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

ABSTRACT

This study aims to analyze the social, economic, and environmental impacts of sand mining activities in the Bone River, particularly in Pauwo Village, Gorontalo Province. Using a descriptive quantitative approach, data were collected through questionnaires and field observations. The results indicate significant impacts across the three aspects. Socially, sand mining activities have led to a shift in employment from agriculture to mining, increased conflicts among residents, and changes in social interaction patterns. Economically, sand mining has become a primary source of income for the local community, though its benefits are short-term and unsustainable. Environmentally, mining activities have degraded water quality, damaged riverbank vegetation, and caused erosion and sedimentation that threaten soil stability around the river. These findings suggest that sand mining in the Bone River Basin provides immediate economic benefits but poses a risk of long-term environmental degradation. Most sand mining activities are conducted illegally without proper permits, highlighting weak oversight and enforcement of regulations. This study recommends sustainable resource management, economic diversification, and enhanced monitoring to balance economic benefits with environmental preservation.

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Keywords: [Sand mining, social impact, economic impact, environmental impact]

1. INTRODUCTION

Indonesia is one of the countries that has abundant natural resources, both biological and non-biological. One of 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.

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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.
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 eco Halim et al. (2019) noted that illegal mining contributes to difficult environmental damage. Another study by the c Ichsan et al., (2018) highlighted the need for strict regulations in managing this activity to reduce its negative impac

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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.

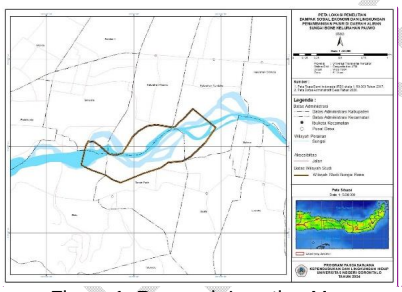

Figure 1: Research Location Map

2.3 Type of Research

The research was conducted with an analytical survey method using a cross-sectional approach, where data collection was carried out at one specific time. It aims to capture a snapshot of the social, economic and environmental conditions affected by sand mining activities simultaneously.

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

Comment [KB4]: Move the mining processes in heading 3.0 Results and Discussion to follow this heading. This means that mining processes should be 2.3. This will allow better flow of the text and understanding

Comment [KB5]: Figure 1 should be enlarged to see the text and map. Currently, it can not be read, and it does not look good.

No	Variables	Research variables	Definitions and Parameters
			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

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2.5 Data Collection and Analysis Techniques

The instrument or tool used for data collection in this study is a questionnaire. The questionnaire is a data collection method that is carried out by giving a set of questions or written statements to respondents (Rahman, 2019). The data analysis techniques that will be carried out by researchers in this study are grouped as follows:
1.Validation and Reliability Test

The validity and reliability test of the questionnaire used in this study aims to determine the extent to which a measuring instrument can be trusted in measuring. This validity test is carried out using ms excel with the criteria, if r count> r table then the statement is declared valid, and if r count < r table then the statement is declared invalid.

2.Normality Test

Data normality is the main requirement that must be met in parametric analysis. This aims to determine whether the data is normally distributed or not. The normality of data is important because with normally distributed data, the data is considered to represent a population. The normality test used in this study is to use the One Sample Kolgomorov-Sirminov method.

3.Hypothesis Test

Hypothesis testing in this study uses linear regression analysis, namely the dependent variable Y, and one independent variable X and has a rank of one. In this study, simple linear regression analysis was used to:

a) Knowing the effect of sand mining activities (X) on social impacts (Y)

b) Knowing the effect of sand mining activities (X) on economic impacts (Y)

c) Knowing the effect of sand mining activities (X) on environmental impacts (Y)

4.Significance Analysis

Significance analysis is used to test the overall significance of the model. If the significance value <0.05, the overall model is significant. (Senjaya et al., 2022).]

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 Process

Transportation to dig sand miners use trucks and pick up trucks. The sand that has been sucked up is collected first on the river body and waiting for sand buyers. mining products in the form of sand are sold to the general public and companies in need. The process of selling sand is transported directly to the mining location, the price of sand sold is IDR 200,000-IDR 350,000 per dumtruk already with the cost of loading sand, the cost of the car is borne by the sand buyer.

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The process of buying and selling sand involves various groups, both for the purposes of building houses, building government projects, and building other projects.

Figure 3: Sand transportation and sales process

Analysis of the social, economic and environmental impacts of sand mining was carried out by giving questionnaires to respondents. The results of the respondents' questionnaires were then analyzed statistically. The results of the construct validity test and the validity of the instrument items show that the instrument is valid with the value of r count> r table. After testing the validity of the items, using the Chornbach alpha formula through the alpha results obtained 0.981> 0.7 with very reliable criteria. Based on the results of the Kolmogorof-Sirminov normality test, the research data is normally distributed, and can be continued in hypothesis testing using linear regression analysis.

Table 3

3.1.1 Relationship between sand mining activities on social impact

Table 4 Summary of Input data for the model analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.590[a]	.348	.335	9.953

a. Predictors: (Constant), Aktivitas_Penambangan_Pasir

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Comment [KB17]: Include the limitation of the data collected, the challenges, and whether it is repeatable.

Comment [KB18]: Add Table 3 of the statistical breakdown of the dataset of the population who conducted the survey. This should account for the total number of people, family breakdown, mean, ……..

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ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2541.153	1	2541.153	25.654	<,001[b]
	Residual	4754.681	48	99.056		
	Total	7295.834	49			

a. Dependent Variable: Dampak_Sosial

b. Predictors: (Constant), Aktivitas_Penambangan_Pasir

Figure 4. Regression analysis results of the influence of sand mining activities on social impacts

3.1.2 Relationship between sand mining activities on economic impact

Table 6 Summary of Input data for the model analysis

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.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.659[a]	.434	.423	11.812

a. Predictors: (Constant), Aktivitas_Penambangan_Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5142.773	1	5142.773	36.857	<,001[b]
	Residual	6697.531	48	139.532		
	Total	11840.304	49			

a. Dependent Variable: Dampak_Ekonomi

b. Predictors: (Constant), Aktivitas_Penambangan_Pasir

Figure 5. Regression analysis results of the effect of sand mining activities on economic impact

3.1.1 Relationship between sand mining activities on environmental impact

Table 8 Summary of Input data for the model analysis

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.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.789[a]	.623	.615	3.588

a. Predictors: (Constant), Aktivitas_Penambangan_Pasir

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Comment [KB22]: Need the statistical quantitative results as done for the respect of the comparison

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ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1021.279	1	1021.279	79.350	<,001[b]
	Residual	617.783	48	12.870		
	Total	1639.063	49			

a. Dependent Variable: Dampak_Lingkungan

b. Predictors: (Constant), Aktivitas_Penambangan_Pasir

Figure 6. Regression analysis results of the effect of sand mining activities on environmental impacts

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The regression analysis results show that there is a strong relationship between Sand Mining Activities and the dependent variable, as indicated by the correlation (R) value 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.

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 show that the river water in the area is turbid and slightly odorous. This indicates an increased level of water pollution, most likely caused by sedimentary materials released during the mining process.

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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 7. Water Conditions in the Bone River in Pauwo Village

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b) Vegetation Conditions on the Riverbank

Much of the vegetation on the riverbank is damaged, which can be caused by the erosion process that occurs due to sand mining. Lost or damaged vegetation will reduce the ability of the area to resist erosion, and disrupt habitat for fauna that depend on riverbank vegetation. Miftahul, (2024) in his research said that in some parts of the river the bone substrate was disturbed, eroded and removed from the river due to the discovery of straightening and dredging of river stones and sand so that the condition of the river water was murky, the shade of vegetation on the riverbanks began to decrease replaced by agricultural land and residential areas and quite a lot of erosion was found on the riverbanks.

Figure 8. Vegetation Condition of the Bone River in Pauwo Village

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c) Erosion and Sedimentation

Observations showed moderate erosion occurring in some parts of the river. This erosion, coupled with visible sedimentation, indicates that the land around the river is no longer stable, and this is exacerbated by continuous sand excavation. These impacts not only damage the local environment, but also have the potential to cause significant flooding and land degradation in the long term (Miftahul, 2024).

Figure 9. The condition of the Bone River in Pauwo Village, which has experienced erosion and sedimentation.

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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 in Bone River, Pauwo Village, have a significant impact on the social aspects of the community. These impacts include changes in employment patterns from the agrarian sector to the mining sector, increased conflict between residents, and disruption of social relations. High mining intensity contributes to the disruption of local community norms and values, which increases the potential for social tension. Sand mining activities show a fairly strong relationship to economic impacts with a correlation value (R) of 0.659. 43.4% of the variation in economic impacts can be explained by this activity. Sand mining contributes to increased community income in the short term, but is less sustainable. This indicates the need for economic diversification to reduce dependence on mining activities. Sand mining has significant negative impacts on the environment, including degradation of river water quality, erosion, sedimentation, and destruction of vegetation around the river. It also increases the risk of natural disasters, such as floods and landslides, which threaten environmental sustainability and the stability of local ecosystems.]

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