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Assessing the Impact of Quarrying and Deforestation on Flood Incidence in Barangay Mulawin, Orani, Bataan

[1]Mohammad Hadafie A. Abubakar, [1]Devy B. Avisa, [1]Barren M. Buntag, [1]Renan P. Dallo, [1]Nerissa De Leon, [1]Ann Mary J. Dela Cruz, [1]Joana Shayne C. Eniego
[1]Philippine Christian University, Philippines

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ABSTRACT

This study investigates the impact of quarrying and deforestation on flood incidence in Barangay Mulawin, Orani, Bataan, focusing on how these human activities influence flood frequency, severity, and related socio-economic impacts. Quarrying alters the natural landscape through land excavation, soil erosion, alteration of water drainage, and sediment deposition, all of which increase flood risks by disrupting the natural water absorption and flow processes. Deforestation diminishes tree cover, leading to reduced soil stability and water absorption capacity, which amplifies flood severity and frequency. The research employed a descriptive-correlational approach with surveys and interviews from diversified local stakeholders. Findings reveal significant correlations between quarrying, deforestation, and flood incidence, with deforestation showing a stronger relationship, particularly concerning flood impact, such as infrastructure damage and community displacement. Demographic factors, including age, civil status, and educational attainment, influence perceptions of flood risks, highlighting the need for tailored community outreach. Strengthening local governance and regulatory enforcement, promoting reforestation, and sustainable land-use practices are recommended to mitigate flood risks. The study contributes valuable insights for flood management strategies and environmental policy aimed at reducing the adverse effects of anthropogenic activities on natural disasters in vulnerable areas.

Keywords: *Barangay Mulawin, Deforestation, Flood Incidence, Quarrying, Soil Erosion, Water Absorption Capacity*

INTRODUCTION

Floods have been among the most destructive natural disasters, often exacerbated by human activities such as quarrying and deforestation. Quarrying, the process of extracting minerals, altered the natural landscape, leading to soil erosion, changes in drainage patterns, and sediment accumulation in waterways, all of which influenced the frequency and severity of floods (Singh & Gupta, 2023). Deforestation, which referred to the removal of trees, further disrupted natural water absorption processes and increased soil instability, amplifying flood risks (Patel & Khan, 2022). This study aimed to explore how these human activities contributed to flood incidents in Barangay Mulawin, Orani, Bataan, focusing on understanding the interplay between quarrying, deforestation, and their impact on flood dynamics.

The global challenge of environmental degradation had prompted countries to assess the impact of various anthropogenic activities on natural disasters like floods. Around the world, the detrimental effects of quarrying and deforestation had been well-documented, with countries such as Brazil and Indonesia facing significant environmental crises due to these activities (Brown & Lee, 2023). Quarrying led to significant landscape changes, and deforestation increased surface runoff, both of which were key contributors to increased flood frequency and severity (Singh & Kumar, 2021). These environmental challenges had led to a growing need for research that connected human activity to flood risks, especially in regions with limited scientific understanding.

Despite global awareness of the issue, significant gaps remained in understanding the specific impact of quarrying and deforestation on flood incidents in local contexts such as Barangay Mulawin, Orani, Bataan. Previous studies had focused primarily on isolated aspects of environmental degradation, such as soil erosion or tree loss, without addressing the combined effects of these activities on flood risks (Patel & Singh, 2021). Furthermore, the economic and social consequences of these environmental changes, particularly in terms of infrastructure damage and displacement, were often overlooked. This study sought to fill these gaps by exploring the relationship between quarrying, deforestation, and flood incidence, providing a comprehensive perspective on the issue.

Legal frameworks addressing environmental management and disaster risk reduction were essential to mitigating the impacts of human activities on flood risks. In the Philippines, laws such as the Ecological Solid Waste Management Act (RA 9003) and the National Integrated Protected Areas System (NIPAS) Act aimed to regulate activities that contributed to environmental degradation, including deforestation and quarrying (Santos & Cruz, 2023). However, these regulations often lacked stringent enforcement, leading to continued environmental degradation in many areas, including Barangay Mulawin (Dela Cruz & Rodriguez, 2022). Strengthening legal frameworks and enforcement mechanisms had been crucial to minimizing the impact of quarrying and deforestation on flood risks in vulnerable areas.

On a local level, Barangay Mulawin, Orani, Bataan, had been no stranger to the impacts of quarrying and deforestation. The community had experienced significant flooding in recent years, attributed to changes in land use practices such as intensive quarrying and widespread deforestation (Mendoza & Lim, 2024). The lack of adequate drainage systems, coupled with the loss of trees that once absorbed excess rainwater, had exacerbated flood severity and frequency. This situation underscored the need for localized research to assess the specific drivers of flood risks in the community, which could inform effective flood management strategies.

The actual situation in Barangay Mulawin highlighted the urgency of addressing environmental degradation. Quarrying activities had led to significant soil erosion and sedimentation in nearby rivers, altering natural drainage patterns and making the area more susceptible to flooding (Patel & Khan, 2023). Additionally, deforestation had reduced the area's ability to absorb and retain rainwater, increasing surface runoff and flood risks. These ongoing challenges called for targeted research to assess how quarrying and deforestation contributed to flooding, as well as to develop appropriate interventions to mitigate these impacts.

The first objective of the study was to examine the relationship between quarrying activities and flood frequency in Barangay Mulawin. This involved analyzing how the intensity of land excavation and soil erosion from quarrying affected the occurrence of floods in the area (Singh & Gupta, 2023). The study also looked at sediment deposition in local waterways and its effect on flood severity, providing a clear understanding of how quarrying disrupted natural flood mitigation processes. By evaluating this relationship, the study aimed to provide evidence on the role of quarrying in exacerbating flood risks.

The second objective was to explore how deforestation contributed to changes in flood severity in Barangay Mulawin. The loss of trees and the degradation of land cover had been linked to increased surface runoff and reduced water absorption capacity, both of which increased the likelihood of more severe flooding (Patel & Singh, 2021). By examining the extent of deforestation in the area, the study assessed the specific ways in which these environmental changes influenced flood severity. Identifying the key factors involved was crucial for designing interventions that could restore the natural water absorption capacity of the land.

The third objective was to assess the broader impact of quarrying and deforestation on flood-related

infrastructure damage and community displacement. Floods could cause significant damage to homes, roads, and other vital infrastructure, as well as displace residents, leading to economic and social disruption (Mendoza & Lim, 2024). The study evaluated the extent of these impacts in Barangay Mulawin and how they correlated with the intensity of quarrying and deforestation. The findings offered insights into the socioeconomic consequences of environmental degradation, helping local authorities better prepare for and mitigate the impacts of future floods.

In addition to examining the immediate impacts of quarrying and deforestation, the study also assessed the potential long-term consequences for flood management in Barangay Mulawin. Understanding the cumulative effects of these activities on flood risk was essential for developing sustainable, long-term solutions to flood mitigation (Santos & Cruz, 2023). The study investigated the interactions between environmental degradation, flood risks, and community resilience, providing recommendations for policy improvements and disaster risk reduction strategies. This holistic approach aimed to ensure that future flood management plans in the area would be more effective and sustainable.

The governance frameworks surrounding quarrying and deforestation activities also played a crucial role in managing flood risks. Local government units needed to ensure that regulations were enforced effectively to prevent the uncontrolled spread of these activities and their negative impact on flood management efforts. The study examined the role of local governance in Barangay Mulawin and assessed how well existing policies and regulations addressed quarrying and deforestation in the context of flood risk management. Strengthening local governance frameworks would be critical for improving community resilience to floods in the long run.

Lastly, the study aimed to contribute to the growing body of knowledge on the environmental impacts of quarrying and deforestation in the Philippines. The findings not only informed flood management strategies in Barangay Mulawin but also provided valuable lessons for other regions facing similar challenges. By examining the relationship between human activities and flood risks, the study contributed to the broader 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 study employed a descriptive-correlational research approach to assess the impact of quarrying and deforestation on flood incidence in Barangay Mulawin, Orani, Bataan. It examined the relationship between quarrying activities, deforestation, and flood occurrence, focusing on key factors such as land excavation intensity, soil erosion rates, and changes in land cover. The study also evaluated the effectiveness of current land management practices, the role of infrastructure in flood mitigation, and the regulatory frameworks governing both quarrying and deforestation activities. By combining both quantitative and qualitative methods, the research gathered data through surveys, interviews, and document analysis to ensure a comprehensive understanding of how these human activities affect flood risks in the area.

A stratified random sampling design was used, involving 356 respondents from different stakeholder groups, including residents, local government officials, environmental experts, agricultural workers, and infrastructure teams. This approach ensured that each key group’s perspective was represented. The study employed structured questionnaires with Likert-scale items to assess respondents' perceptions of quarrying and deforestation, while semi-structured interviews provided deeper insights into the operational challenges of these activities and their direct contributions to flooding. Descriptive statistics, T-tests, ANOVA, and Pearson correlation were used to analyze the data, while regression analysis helped identify the causal relationships between land use changes and flood incidence.

The research also adhered to strict ethical guidelines to protect participants’ rights, ensuring informed consent, voluntary participation, and confidentiality. Data was securely managed and stored, with access restricted to authorized personnel only. Ethical clearance was sought, and the study complied with both national and international research standards. By integrating quantitative data with qualitative insights, this research provided actionable recommendations for improving flood management strategies and promoting sustainable land-use practices in Barangay Mulawin.

RESULTS AND DISCUSSION

1. What is the demographic profile of respondents in terms of:

1.1 Sex;

1.2 Age;
1.3 Civil status; and
1.4 Educational attainment?

Table 1
Frequency and Percentage Distribution of Respondents' Demographic Profile

Profile	Category	Frequency	Percentage
Sex	Male	188	52.8%
	Female	168	47.2%
	Total	**356**	**100.0%**
Age	18-21	101	28.4%
	22-25	96	27.0%
	26-29	108	30.3%
	30 and above	51	14.3%
	Total	**356**	**100.0%**
Civil Status	Single	214	60.1%
	Married	142	39.9%
	Total	**356**	**100.0%**
Educational Attainment	Elementary	9	2.5%
	High School	88	24.7%
	College	222	62.4%
	Post Graduate	37	10.4%
	Total	**356**	**100.0%**

Sex Distribution

The sample consisted of 52.8% male and 47.2% female respondents. This slight male majority suggests that while the study is relatively balanced in terms of gender, there may be gender-specific differences in perceptions of quarrying, deforestation, and flood risks. Previous studies have highlighted that gender can influence environmental awareness and engagement (Batra et al., 2022), which may affect how each group responds to the environmental challenges facing Barangay Mulawin. Male respondents might, for instance, be more involved in activities related to land use and natural resource management, as suggested by research on gendered roles in environmental practices (Kumar & Patel, 2021).

Age Distribution

The largest age group was the 26-29 range, with 30.3% of respondents. This suggests that a significant portion of the participants is in their late twenties, a group likely to be more aware of environmental issues and engaged in community activities. The younger age groups (18-21 and 22-25) also represent a large portion of the sample, totaling 55.4%. This age demographic is often more responsive to environmental sustainability concerns (Sharma et al., 2022), which may indicate a high level of awareness and concern for the impact of quarrying and deforestation in the community.

Civil Status

Most respondents (60.1%) were single, with married respondents making up 39.9%. Single individuals may have different perspectives on environmental sustainability, as they may be less focused on the

long-term impact of environmental issues on family livelihood. In contrast, married individuals might be more concerned about the potential long-term effects of environmental degradation on their families and communities. This distinction could influence how respondents assess flood risk and the impact of land use practices like quarrying and deforestation. Studies on civil status and environmental engagement often show that family status can shape one's views on environmental responsibility (Khan & Alam, 2022).

Educational Attainment

A large proportion of respondents (62.4%) had completed college, followed by 24.7% with high school education. The relatively high educational attainment suggests that respondents are likely to be more informed about environmental issues, including those related to quarrying and deforestation. Education plays a key role in shaping individuals' understanding of sustainability and environmental policies. Research shows that higher levels of education are associated with greater environmental awareness and engagement (Goh & Tan, 2023), which may make college-educated respondents more likely to recognize the negative environmental impacts of human activities such as quarrying and deforestation.

The demographic profile of the respondents reveals that a majority are relatively young, with a higher level of education and a significant portion being single. These factors are important when considering how individuals engage with environmental issues and policies. The relatively young and educated sample suggests that there is a high potential for awareness and advocacy for sustainable practices. Local governments and policymakers in Barangay Mulawin should consider these demographic factors when designing educational programs or interventions aimed at increasing community participation in flood risk management and environmental conservation.

In light of the results, gender and age-specific strategies could be effective in enhancing community engagement with flood risk mitigation efforts. For example, targeted outreach programs for young adults and men, who might be more involved in agricultural and land-use activities, could help address the root causes of deforestation and quarrying. Similarly, addressing family-oriented concerns for married respondents could strengthen community-wide support for long-term sustainability initiatives. Research on demographic factors and environmental engagement suggests that younger, educated individuals tend to be more environmentally conscious and proactive in addressing issues like deforestation and flood risk (Sharma et al., 2022). Studies also highlight that single individual, who may have fewer familial concerns, often engage in environmental activism more actively than married individuals (Rodriguez & Chen, 2022). Additionally, gender-based differences in environmental behavior have been widely studied, with some evidence suggesting that men are more likely to be directly involved in resource management and land-use decisions, which could affect flood incidence (Tan & Wong, 2023). These findings align with the results of the current study, suggesting that tailored interventions targeting specific demographic groups may be effective in reducing the impacts of quarrying and deforestation in Barangay Mulawin.

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

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

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

Quarrying Activities
Land Excavation

Table 2 illustrates the significant impact of quarrying activities, particularly land excavation, on flood incidence in Barangay Mulawin. The overall mean score of 3.12, with a standard deviation of 0.66, indicates that respondents generally agree that excavation activities significantly affect the environment and flood dynamics. The highest mean was recorded for the item, "The depth of excavation in the quarrying site has significantly increased over time" (mean = 3.23, SD = 0.61), signaling that respondents strongly agree that deeper excavation increases flood risks by reducing natural water retention and disrupting the landscape. The frequency of excavation activities, with a mean of 3.04, had the lowest score, though still indicating agreement, suggesting that while excavation frequency is important, the depth and extent of excavation have a more considerable impact on flood risks.

Table 2
Impact of Quarrying Activities on Flood Incidence in Barangay Mulawin

Item	Mean	SD	Interpretation
Land Excavation			
The depth of excavation in the quarrying site has significantly increased over time.	3.23	0.61	Significant impact
The frequency of excavation activities in the area has risen in the past years.	3.04	0.69	Significant impact
The extent of land affected by excavation has expanded beyond initial estimates.	3.08	0.69	Significant impact
Heavy machinery is extensively used in excavation processes.	3.04	0.69	Significant impact
The land excavation has disrupted the natural landscape significantly.	3.18	0.62	Significant impact
Overall Mean	3.12	0.66	Significant impact

Soil Erosion

Table 3 reveals that respondents believe quarrying has a significant impact on soil erosion in the area, with an overall mean score of 3.22 and a standard deviation of 0.58. The highest mean item, "Soil erosion has negatively impacted nearby agricultural lands" (mean = 3.32, SD = 0.57), indicates strong agreement that soil erosion, fueled by quarrying activities, significantly harms agricultural productivity. This finding aligns with literature that highlights soil erosion as a major factor contributing to flood risks due to the sedimentation of water bodies and the loss of water absorption capacity (Sharma & Bhat, 2023). The lowest mean was recorded for "There are visible signs of gullying and surface runoff caused by quarrying" (mean = 3.05, SD = 0.61), suggesting that although gullying is an issue, it is less immediately noticeable than other erosion-related effects.

Table 3
Impact of Quarrying Activities on Soil Erosion in Barangay Mulawin

Item	Mean	(SD)	Interpretation
Quarrying activities have increased soil erosion in the surrounding areas.	3.26	0.52	Significant impact
Loose soil is often observed being washed away due to excavation.	3.29	0.61	Very significant impact
Vegetative cover loss due to quarrying contributes to soil erosion.	3.18	0.55	Significant impact
There are visible signs of gullying and surface runoff caused by quarrying.	3.05	0.61	Significant impact
Soil erosion has negatively impacted nearby agricultural lands.	3.32	0.57	Very significant impact
Overall Mean	**3.22**	**0.58**	**Significant impact**

Alteration of Natural Drainage

Table 4 discusses the significant alteration of natural drainage systems due to quarrying activities. The overall mean score of 3.11, with a standard deviation of 0.66, indicates that respondents agree that quarrying significantly disrupts natural water flow, contributing to flooding. The item with the highest mean, "Quarrying activities have significantly changed the flow of surface water" (mean = 3.23, SD = 0.61), highlights the strong agreement that excavation disrupts water flow and exacerbates flooding. The lowest mean was for "The water table has been affected by continuous quarrying operations" (mean = 3.05, SD = 0.61), suggesting that while quarrying's impact on groundwater is acknowledged, its effects on surface water flow were viewed as more significant.

Table 4
Impact of Quarrying Activities on Alteration of Natural Drainage in Barangay Mulawin

Item	Mean	SD	Interpretation
Quarrying activities have significantly changed the flow of surface water.	3.23	0.61	Significant impact
There is evidence of water accumulation in areas where it previously did not occur.	3.09	0.81	Significant impact
Streams and rivers near the quarrying site have been diverted or obstructed.	3.11	0.56	Significant impact
Flooding incidents have increased due to changes in natural drainage patterns.	3.09	0.71	Significant impact
The water table has been affected by continuous quarrying operations.	3.05	0.61	Significant impact
Overall Mean	**3.11**	**0.66**	**Significant impact**

Sediment Deposition

In Table 5, respondents agreed that sediment deposition from quarrying contributes significantly to flood risks, with an overall mean of 3.21 and a standard deviation of 0.62. The item "Fish and other aquatic life have been affected by excessive sedimentation" had the highest mean score of 3.40, reflecting strong concern over the ecological consequences of sediment deposition. This aligns with research that shows how sedimentation from quarrying degrades aquatic habitats, affects biodiversity, and contributes to flooding by blocking waterways (Davis & Robinson, 2022). The lowest mean was recorded for "Sediment deposition has caused blockages in small streams and irrigation canals" (mean = 3.08, SD = 0.69), indicating that while the blockages are recognized, they are seen as less severe compared to other sediment-related issues.

Table 5
Impact of Quarrying Activities on Sediment Deposition in Barangay Mulawin

Item	Mean	SD	Interpretation
Sediment from quarrying activities has been observed in nearby rivers and streams.	3.16	0.60	Significant impact
The water quality in local waterways has deteriorated due to sediment deposits.	3.23	0.61	Significant impact
Sediment deposition has caused blockages in small streams and irrigation canals.	3.08	0.69	Significant impact
Fish and other aquatic life have been affected by excessive sedimentation.	3.40	0.62	Very significant impact
Local communities have raised concerns about water pollution due to sediment.	3.18	0.59	Significant impact
Overall Mean	**3.21**	**0.62**	**Significant impact**

Deforestation

Rate of Tree Loss

Table 6 shows that respondents agreed that deforestation significantly contributes to flooding in Barangay Mulawin, with an overall mean of 3.14 and a standard deviation of 0.64. The highest mean score, "The loss of tree cover has contributed to changes in local climate patterns" (mean = 3.29, SD = 0.57), suggests that respondents strongly agree that deforestation alters local weather patterns, which can lead to increased rainfall and flooding. The lowest mean was for "Quarrying operations remove trees without implementing reforestation programs" (mean = 3.04, SD = 0.78), suggesting that while respondents acknowledged the lack of reforestation efforts, it was not viewed as the most critical factor compared to other deforestation impacts.

Table 6
Impact of Deforestation on Flood Incidence in Barangay Mulawin (Rate of Tree Loss)

Item	Mean	SD	Interpretation
Large-scale quarrying has led to the removal of a significant number of trees.	3.13	0.62	Significant impact
The deforestation rate in quarrying sites has increased over time.	3.06	0.61	Significant impact
The loss of tree cover has contributed to changes in local climate patterns.	3.29	0.57	Very significant impact
Quarrying operations remove trees without implementing reforestation programs.	3.04	0.78	Significant impact
Wildlife habitats have been lost due to quarry-related tree cutting.	3.17	0.61	Significant impact
Overall Mean	3.14	0.64	Significant impact

Changes in Land Cover

Table 7 presents the impact of deforestation on land cover in Barangay Mulawin, with an overall mean of 3.13 and a standard deviation of 0.63. The item "The land cover has shifted from natural greenery to exposed soil and rocks" had the highest mean score of 3.17, indicating strong agreement that land cover changes, particularly the transition from vegetation to bare soil, increase flood risks by reducing water retention and increasing erosion. The lowest mean was for "The soil in previously vegetated areas has become more susceptible to erosion" (mean = 3.03, SD = 0.72), showing that while respondents agree that erosion is a concern, it is seen as less critical than the land cover transformation itself.

Table 7
Impact of Deforestation on Flood Incidence in Barangay Mulawin (Changes in Land Cover)

Item	Mean	SD	Interpretation
Quarrying has transformed the natural landscape into barren land.	3.16	0.56	Significant impact
The area covered by vegetation has drastically decreased due to quarrying.	3.15	0.63	Significant impact
The land cover has shifted from natural greenery to exposed soil and rocks.	3.17	0.63	Significant impact
The ecosystem balance has been altered due to significant land cover changes.	3.16	0.62	Significant impact
The soil in previously vegetated areas has become more susceptible to erosion.	3.03	0.72	Significant impact
Overall Mean	**3.13**	**0.63**	**Significant impact**

Reduction in Soil Stability

Table 8 shows the significant impact of deforestation on soil stability, with an overall mean of 3.04 and a standard deviation of 0.74. The item "Quarrying activities have led to increased soil loosening and weakening" had the highest mean of 3.11, indicating that respondents perceive quarrying as a key factor in soil instability, which can contribute to landslides and flooding. The lowest mean was recorded for "Quarrying operations have significantly reduced soil compactness" (mean = 2.96, SD = 0.85), suggesting that while soil compaction is a concern, it is not as significant as other forms of soil instability.

Table 8
Impact of Deforestation on Flood Incidence in Barangay Mulawin (Reduction in Soil Stability)

Item	Mean	SD	Interpretation
Quarrying activities have led to increased soil loosening and weakening.	3.11	0.56	Significant impact
The slopes near the quarrying site have become more prone to landslides.	3.04	0.72	Significant impact
The absence of vegetation has made the soil more susceptible to displacement.	3.06	0.72	Significant impact
Quarrying operations have significantly reduced soil compactness.	2.96	0.85	Significant impact
The removal of topsoil has contributed to the loss of fertile ground.	3.02	0.84	Significant impact
Overall Mean	**3.04**	**0.74**	**Significant impact**

Loss of Natural Water Absorption Capacity

Table 9 reveals that respondents agree that the loss of natural water absorption capacity due to deforestation and quarrying significantly contributes to flooding, with an overall mean of 3.18 and a standard deviation of 0.64. The highest mean was for "Exposed bedrock from quarrying prevents natural water seepage into the ground" (mean = 3.25, SD = 0.56), indicating strong agreement that excavation exposes bedrock, which hinders natural water absorption and increases surface runoff. The lowest mean was for "Heavy quarry equipment compresses soil, reducing its water retention" (mean = 3.09, SD = 0.81), suggesting that although soil compaction is acknowledged, it is perceived as less impactful compared to other factors.

Table 9
Impact of Deforestation on Flood Incidence in Barangay Mulawin (Loss of Natural Water Absorption Capacity)

Item	Mean	SD	Interpretation
Clearing land for quarrying diminishes the soil's water absorption ability.	3.19	0.62	Significant impact
Heavy quarry equipment compresses soil, reducing its water retention.	3.09	0.81	Significant impact
Without tree cover, rainwater runs off faster, worsening groundwater depletion.	3.17	0.62	Significant impact
Exposed bedrock from quarrying prevents natural water seepage into the ground.	3.25	0.56	Significant impact
Erosion caused by quarrying weakens soil structure, harming water storage.	3.18	0.59	Significant impact
Overall Mean	**3.18**	**0.64**	**Significant impact**

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

3.1 Flood frequency (number of flood occurrences per year)

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

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

Flood Frequency

Table 10
Evaluation of the Frequency and Severity of Floods in Barangay Mulawin in Terms of Flood Frequency

Items	Mean	SD	Description	Interpretation
The frequency of flooding has increased due to quarrying activities.	3.17	0.62	Agree	Significant impact
Heavy rainfall now leads to floods more often than before.	3.22	0.55	Agree	Significant impact
Quarrying sites contribute to more frequent water runoff events.	3.18	0.62	Agree	Significant impact
Flooding occurs more often in areas near active quarrying sites.	3.09	0.71	Agree	Significant impact
The loss of vegetation has contributed to increased flooding events.	3.08	0.74	Agree	Significant impact
Overall	**3.15**	**0.65**	**Agree**	**Significant impact**

Table 10 summarizes the evaluation of flood frequency in Barangay Mulawin. The overall mean score is 3.15, with a standard deviation of 0.65, indicating that respondents generally agree that flood frequency has increased significantly. The data highlights that respondents recognize quarrying activities, heavy rainfall, and vegetation loss as contributing factors to the rise in flood frequency. The item with the highest mean, "Heavy rainfall now leads to floods more often than before" (mean = 3.22, SD = 0.55), strongly suggests that respondents believe the frequency of floods has been exacerbated by changing rainfall patterns. This finding aligns with literature emphasizing how climate change and environmental degradation, including deforestation, intensify flood occurrences (Cheng & Xu, 2022). On the other hand, the item with the lowest mean, "The loss of vegetation has contributed to increased flooding events" (mean = 3.08, SD = 0.74), although still agreeing, indicates a slightly lesser perception of vegetation loss as a key factor in flood frequency, though it remains significant.

Flood Severity

Table 11
Evaluation of the Frequency and Severity of Floods in Barangay Mulawin in Terms of Flood Severity

Items	Mean	SD	Description	Interpretation
Flooding in the area has become more intense over the years.	3.53	0.52	Strongly Agree	Very significant impact
Floodwaters in the community now reach higher levels than before.	3.26	0.52	Agree	Significant impact
Recent floods last longer than in previous years.	3.27	0.61	Strongly Agree	Very significant impact
The destruction caused by flooding has worsened over time.	3.18	0.55	Agree	Significant impact
Roads and bridges suffer severe damage due to flooding.	3.53	0.52	Strongly Agree	Very significant impact
Overall	3.35	0.54	Strongly Agree	Very significant impact

Table 11 evaluates the severity of flooding in Barangay Mulawin, where the overall mean is 3.35 with a standard deviation of 0.54, reflecting that respondents strongly agree that the severity of flooding has increased significantly. The highest mean item, "Flooding in the area has become more intense over the years" (mean = 3.53, SD = 0.52), indicates that respondents strongly perceive that floods have become more intense and damaging. This result underscores the link between increasing flood severity and environmental changes, including land use and deforestation (Shao & Chen, 2024). Conversely, the lowest mean, "The destruction caused by flooding has worsened over time" (mean = 3.18, SD = 0.55), while still indicating agreement, suggests that some respondents may perceive the destruction to have become less significant compared to other aspects of flooding, such as intensity and duration.

Flood Impact

Table 12 evaluates the overall impact of flooding on Barangay Mulawin. The overall mean score of 3.18 with a standard deviation of 0.61 suggests that respondents generally agree that floods have a significant impact on the community in terms of infrastructure damage, livelihood disruption, and community displacement. The item with the highest mean, "Local businesses have suffered losses due to repeated floods" (mean = 3.27, SD = 0.61), highlights the significant economic losses suffered by local businesses, a key finding in line with studies on the economic impact of floods on local economies (Sharma & Bhat, 2023). The lowest mean, "Many families have been displaced due to frequent flooding" (mean = 3.04, SD = 0.69), although indicating agreement, suggests that displacement is perceived as a slightly less significant issue compared to the economic impacts of flooding.

Table 12
Evaluation of the Frequency and Severity of Floods in Barangay Mulawin in Terms of Flood Impact

Items	Mean	SD	Description	Interpretation
Flooding has led to significant economic losses in the community.	3.26	0.52	Agree	Significant impact
Many families have been displaced due to frequent flooding.	3.04	0.69	Agree	Significant impact
The loss of crops due to floods has negatively affected food supply.	3.18	0.62	Agree	Significant impact
Health problems have increased due to contaminated floodwaters.	3.15	0.60	Agree	Significant impact
Local businesses have suffered losses due to repeated floods.	3.27	0.61	Strongly Agree	Very significant impact
Overall	**3.18**	**0.61**	**Agree**	**Significant impact**

4. Is there a significant difference in how respondents evaluate flood incidence when grouped according to their demographic profile?

Evaluation Based on Sex

The analysis indicates no significant difference between male and female respondents in terms of how they evaluate flood incidence, with a mean score of 3.20 for males and 3.18 for females. The p-value of 0.487 is greater than 0.05, suggesting that sex does not significantly affect perceptions of flood frequency, severity, or impact in Barangay Mulawin. This result aligns with research suggesting that environmental risks like flooding are commonly perceived similarly across genders, as they impact the entire community (Goh & Tan, 2023).

Evaluation Based on Age:

A significant difference was found in how respondents evaluate flood incidence based on age. The F-value of 4.764 and a p-value of 0.003 indicate that age influences how flood risks are perceived. Younger respondents, particularly those aged 18-21 (mean = 3.23), tend to view floods as more frequent and severe compared to older age groups, with the 26-29 group showing the highest

perception (mean = 3.30). This could be due to the younger population's direct involvement in education or community activities, which might make them more aware of flood impacts. In contrast, older respondents may have more life experience with recurrent floods, which could affect their perception of flood risk. These findings are consistent with the idea that age influences the perception of environmental risks (Sharma & Bhat, 2023).

Table 13
Summary of Evaluation on the Flood Incidence Based on Demographic Profile

Profile	Category	Mean	t-value / F-value	p-value	Decision	Remarks
Sex	Male	3.20	0.483	0.487	Fail to reject	Not significant
	Female	3.18				
Age	18-21	3.23	4.764	0.003	Reject	Significant
	22-25	3.03				
	26-29	3.30				
	30 and above	3.20				
Civil Status	Single	3.15	13.39	0.000	Reject	Significant
	Married	3.25				
Education	High School	2.67	3.369	0.019	Reject	Significant
	Bachelor's Degree	3.17				
	Master's Degree	3.21				
	Post Graduate	3.24				

Evaluation Based on Civil Status

Significant differences were observed between single and married respondents. Married respondents (mean = 3.25) perceived flood risks to be slightly more severe than single individuals (mean = 3.15), as evidenced by the t-value of 13.39 and the p-value of 0.000. This may reflect the additional responsibilities and concerns that married individuals have, especially regarding the safety of their families and property. The results are in line with studies showing that individuals with families tend to be more acutely aware of environmental threats, as they have a greater vested interest in ensuring the safety of their dependents (Sharma & Bhat, 2023).

Evaluation Based on Educational Attainment

A significant relationship was found between educational attainment and the evaluation of flood incidence. The F-value of 3.369 and the p-value of 0.019 show that respondents with higher levels of education, such as bachelor's, master's, and post-graduate degrees, have a more nuanced understanding of flood risks. These respondents (mean = 3.17 for bachelor's, 3.21 for master's, and 3.24 for post-graduate) are more likely to perceive floods as a critical issue compared to those with only a high school education (mean = 2.67). Higher educational attainment is often linked to better awareness and understanding of environmental issues, as educated individuals tend to be more informed about the socio-economic and environmental consequences of natural disasters (Sharma & Bhat, 2023).

The analysis reveals that demographic factors such as age, civil status, and educational attainment significantly influence how respondents evaluate flood incidence, with no significant difference between males and females. These findings highlight the importance of tailoring flood management and awareness programs to specific demographic groups. For instance, interventions for younger individuals or those with lower educational levels may need to focus on increasing environmental

awareness, while programs for married individuals could emphasize family-oriented flood preparedness. By understanding these demographic influences, more effective and inclusive flood mitigation strategies can be developed that address the unique needs of the community.

5. Is there a significant relationship between quarrying, deforestation, and flood incidence (flood frequency, flood severity, and flood impact)?

Relationship Between Quarrying, Deforestation, and Flood Incidence

Table 14 presents the correlation coefficients between quarrying, deforestation, and flood incidence, focusing on the frequency, severity, and impact of floods. For quarrying activities, the correlation coefficients with flood frequency, severity, and impact are 0.21, 0.22, and 0.11, respectively, with p-values of 0.000, indicating statistically significant relationships with all three dimensions. For deforestation, the correlation coefficients are 0.32 (frequency), 0.33 (severity), and 0.47 (impact), all with p-values of 0.000, confirming significant relationships across all aspects of flood incidence.

These results suggest that both quarrying and deforestation significantly contribute to flood risks in terms of frequency, severity, and impact. Quarrying activities show a moderate positive correlation with flood frequency, severity, and impact, meaning that as quarrying activities increase, the likelihood of floods occurring more frequently, being more severe, and causing greater damage also increases. Quarrying disrupts the natural landscape by removing vegetation, compressing soil, and altering drainage systems, which reduces the land's ability to absorb water, leading to higher surface runoff and more frequent and intense flooding. This is consistent with previous studies that indicate how quarrying activities contribute to environmental degradation and exacerbate flood risks (Kim & Park, 2023).

Moreover, deforestation shows a stronger relationship with flood incidence, particularly with the flood impact dimension, where the r-value is 0.47. This suggests that deforestation not only increases the frequency and severity of floods but also amplifies their consequences, including displacement and property damage. Deforestation reduces the land's capacity to absorb and retain water, which increases surface runoff and worsens flooding. These findings are in line with research that highlights the significant role of deforestation in enhancing flood risks (Wang & Zhang, 2023). Both quarrying and deforestation significantly contribute to flood risks, underscoring the importance of sustainable land management practices, such as reforestation and regulated quarrying, to reduce flood incidence and its associated damage.

Table 14
Significant Relationship Between Quarrying, Deforestation, and Flood Incidence (Flood Frequency, Flood Severity, and Flood Impact)

Variables	Flood Incidence	r-value	p-value	Decision on H0	Remarks
Quarrying Activities	Frequency	0.219**	0.000	Rejected	Significant
	Severity	0.227**	0.000	Rejected	Significant
	Impact	0.113*	0.048	Rejected	Significant
	Total Measure	0.243**	0.000	Rejected	Significant
Deforestation	Frequency	0.326**	0.000	Rejected	Significant
	Severity	0.339**	0.000	Rejected	Significant
	Impact	0.475**	0.000	Rejected	Significant
	Total Measure	0.357**	0.000	Rejected	Significant

The findings from Table 14 confirm that both quarrying and deforestation have a statistically significant positive relationship with all dimensions of flood incidence—frequency, severity, and impact. Quarrying activities contribute to increased flood risks by disrupting natural drainage patterns, eroding soil, and removing vegetation. Deforestation exacerbates these issues by further reducing the land's ability to absorb water, thus leading to higher flood frequency and severity. These results align with previous studies, such as those by Kim and Park (2023) and Wang and Zhang (2023), which highlight the strong connections between land degradation activities and the heightened risk of floods. The higher correlation coefficients for deforestation, especially in terms of flood impact ($r = 0.47$), suggest that deforestation may have a more profound and lasting impact on flood incidence compared to quarrying. The loss of natural water absorption capacity due to deforestation not only leads to more frequent and intense floods but also causes greater socio-economic damage, including infrastructure destruction and displacement. The significant impact of deforestation on flood incidence calls for urgent measures such as forest conservation, reforestation, and more stringent regulation of land use activities.

Overall, these findings emphasize the need for integrated flood management strategies that consider both human activities, like quarrying, and broader environmental changes, such as deforestation. Effective flood management should include sustainable land-use practices that reduce surface runoff and enhance the land's ability to manage water. This includes implementing policies that regulate quarrying operations and promote reforestation and other conservation efforts to mitigate the long-term impacts of flooding in vulnerable areas like Barangay Mulawin.

CONCLUSION

The study concludes that quarrying and deforestation significantly contribute to the increased frequency and severity of floods in Barangay Mulawin, Orani, Bataan. Quarrying disrupts the natural landscape through extensive land excavation, soil erosion, alteration of drainage patterns, and sediment deposition, all of which impair the environment's ability to absorb and manage water flow. Similarly, deforestation reduces vegetation cover, leading to diminished soil stability and water absorption capacity, thereby intensifying surface runoff. These environmental changes collectively exacerbate flood risks, causing more frequent and severe flood events that adversely affect local communities.

Moreover, the socio-economic impacts of these floods are profound, including damage to infrastructure, disruption of livelihoods, and displacement of residents. The study revealed that stakeholders perceive these impacts as significant, underscoring the urgent need for effective and sustainable flood management strategies. Also notable is the influence of demographic factors such as age, civil status, and education on perceptions of flood risk, which suggests tailored community engagement and education programs could enhance local resilience and participation in environmental conservation efforts.

Finally, strengthening regulatory enforcement of quarrying and deforestation activities, along with promoting reforestation and sustainable land use, are critical steps toward mitigating flood risks. Local governance plays a vital role in implementing these measures to ensure environmental protection and disaster risk reduction. The study provides valuable insights for policymakers, researchers, and communities, emphasizing an integrated approach to environmental management to safeguard vulnerable areas against the adverse effects of anthropogenic activities on floods.

Recommendations

Based on the findings and conclusions of the study, the following recommendations are proposed to mitigate the impacts of quarrying and deforestation on flood incidence in Barangay Mulawin:

First, it is essential to strengthen the enforcement of environmental regulations governing quarrying and deforestation activities. Local government units should implement strict monitoring and control mechanisms to ensure responsible quarrying practices, including limiting excavation depths, controlling soil erosion, and preventing sediment deposition in waterways. Reforestation programs should be mandated and supported to restore vegetation cover, enhance soil stability, and improve natural water absorption capacity. Community involvement in these efforts is critical, promoting awareness and active participation in sustainable land-use practices.

Second, adopting nature-based flood management strategies can effectively reduce flood risks. This includes restoring and protecting watersheds, replanting native tree species, and rehabilitating natural drainage systems to increase the landscape's ability to absorb and manage water flow during heavy rains. Implementing green infrastructure, such as permeable surfaces and rain gardens, along with traditional gray infrastructure, will provide comprehensive flood mitigation.

Lastly, continuous research, monitoring, and education programs should be established. Long-term environmental monitoring using technologies like remote sensing can assess changes in land use and flood patterns, guiding adaptive management strategies. Education campaigns tailored to diverse demographic groups can increase community resilience and support for environmental conservation. Coordinated efforts between policymakers, local stakeholders, and environmental experts are necessary for sustainable flood management and disaster risk reduction in Barangay Mulawin.

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