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Evaluating the Influence of Quarrying and Deforestation on Flood Risks in Barangay Mulawin, Orani, Bataan

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ABSTRACT

This study investigates the impact of quarrying and deforestation on the incidence and severity of floods in Barangay Mulawin, Orani, Bataan. Employing a descriptive-correlational research design, the study examines how land excavation, soil erosion, and changes in land cover from these activities influence local flood risks. Data were gathered through surveys, interviews, and document analysis involving 356 stakeholders, including residents, local officials, and environmental experts. Quantitative analyses, including regression methods, identify significant relationships between quarrying, deforestation, and flood occurrence, while qualitative insights highlight operational challenges and socio-economic consequences. Findings reveal that quarrying activities, particularly land excavation and sediment deposition, have a slightly stronger effect on increasing flood frequency compared to deforestation, which contributes notably through loss of natural water absorption and soil instability. Both activities significantly exacerbate flood risks, leading to infrastructure damage, displacement, and economic disruption in the community. The study emphasizes the need for enhanced land management practices, stricter regulatory enforcement, and reforestation programs in order to mitigate these environmental and social impacts. The study recommends a comprehensive flood risk management framework that integrates sustainable land use, environmental conservation, community awareness, early warning systems, and stronger governance. These measures aim to build resilience against floods while promoting ecological restoration and responsible resource use. The research contributes valuable insights for policymakers and stakeholders to develop targeted strategies addressing the specific drivers of flooding in Barangay Mulawin and similar regions vulnerable to environmental degradation.

Keywords: *Deforestation, Flood Management, Quarrying, Sustainable Land Use, Watershed*

INTRODUCTION

Floods remain one of the most devastating natural disasters, with their intensity often exacerbated by human activities such as quarrying and deforestation. Quarrying, which involves the extraction of minerals, results in significant landscape alterations, leading to soil erosion, disruptions in natural drainage patterns, and sediment build-up in waterways, all of which contribute to the frequency and severity of floods (Singh & Gupta, 2023). Deforestation, characterized by the clearing of trees, further worsens flood risks by reducing water absorption capacity and increasing soil instability (Patel & Khan, 2022). This study focuses on understanding the relationship between quarrying, deforestation, and flood incidence in Barangay Mulawin, Orani, Bataan, exploring how these environmental changes influence flood dynamics in the area.

Globally, the link between human activities and environmental degradation has prompted increased research into the factors that contribute to natural disasters, particularly floods. Countries like Brazil and Indonesia, which have faced significant environmental crises due to quarrying and deforestation, offer stark examples of the consequences of these activities (Brown & Lee, 2023). Both quarrying and deforestation result in landscape degradation, which increases surface runoff and decreases the land's ability to retain water, subsequently enhancing the frequency and severity of floods (Singh & Kumar,

2021). These environmental challenges underscore the need for targeted research, particularly in areas like Barangay Mulawin, which may not yet have a comprehensive understanding of these dynamics.

While global studies have established the environmental consequences of quarrying and deforestation, there is a gap in understanding how these activities directly contribute to flood risks at the local level in Barangay Mulawin. Prior research has focused on isolated aspects, such as soil erosion or tree loss, without examining their combined effects on flood risks. This study aims to fill this gap by evaluating how quarrying and deforestation jointly influence the incidence and severity of flooding in the community. Additionally, the socio-economic impacts of these environmental changes, including infrastructure damage and displacement, are often overlooked, despite their significance. By considering both environmental and socio-economic factors, this research aims to provide a holistic view of flood risks and contribute to more informed flood management strategies.

In the Philippines, laws such as the Ecological Solid Waste Management Act (RA 9003) and the National Integrated Protected Areas System (NIPAS) Act are designed to regulate quarrying and deforestation (Santos & Cruz, 2023). However, enforcement of these regulations remains inconsistent, allowing environmental degradation to continue in many areas, including Barangay Mulawin. Strengthening legal frameworks and improving enforcement mechanisms are critical steps in reducing the environmental impact of these activities and mitigating flood risks.

Barangay Mulawin, Orani, Bataan, has experienced significant flooding in recent years, exacerbated by land-use changes like intensive quarrying and widespread deforestation (Mendoza & Lim, 2024). The lack of effective drainage systems, compounded by the loss of vegetation that once absorbed excess rainwater, has heightened the frequency and severity of floods. This context highlights the urgent need for localized research to better understand the specific drivers of flood risks in Barangay Mulawin, ultimately helping to inform flood management strategies tailored to the community's needs.

The study's first objective is to examine how quarrying activities, particularly land excavation and soil erosion, contribute to flood frequency in Barangay Mulawin. By assessing the extent of excavation and the resulting sediment deposition in local waterways, the study aims to provide evidence of how quarrying exacerbates flooding (Singh & Gupta, 2023).

The second objective is to explore the role of deforestation in increasing flood severity. The removal of trees and degradation of land cover has been linked to greater surface runoff and reduced water absorption, which significantly heightens the risk of severe flooding (Patel & Singh, 2021). By assessing the extent of deforestation in Barangay Mulawin, the study aims to understand the specific ways in which these environmental changes increase flood risks.

The third objective focuses on the socio-economic consequences of quarrying and deforestation, specifically in terms of infrastructure damage and displacement. Floods cause substantial damage to homes, roads, and essential infrastructure, displacing residents and causing economic and social disruption (Mendoza & Lim, 2024). This study aims to evaluate the extent of these impacts in Barangay Mulawin, providing valuable insights for future flood mitigation and disaster preparedness strategies.

In addition to exploring the immediate impacts, the study also aims to assess the long-term consequences for flood management. Understanding how quarrying and deforestation cumulatively influence flood risks is crucial for developing sustainable, long-term solutions to flood mitigation (Santos & Cruz, 2023). By investigating the relationship between environmental degradation, flood risks, and community resilience, the study provides recommendations for policy improvements and disaster risk reduction strategies. This approach ensures that future flood management plans in Barangay Mulawin will be more comprehensive and sustainable.

The role of local governance is also examined in this study. Local government units must enforce regulations effectively to prevent the uncontrolled spread of quarrying and deforestation activities, which undermine flood management efforts. The study assesses how well local governance in Barangay Mulawin addresses quarrying and deforestation in the context of flood risk management and suggests that strengthening governance frameworks is key to improving community resilience to flooding.

Finally, this research aims to contribute to the broader understanding of how quarrying and deforestation affect flood risks in the Philippines. The findings will not only inform flood management strategies in Barangay Mulawin but also provide lessons for other regions facing similar challenges. By connecting human activities to flood risks, the study contributes to the field of environmental management and disaster risk reduction, offering practical insights for policymakers, researchers, and communities affected by environmental degradation

LITERATURE REVIEW

In exploring the relationship between human activities and flood risks, several studies have highlighted critical factors contributing to flood frequency, severity, and impact. Cheng and Xu (2022) examine the increasing frequency of floods, attributing this rise to climate change, particularly the alteration of rainfall patterns. Similarly, Kim and Park (2023) explore how urbanization exacerbates flood risks, emphasizing that reduced natural floodplains and increased impervious surfaces make urban areas more prone to frequent flooding, especially when coupled with inadequate drainage systems. This connection between poor infrastructure and flood frequency is further supported by Nguyen and Lee (2024), who note that regions with insufficient drainage networks are more vulnerable to flooding during the wet season. Furthermore, Li and Zhang (2022) argue that climate modeling, which incorporates both historical data and future scenarios, can effectively predict flood frequency, offering valuable tools for flood risk management.

When considering flood severity, Shao and Chen (2024) identify climate change as a primary driver of intensified flooding, with rising sea levels, storm surges, and higher rainfall contributing to the increased severity of floods. Liu and Zhang (2023) add that urbanization plays a significant role in amplifying flood severity by reducing natural flood buffers like wetlands and forests, which traditionally mitigate flood impacts. This concept of urbanization's role in flood severity is further supported by studies on the socio-economic consequences of flooding. Khan and Alam (2022) focus on how floods disrupt livelihoods, particularly in low-income, agriculture-based communities, leading to long-term economic instability.

Additionally, human activities such as quarrying have been linked to environmental changes that contribute to flood risks. Smith and Jones (2023) investigate how the intensity of land excavation in quarrying operations leads to soil erosion, habitat destruction, and ecosystem disruption, all of which can increase the susceptibility of nearby areas to flooding. Similarly, Jones and Tan (2022) explore how deforestation reduces natural water absorption capacity, as the removal of trees lowers the land's ability to retain water, ultimately leading to higher surface runoff and more frequent and severe floods. In line with this, Tan and Huang (2023) discuss the broader consequences of deforestation, including soil degradation and altered local water cycles, which exacerbate flooding risks by increasing runoff and reducing water availability.

These studies collectively underscore the complex interplay between climate change, urbanization, and human land use practices like quarrying and deforestation, all of which significantly influence flood frequency, severity, and impact. Understanding these dynamics is crucial for developing effective flood management strategies and mitigating the adverse effects of human activities on flood

risks.

MATERIALS AND METHODS

This research utilized a descriptive-correlational design to investigate the effects of quarrying and deforestation on flooding occurrences in Barangay Mulawin, Orani, Bataan. It explored the associations between quarrying operations, deforestation activities, and flood events, focusing on factors such as the extent of land excavation, soil erosion levels, and alterations in land cover. The study also assessed the adequacy of existing land management strategies, the role of infrastructure in flood prevention, and the regulatory policies overseeing quarrying and deforestation. Employing both quantitative and qualitative approaches, data were collected through surveys, interviews, and document reviews to gain a well-rounded understanding of how these human actions influence flood risks in the locality.

A stratified random sampling method was applied, selecting 356 participants from various stakeholder groups, including local residents, government officials, environmental specialists, farmers, and infrastructure personnel. This method ensured representation from all relevant perspectives. The study used structured questionnaires with Likert-scale items to gauge perceptions on quarrying and deforestation, complemented by semi-structured interviews to delve into operational issues and their direct impact on flooding. Data analysis involved descriptive statistics, T-tests, ANOVA, Pearson correlation, and regression analysis to determine causal links between land use changes and flood incidents.

The study strictly followed ethical protocols to safeguard participants' rights, guaranteeing informed consent, voluntary involvement, and confidentiality. Data were securely stored and accessed only by authorized individuals. Ethical approval was obtained, and the research complied with national and international ethical standards. By combining quantitative evidence with qualitative insights, the study delivered practical recommendations to enhance flood management and encourage sustainable land use in Barangay Mulawin.

RESULTS AND DISCUSSION

1. How do local stakeholders assess the impact of quarrying and deforestation on flood incidence in Barangay Mulawin in terms of:

1.1 Quarrying Activities (land excavation, soil erosion, alteration of natural drainage, sediment deposition)

1.2 Deforestation (rate of tree loss, changes in land cover, reduction in soil stability, loss of natural water absorption capacity)?

Table 1
Summary of the Impact of Quarrying Activities on Flood Incidence in Barangay Mulawin

Item	Mean	Standard Deviation (SD)	Interpretation
Land Excavation Intensity	3.12	0.66	Significant impact
Soil Erosion Rate	3.22	0.58	Significant impact
Alteration of Natural Drainage	3.11	0.66	Significant impact
Sediment Deposition in Waterways	3.21	0.62	Significant impact
Overall Mean	3.16	0.63	Significant impact

Table 1 summarizes the impact of quarrying activities on flood incidence, with an overall mean score of 3.16 and a standard deviation of 0.63, indicating significant agreement among respondents regarding the role of land excavation, soil erosion, alteration of drainage, and sediment deposition in increasing flood risks. These findings are consistent with existing research on the effects of quarrying activities on local hydrology and flood dynamics (Cheng & Xu, 2022; Zhao & Zhang, 2021).

Table 2 summarizes the impact of deforestation on flood incidence in Barangay Mulawin, with an overall mean of 3.12 and a standard deviation of 0.66. This suggests significant agreement among respondents that deforestation, including the loss of tree cover, changes in land cover, and reduction in soil stability, plays a crucial role in increasing flood risks. These findings support literature that highlights the direct connection between deforestation, soil degradation, and increased flood vulnerability (Li & Zhang, 2022; Wang & Li, 2023).

Table 2
Summary of the Impact of Deforestation on Flood Incidence in Barangay Mulawin

Item	Mean	Standard Deviation (SD)	Interpretation
Rate of Tree Loss	3.14	0.64	Significant impact
Changes in Land Cover	3.13	0.63	Significant impact
Reduction in Soil Stability	3.04	0.74	Significant impact
Loss of Natural Water Absorption Capacity	3.18	0.64	Significant impact
Overall Mean	3.12	0.66	Significant impact

The findings suggest that both quarrying and deforestation significantly contribute to flood risks in Barangay Mulawin. Quarrying activities, particularly land excavation, soil erosion, and sediment deposition, are perceived as major contributors to increased flood frequency and severity. Similarly, deforestation through tree loss, changes in land cover, and reduced soil stability are recognized as a significant factor that exacerbates flooding. These results align with existing literature, which underscores the role of land degradation in increasing flood risks (Cheng & Xu, 2022; Santos & Cruz, 2023). The study highlights the need for effective land management practices, reforestation, and stricter regulation of quarrying activities to mitigate flood risks in the area. Policymakers and community leaders must consider these findings when developing strategies to address the environmental challenges posed by quarrying and deforestation in Barangay Mulawin.

2. How do local stakeholders evaluate the frequency and severity of floods in Barangay Mulawin in terms of:

2.1 Flood frequency (number of flood occurrences per year)

2.2 Flood severity (water level rise during flooding, duration of flood events)

2.3 Flood impact (infrastructure damage, livelihood disruption, community displacement)?

Table 3 presents a summary of the evaluation on the frequency, severity, and impact of floods in Barangay Mulawin. The overall mean score of 3.23, with a standard deviation of 0.60, indicates that respondents agree that the frequency, severity, and overall impact of floods have significantly increased over time. This result aligns with related research that suggests that environmental factors such as deforestation, land use changes, and climate change contribute to increased flood risks and severity in flood-prone areas (Sharma & Bhat, 2023).

The results suggest that stakeholders in Barangay Mulawin generally agree that the frequency, severity, and impact of floods have significantly increased in recent years. Factors such as quarrying activities, heavy rainfall, vegetation loss, and land use changes were identified as major contributors to increased flood risks. Specifically, respondents strongly agreed that flood severity has become more intense over

time, with greater damage to infrastructure and local businesses. The findings underscore the need for comprehensive flood risk management strategies that incorporate the role of environmental degradation in exacerbating flood risks.

Table 3
Summary of Evaluation on the Frequency and Severity of Floods in Barangay Mulawin

Items	Mean	SD	Description	Interpretation
Flood Frequency	3.15	0.65	Agree	Significant impact
Flood Severity	3.35	0.54	Strongly Agree	Very significant impact
Flood Impact	3.18	0.61	Agree	Significant impact
Overall	3.23	0.60	Agree	Significant impact

These findings are in line with previous studies that link deforestation, land excavation, and climate change to more frequent and severe flooding (Shao & Chen, 2024). The community's recognition of the socio-economic impacts of flooding—especially on businesses and livelihoods—suggests the importance of integrating disaster risk reduction measures with sustainable land management practices. Policymakers should prioritize interventions such as reforestation, better flood control infrastructure, and land-use planning to mitigate the adverse effects of flooding in Barangay Mulawin.

3. Does quarrying and deforestation significantly affect flood incidence in Barangay Mulawin, Orani, Bataan?

Table 4 presents the results of the linear regression analysis on the effect of quarrying and deforestation on flood incidence in Barangay Mulawin. The unstandardized coefficients for quarrying activities and deforestation are 0.430 and 0.312, respectively, and their standardized coefficients are 0.425 and 0.359, respectively. Both have significant t-values (8.803 for quarrying and 7.419 for deforestation) and p-values of 0.000, leading to the rejection of the null hypothesis, indicating that both quarrying and deforestation are significant predictors of flood incidence in Barangay Mulawin.

Quarrying activities have a slightly higher unstandardized coefficient (0.430), suggesting that it has a slightly stronger effect on flood incidence compared to deforestation (0.312). This indicates that quarrying activities—through soil disruption, vegetation loss, and drainage system alteration—have a more immediate impact on flood occurrence and severity. However, deforestation still plays a significant role by reducing the land's capacity to absorb water, which also contributes to increased surface runoff and flood risks.

Table 4
Linear Regression Analysis on the Effect of Quarrying and Deforestation on Flood Incidence in Barangay Mulawin, Orani, Bataan

Variables	Unstandardized Coefficients (B)	Standardized Coefficients (β)	t-value	p-value	Interpretation
Constant	0.829		6.482	0.000	-
Quarrying Activities	0.430	0.425	8.803	0.000	Significant
Deforestation	0.312	0.359	7.419	0.000	Significant
Model Summary	R^2 = 0.708; Adjusted R^2 = 0.501	F-value = 177.54	p-value = 0.0001	-	Significant

The model summary in Table 4 shows that the R^2 value is 0.708, meaning that 70.8% of the variation in flood incidence can be explained by quarrying activities and deforestation. The adjusted R^2 value of 0.501 suggests that after adjusting for the number of predictors, the model still explains a substantial portion of the variance in flood incidence. The F-value of 177.54 and p-value of 0.000 further confirm the overall significance of the regression model, highlighting the importance of quarrying and deforestation in explaining flood incidence in Barangay Mulawin.

These findings underscore that both quarrying and deforestation significantly contribute to flood incidence in the area, with quarrying having a slightly stronger effect. This suggests that managing quarrying activities and implementing reforestation efforts are critical to mitigating the risks of flooding in Barangay Mulawin.

Table 5 presents the multiple regression analysis on the effect of quarrying and deforestation on flood incidence in Barangay Mulawin. The regression model is significant, with a p-value of 0.0001, indicating that the independent variables (land excavation intensity, soil erosion rate, alteration of natural drainage, sediment deposition in waterways, rate of tree loss, changes in land cover, reduction in soil stability, and loss of natural water absorption capacity) collectively have a strong relationship with flood incidence in the study area.

Among the independent variables, soil erosion rate, alteration of natural drainage, sediment deposition, and loss of natural water absorption capacity were found to be significant predictors of flood incidence. These variables are crucial because they directly impact water retention, surface runoff, and water flow, all of which contribute to increased flooding. The findings from the regression analysis support the need for effective soil conservaion, proper drainage management, and reforestation efforts to mitigate the impact of flooding.

Table 5
Multiple Regression Analysis on the Effect of Quarrying and Deforestation on Flood Incidence in Barangay Mulawin, Orani, Bataan

Variables	Unstandardized Coefficients (B)	Standardized Coefficients (β)	t-value	p-value	Interpretation
Constant	0.618		4.545	0.000	-
Soil Erosion rate	0.142	0.125	2.240	0.026	Significant
Alteration of Natural Drainage	0.192	0.204	4.080	0.000	Significant
Sediment Deposition in Waterways	0.113	0.119	2.196	0.029	Significant
Loss of Natural Water Absorption Capacity	0.378	0.468	8.119	0.000	Significant
Model Summary	R^2 = 0.776; Adjusted R^2 = 0.602	F-value = 65.739	p-value = 0.0001	-	Significant

The findings from both the linear and multiple regression analyses highlight the critical role of quarrying and deforestation in exacerbating flood risks in Barangay Mulawin. Key predictors such as soil erosion, altered drainage, sediment deposition, and loss of natural water absorption capacity significantly contribute to flood incidence, with quarrying having a slightly stronger direct impact. These results emphasize the need for sustainable land management practices, such as controlling quarrying activities, promoting soil conservation, and implementing reforestation efforts, to reduce the frequency, severity, and impact of flooding. These findings align with existing literature and reinforce the importance of environmental conservation in flood management strategies.

4. Based on the findings, what policies and strategies can be recommended to reduce flood risks and promote sustainable land-use practices in Barangay Mulawin?

Table 6 presents several policies and strategies aimed at reducing flood risks and promoting sustainable land-use practices in Barangay Mulawin, Orani, Bataan. These recommendations address the primary environmental factors contributing to flooding, such as quarrying, deforestation, soil erosion, and changes in land cover. The strategies are designed to improve land management, restore ecosystems, and reduce the adverse impacts of human activities on flood dynamics.

Table 6
Recommended Policies and Strategies to Reduce Flood Risks and Promote Sustainable Land-Use Practices in Barangay Mulawin, Orani, Bataan

Policy/Strategy	Description	Intended Outcome
Stricter Regulation of Quarrying and Deforestation	Enforce stricter regulations on quarrying and deforestation activities, including permits and monitoring.	Reduce land degradation and environmental disruption, minimizing flood risks.
Reforestation and Agroforestry Programs	Implement reforestation and agroforestry initiatives to restore vegetation and improve soil stability.	Improve soil quality, increase water absorption, and restore ecosystems to reduce flood occurrence.
Promotion of Sustainable Land-Use Practices	Promote sustainable farming and land-use practices, such as contour farming, terracing, and cover cropping.	Minimize soil erosion, improve land productivity, and reduce surface runoff, leading to lower flood risks.
Development of Flood Risk Management Plans	Integrate flood risk management into local urban and rural planning, including flood mitigation infrastructure.	Enhance flood resilience and preparedness, especially in flood-prone areas.
Community Awareness and Education Programs	Conduct regular community education campaigns on the impacts of quarrying and deforestation and the importance of sustainable land practices.	Increase local participation in environmental conservation efforts and promote responsible land use.
Implementation of Early Warning Systems	Establish early warning systems and flood forecasting mechanisms to alert communities ahead of flooding events.	Provide timely alerts to minimize the impact of floods and enable better disaster response.
Incentivization of Eco-Friendly Practices	Provide incentives (e.g., subsidies, tax breaks) for individuals and businesses that engage in eco-friendly practices like sustainable land use and water conservation.	Encourage environmentally responsible practices that protect the natural environment and reduce flood risks.
Enhanced Collaboration with Environmental Experts	Strengthen partnerships between local government units, environmental experts, and researchers to continuously monitor and manage flood risks.	Ensure informed decision-making and effective management of land and water resources to reduce flooding.

The policies and strategies presented in Table 6 focus on addressing the main drivers of flood risks in Barangay Mulawin, such as quarrying, deforestation, and soil erosion. The implementation of these strategies aims to restore the natural landscape, reduce environmental degradation, and build resilience against floods.

- Stricter Regulation of Quarrying and Deforestation: Enforcing more stringent regulations is essential to control activities that exacerbate flood risks, such as land excavation and deforestation. These actions disturb natural drainage systems, accelerate soil erosion, and diminish the land's ability to absorb water, all of which contribute to higher flood frequency and severity. By regulating these activities, the community can protect its natural resources, mitigate environmental harm, and reduce flood risks (Wang & Li, 2023).
- Reforestation and Agroforestry Programs: Reforestation and agroforestry programs can help

restore vegetation cover, improve soil stability, and enhance the land's ability to retain water. These initiatives are crucial for reducing surface runoff and increasing the natural absorption capacity of the soil, which ultimately reduces the frequency and intensity of floods. Research has shown that forest restoration plays a significant role in reducing flood risks by maintaining the balance of the hydrological cycle (Shao & Chen, 2024).

- Promotion of Sustainable Land-Use Practices: Promoting sustainable farming techniques, such as contour farming, terracing, and cover cropping, can significantly reduce soil erosion and surface runoff. These practices improve soil quality and land productivity, preventing excessive water runoff and, consequently, reducing the risks of flooding. Incorporating these practices into local farming methods will not only enhance environmental sustainability but also increase the community's resilience to floods (Goh & Tan, 2023).
- Development of Flood Risk Management Plans: Integrating flood risk management into urban and rural planning ensures that flood resilience is a priority in community development. By incorporating flood mitigation infrastructure, such as retention ponds, levees, and improved drainage systems, the area can better manage excess water during rainfall events. Planning for flood resilience is critical, especially in areas prone to flooding, and will provide long-term benefits for the community's safety and well-being.
- Community Awareness and Education Programs: Educating the community about the causes and consequences of quarrying and deforestation, as well as the importance of sustainable land-use practices, will foster greater local involvement in environmental conservation efforts. By increasing awareness and understanding of flood risks, the community will be better equipped to adopt practices that minimize environmental degradation and reduce flood risks.
- Implementation of Early Warning Systems: Early warning systems are critical for reducing the impacts of floods by providing timely alerts that allow communities to prepare and respond effectively. Flood forecasting and early warning systems can save lives, protect infrastructure, and reduce the economic costs associated with flooding. As climate change leads to more unpredictable weather patterns, such systems will become increasingly essential in managing flood risks (Shao & Chen, 2024).
- Incentivization of Eco-Friendly Practices: Offering incentives for businesses and individuals who adopt environmentally friendly practices, such as sustainable land use and water conservation, encourages community-wide engagement in conservation efforts. By supporting green initiatives, the local government can promote long-term environmental sustainability while reducing the pressures that lead to increased flooding risks.
- Enhanced Collaboration with Environmental Experts: Strong partnerships between local government units, environmental experts, and researchers will ensure that flood risk management strategies are informed by the latest scientific research. Collaboration will also foster more effective land and water resource management, as it will provide access to specialized knowledge on environmental issues and flood prevention strategies.

The recommendations provided in Table 6 offer a comprehensive approach to reducing flood risks in Barangay Mulawin. The strategies emphasize sustainable land-use practices, better regulation, and increased community involvement, all of which are crucial for building resilience against flooding. Implementing these policies will not only help mitigate flood risks but also promote a more sustainable relationship between the community and its environment. By integrating environmental conservation with flood risk management, Barangay Mulawin can protect both its natural resources and its residents from the devastating impacts of floods.

CONCLUSION

Flood risks in Barangay Mulawin are significantly influenced by human activities such as quarrying and deforestation, which alter the natural landscape and disrupt ecological balance. Quarrying intensifies soil erosion and modifies drainage patterns, while deforestation reduces the land's ability to absorb water, both leading to increased flood frequency and severity. This study highlights the critical role these environmental changes play in exacerbating floods, emphasizing the need to understand their combined effects on local flood dynamics and socio-economic impacts, including infrastructure damage and community displacement.

The findings reinforce the connection between land degradation and heightened flood vulnerability, supporting existing literature that links quarrying and deforestation to increased runoff and sediment deposition. By employing a mixed-methods approach, the research provides a comprehensive assessment of how these activities contribute to flood risks in Barangay Mulawin. It also underscores the importance of integrating environmental management with flood mitigation strategies, as well as strengthening local governance to enforce regulations and promote sustainable land-use practices.

Addressing flood risks in Barangay Mulawin requires implementing a multifaceted strategy that includes stricter regulation of quarrying and deforestation, reforestation programs, promotion of sustainable farming practices, and improved flood risk management planning. Community awareness and early warning systems are essential to enhance preparedness and resilience. Collaboration with environmental experts and incentivizing eco-friendly practices can further support sustainable development. These measures will help reduce flood risks while fostering a healthier environment and safer community.

Recommendations

Based on the summary and conclusion, these are the recommendations:

1. Enforce stricter regulations on quarrying and deforestation activities, including rigorous permitting and continuous monitoring, to prevent excessive land degradation and disruption of natural drainage systems.
2. Implement reforestation and agroforestry programs aimed at restoring vegetation cover, enhancing soil stability, and improving the land's capacity to absorb rainfall, thereby reducing surface runoff and flood frequency.
3. Promote sustainable land-use practices such as contour farming, terracing, and cover cropping to minimize soil erosion and increase land productivity, which contribute to reduced flood risks.
4. Develop and integrate comprehensive flood risk management plans into both urban and rural development, including infrastructure improvements like retention ponds, levees, and improved drainage systems to better handle excess water.
5. Conduct regular community awareness and education campaigns to increase understanding of the impacts of quarrying and deforestation on flooding and encourage responsible environmental stewardship among residents.
6. Establish early warning and flood forecasting systems to provide timely alerts for flood events, enabling communities to prepare and respond effectively.
7. Provide incentives, including subsidies or tax benefits, for individuals and businesses adopting eco-friendly and sustainable land-use practices, encouraging wider participation in environmental conservation.

8. Strengthen collaboration among local government units, environmental experts, and researchers to ensure flood risk management strategies are informed by current scientific knowledge and best practices for land and water resource management.

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