The r = 0.590 or the correlation coefficient shows a reasonably strong relationship between sand mining activities and social impacts.
b) The R^2 = 0.348 value indicates that sand mining activities can explain as much as 34.8% of the variation in social impacts. In comparison, 65.2% is influenced by other variables not analyzed in this study.
c) Adjusted R^2 = 0.335 shows consistency that about 33.5% of the variation in social impacts is influenced by mining activities.
d) F-statistic = 25.65 indicates that the regression model is significant and can explain the relationship between the independent and dependent variables.
e) Sig (p-value) = 0.001 This value is smaller than 0.05, indicating that the effect of sand mining activities on social impacts is statistically significant.
2) The effect of sand mining activities on economic impacts
a) r = 0.659, or The correlation coefficient shows a strong relationship between sand mining activities and economic impacts.
b) R^2 = 0.434 indicates that sand mining activities explain 43.4% of the variation in economic impact, while other variables outside the model influence 56.6%.
c) Adjusted R^2 = 0.423 shows the stability of the model with a reasonably strong influence (42.3%).
d) F-statistic = 36.85 indicates that the regression model is significant and can be used to explain the influence of independent variables on economic impact.
e) Sig (p-value) = 0.001 <0.05 indicates that sand mining activities significantly influence economic impacts.
3) The influence of sand mining activities on environmental impacts
a) r = 0.789, or The correlation coefficient shows a robust relationship between sand mining activities and environmental impacts.
b) R^2 = 0.623 indicates that 62.3% of the variation in environmental impacts is explained by sand mining activities, while other variables outside the model influence 37.7%.
c) Adjusted R^2 = 0.615; this value indicates that the regression model remains strong and consistent with an influence of 61.5%.
d) F-statistic = 79.35. This value indicates that the regression model is highly significant.
e) Sig (p-value) = 0.001 < 0.05. This value indicates that the effect of sand mining activities on environmental impacts is highly statistically significant.

3.2 Discussion

This research was conducted to analyze the social, economic and environmental impacts of sand mining activities in the Bone River Basin, Pauwo Village, Gorontalo Province. Illegal sand mining activities in this area have caused significant changes in people's lives and the surrounding environment. In the context of sustainable development, sand mining activities become an urgent issue, especially when conducted without a permit and without considering ecological aspects and the long-term welfare of the community. The results of data analysis obtained from questionnaires and field observations show that there are significant impacts of sand mining activities in Bone River on social, economic and environmental aspects.

3.2.1. Impact on social aspects

Based on the results of the regression analysis, the correlation value (R) of 0.590 shows that there is a moderate positive relationship between sand mining activities and social impacts in Pauwo Village. This means that the higher the sand mining activity, the greater the impact on social aspects that occur in the area. The coefficient of determination (R Square) of 0.348 indicates that 34.8% of the variation in social impacts can be explained by sand mining activities. Meanwhile, the remaining 65.2% is explained by other factors not included in this regression model. The Adjusted R Square value of 0.335 supports this result by considering the adjustment of the number of predictor variables in the model. The Std. Error of the Estimate value of 9.953 indicates the level of standard deviation between the predicted value of social impact generated by the model and its actual value. This value reflects the difference between the predicted results and the real conditions that can still be tolerated.

The ANOVA test results show that the regression model used is statistically significant, with an F-statistic value of 25.654 and a significance value (Sig.) of less than 0.001. This shows that sand mining activities have a significant influence on social impacts in Pauwo Village.

Overall, the results of the analysis show that sand mining activities make a significant contribution to social changes or impacts that occur in the community. However, there are still other factors outside of sand mining activities that play a role in influencing these social impacts, given the coefficient of determination value that does not reach 100%. This means that the greater the mining intensity, the greater the influence on the social life of the community. This activity causes shifts in employment patterns, increased potential for conflict, and changes in social interactions. These results show that the social impact of sand mining is closely related to changes in social interactions in the community.

According to Weber's social action theory cited in Supraja (2015), changes in the structure of society due to economic activities (in this case sand mining) can cause changes in the social action patterns of individuals and groups. Communities that used to depend on the agrarian sector are now starting to shift to the mining sector, which brings social consequences, such as income inequality and potential conflicts between residents. From the results of the analysis, mining activities carried out without government permission have the potential to increase social uncertainty, where previously prevailing community norms and values begin to shift. This is in line with human ecology theory, which emphasizes that irregular changes in the use of natural resources can cause disruptions in the interaction between humans and their environment.

3.2.2. Impact on economic aspects

The analysis results show that there is a fairly strong relationship between Sand Mining Activities and Economic Impacts, with a correlation value (R) of 0.659. In addition, the R Square (R^2) value of 0.434 indicates that sand mining activities can explain 43.4% of the variation in economic impacts. The remaining 56.6% is explained by other factors not included in this model.

The Adjusted R Square value of 0.423 provides a more realistic picture of the model's capabilities after adjusting for the number of samples and variables. This shows that the regression model used is quite valid in explaining the relationship between the predictor variables and the dependent variable.

In the ANOVA table, the F-statistic value of 36.857 with a significance level p-value <0.001 confirms that the regression model is statistically significant. This means that the relationship between sand mining activities and overall economic impacts does not occur by chance. With a Standard Error of the Estimate value of 11.812, this model has a moderate level of prediction error.

The economic impact of sand mining activities can be analyzed using sustainable development theory. Many people earn income from this activity, either as miners, transporters or sellers. However, long-term economic impacts need to be considered given the potential for environmental degradation that could be detrimental to other economic productivity, such as agriculture. While these activities provide economic benefits in the short term, such as increased income for surrounding communities, the negative effects in the long term could potentially hinder sustainable economic growth. In this theory, sustainability refers to the balance between economic gain, social welfare and environmental sustainability. Unregulated mining activities can permanently damage the environment, resulting in the degradation of natural resources that play an important role in supporting the local economy in the future. A decline in water and land quality, for example, will affect agricultural productivity and the availability of clean water (Pertiwi, 2021).

3. Impact on environmental aspects

The results of the regression analysis show that there is a strong relationship between Sand Mining Activities and the dependent variable, as indicated by the correlation value (R) of 0.789. The R Square (R^2) value of 0.623 indicates that sand mining activities are able to explain 62.3% of the variation in the dependent variable, while the rest (37.7%) is influenced by other factors not included in this model.

In addition, the Adjusted R Square value of 0.615 confirms that this model remains reliable even though it has been adjusted for the number of samples and variables. The Standard Error of the Estimate value of 3.588 indicates that the level of prediction error in this model is relatively low, which indicates that the model has good accuracy. This is in line with research conducted by (Rosita et al., 2022) which states that the negative impacts on the environment caused are air pollution, sound and soil conditions during the rainy season cannot hold water infiltration so that the surrounding community settlements have many puddles. The results of the field assessment show that sand mining activities affect the following environmental impacts.

a) River Water Quality

Observations showed that the river water in the area was turbid (Figure 3) and slightly smelly. This indicates an increased level of water pollution, which is most likely caused by sedimentary materials released during the mining process.This impact indicates that mining activities have damaged the aquatic ecosystem and reduced river water quality, potentially affecting the life of aquatic biota. This is in accordance with the results of research conducted by Arisandi, (2022) which states that the Bone River still looks clear, except in the downstream section where the turbidity increases to 80 NTU, this is due to the C excavation mining activity, which causes turbidity levels and exceeds the PerMenKes limit.

Figure 3. Water Conditions in the Bone River in Pauwo Village

b) Vegetation Conditions on the Riverbank

Observations show that mining activities have eroded the riparian area of the riverbank as shown in Figure 4. Some vegetation habitats were affected by cliff erosion so that vegetation in the area fell down. According to Damseth et, al (2024) sand mining damages vegetation by altering sediment flow and deposition, leading to bank erosion and loss of river ecosystem services. This disturbance affects the natural habitat, resulting in reduced plant life and ecological balance in the river environment.

Figure 4. Vegetation Condition of the Bone River in Pauwo Village

c) Erosion and Sedimentation

Based on field observations, Bone River bank erosion, especially in the sand mining area, occurs massively, as shown in Figure 5 below. According to (**Arora & Kumar, 2024),** disruption of the natural flow of rivers due to sand mining leads to bank erosion, increased sedimentation, and decreased water quality. These changes adversely affect aquatic biodiversity and increase the risk of flooding, significantly impacting the river ecosystem.Erosion caused by sand mining will have further impacts. As stated by Damseth (2024), erosion increases sedimentation and turbidity, and the amount of pollutants stored in the water increases. Sand and gravel mining is the cause of river flooding, riverside land degradation, loss of productive land, and changes in river flow.

Figure 5. The condition of the Bone River in Pauwo Village, which has experienced erosion and sedimentation.

The environmental damage caused by sand mining in Bone River can be explained using ecosystem theory. Mining activities have caused significant environmental degradation, such as decreased water quality, vegetation damage, and erosion and sedimentation that damage the river ecosystem. Ecosystem theory emphasises the importance of maintaining a balance between the components of nature, including water, land, and living organisms (Djohar, 2017). The erosion and sedimentation observed in Pauwo Village's Bone River indicates that mining activities have accelerated the process of land degradation, which will ultimately disrupt the ecological functions of the river as a habitat for various species and as a water resource for humans. This damage not only impacts biodiversity, but also ecosystem services that are critical to society, such as flood control and clean water provision.

Overall, sand mining in the Bone River basin of KelurahanPauwo has a significant environmental impact, with most environmental indicators in the moderate category. This activity has a direct impact on water quality, vegetation health, soil stability, and air and sound quality. Although the impacts do not reach critical levels, if these activities continue without adequate intervention or regulation, more severe environmental damage is likely to occur in the future. Therefore, mitigation measures are needed to reduce these negative impacts, both through enforcement of mining regulations and environmental restoration in the affected watershed areas.]

4. CONCLUSION

Sand mining activities significantly affect the social aspects of changing social dynamics in the community. While sand mining provides short-term economic benefits, such as increased income for local communities, the long-term consequences can hinder sustainable economic growth. Moreover, sand mining causes environmental damage, such as erosion and degraded ecosystems.

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DETAILS OF THE AI USAGE ARE GIVEN BELOW:

1.

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