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Environmental Risk Assessment and Management: A Case Study on Project NOAH in Libagon District

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Abstract
This study examines the application of environmental risk assessment and management in selected schools in the Libagon District, Southern Leyte, Philippines using the Department of Science and Technology's Project NOAH. The objectives of the study were to assess the vulnerability of schools in the Libagon District to natural hazards such as storm surges, landslides, and floods using Geographic Information System techniques. The paper applied a mixed approach in assessing the risks. The results of the study showed that the schools were adequately prepared for earthquake-related risks. However, the schools were not adequately prepared for storm surges. The schools identified as highly vulnerable to storm surges were Gakat Elementary School, Rito Monte de Ramos Sr. Memorial National High School, and Nahulid Elementary School. Kawayan Elementary School, Mayuga Elementary School, and Magkasag Elementary Schools were identified as highly vulnerable to landslide risks. The schools were not vulnerable to flood risks. The paper concluded that Geographic Information System tools were useful in disaster risk reduction.

Keywords: Environmental Risk Assessment; Project NOAH; Disaster Risk Reduction; Geographic Information System (GIS); Libagon District

1. Introduction

As natural disasters become more frequent and destructive around the world, due to the combined influence of climate change and population vulnerability, stronger climate consideration in environment risk assessment, and disaster management at the local scale is needed. Disaster risk management, through hazard mapping, the analysis of vulnerabilities, and the identification of elements-at-risk (as informed by analysis of spatial data, remote sensing, and Geographic Information Systems, or GIS), facilitates the minimization of losses (Westen 2013) [7]. Directly citing international standards of best practice framed by the associations which prioritizes on engaging communities Project NOAH, as used within the Libagon District, then, demonstrates a local framework for school resiliency, through the means of both globally sanctioned processes and GIS apparatuses. Utilized alongside a multi-hazard assessment framework and early warning systems, Project NOAH facilitates localized decision-making and preparedness strategies, therefore making it a vital model for both disaster management and environmental risk mitigation for rural communities vulnerable to hazards, like Libagon.

According to Susilowardhani (2014) [4] The integration of climate change adaptation into environmental planning, as demonstrated by Semarang City's use of Strategic Environmental Assessment (SEA), highlights the critical role of proactive frameworks in mitigating disaster risks. Semarang, a densely populated coastal city in Indonesia, faces recurring hazards such as floods, landslides, and sea level rise, largely intensified by climate variability. Similarly, Libagon District, though geographically different, is also exposed to environmental hazards that threaten community safety and educational continuity. By employing Project NOAH, Libagon mirrors SEA's objectives by utilizing localized data, early warning systems, and multi-stakeholder engagement to manage environmental risks effectively. Both cases underscore the importance of integrating climate resilience into local planning—through data-driven risk assessments, community-based strategies, and institutional collaboration to reduce vulnerabilities and safeguard development. Project NOAH in Libagon exemplifies how localized disaster risk management aligns with global approaches, such as SEA, in fostering climate-resilient communities through informed planning and responsive governance.

What the country has seen in terms of disaster risk reduction and management, however, is through Project NOAH, today known as Project NOAH under the University of the Philippines Resilience Institute, which has had a life-changing impact by shifting the country's attention from hazard to complete risk mapping. This new approach to understanding these risks, which is found in the Integrated Scenario-based Assessments of Impacts and Hazards (ISAIAH) program, leverages advanced technology and participatory data collection to provide communities with localized and actionable insight for better disaster preparedness. This initiative increases the capacity of local government units and communities for engagement through workshops, open-source mapping via OpenStreetMap, and tools such as WebSAFE for impact assessments (Cadiz 2018) [1]. Since the work of Project NOAH is then focused on interpreting this information for feasible response recommendations, these methodologies are, therefore, directly applicable and are found to be quite useful in the context of Libagon District provide evidence-based planning on the mitigation of environmental risk in schools and the community. The goals of the Libagon case study, which seeks to increase resilience and promote informed decision-making in communities prone to natural hazards and climate change, echo the project's focus on public engagement, scientific knowledge and scenario planning.

Based on the study of Ueno et. al. (2008) [6]. Project NOAH is an indispensable tool to Libagon District, noting that it is the same circumstances of geological/environmental that caused the disastrous Guinsaugon landslide in Southern Leyte that killed hundreds of lives in 2006, and it is from here that we can assess the importance of this knowledge for disaster risk assessment. Geologic surveys noted that smectite, a clay mineral that expands when wet, contributed significantly to slope instability, further accelerated by fault zone activity, hydrothermal alteration, and high rainfall. This confluence of natural factors highlights the importance of well-structured and sufficiently sensitive environmental risk assessment framework that covers geotechnical, climatic, and hydrological data—which is exactly what it is that Project NOAH offers. With the use of NOAH's scientifically and factually-sound tools, such as hazard and risk mapping, as well as community-based monitoring, vulnerable areas that may pose threats to people in the Libagon District, especially those living in the fault lines and unstable slopes in and around schools and settlements, can be identified beforehand. It is a relevant and emergent approach following Guinsaugon that combines scientific data and localized risk mitigation to show the importance of applying the lessons of Project NOAH to the risks faced by Libagon moving forward.

2. Risk Assessment Models and Frameworks in Environmental Management

This risk management procedure will utilize the Spatial-Geographic Information Systems (GIS) of Project NOAH to assess natural disaster hazards in Libagon District Schools. The initial steps are the identification phase, where historical data about natural disasters affecting the area of the project (e.g. storm surge, floods, landslides) is collected, and geographic information systems (GIS) are used to create maps of hazard-prone areas by overlaying data layers (e.g. soil types, topography, seismic activity). Specialists in the school physical environment are involved to further detect risks existing on school grounds through field surveys and expert consultations. During the risk assessment, these relevant GIS data are used to evaluate the vulnerability of each school to each of the identified hazards through modeling hazard scenarios. This entails assessing the likelihood and effect of each risk, with corresponding hazard levels (e.g., high, medium, low). Afterward, during the risk evaluation phase, the risks are categorized according to their severity, probability and the consequences they bring. This prioritization is corroborated by stakeholders like school administrators and local authorities to guarantee that the most critical risks are initially mitigated. The focus of the mitigation phase is on strategies to reduce these risks, including engineering solutions (retrofitting buildings), improving drainage systems, and developing early warning systems. Moreover, emergency response plans are developed for each school and GIS data is included to monitor hazards in real time. During the monitoring and review phase, the GIS data needs to be regularly updated and the risks re-assessed, and the effectiveness of mitigation measures reviewed. Safety drills and stakeholder feedback are important parts of readiness as well. All activities carried out during risk management are logged and summary reports are produced for the stakeholders, providing transparency and promoting the continuous improvement of the plan.

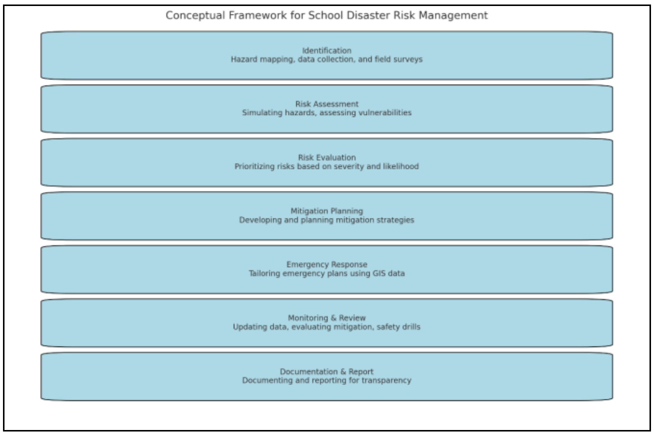


Fig 1: Conceptual framework on GIS-Based Risk Management for Libagon District (Project NOAH)

3. Identifying and Managing Environmental Hazards

This method will assist in the identification and managing environmental hazards such as flooding, landslide and storm surge in Libagon district schools using spatial-geographic information system; GIS and spatial analysis, DOST Project NOAH (National Operational Assessment of Hazards) data, survey and interview.

The risk analysis is intended to determine if Libagon District schools are prone to natural disasters: Gakat ES, RMSMNHS, Nahulid ES, Otikon ES, Tigbao ES, Libagon CES, LAFI, Libagon NHS, Kawayan ES, Mayuga ES and Magkasag ES. Risks include flooding, storm surge and landslides. Furthermore, the percentage of probability and the rate of impact of the occurrence of the risk that will be experienced by the schools can be used to determine the safety and preparedness of the schools in Libagon District. Qualitative Risk Analysis is used in the probability and impact of occurrence for each identified risk will be assessed by the project manager, with input from the project team using the following approach adapted form *EPLC*

(Enterprise Performance Life Cycle) Risk Management Plan (v 1.0):

Table 1: Risk Probability of Occurrence

Probability range	Natural language expression	Probability value used for calculations	Numeric score
68 % through 99 %	High	84.5%	5
34 % through 67 %	Medium	50.5 %	4
1% through 33	Low	17 %	1

Probability

- High- Greater than <*70%*> probability of occurrence.
- Medium-Between <*30%*> and <*70%*> probability of occurrence.
- Low-Below <*30%*> probability of occurrence.

Table 2: Risk Impact

Impact Description	Natural Language Expression	Numeric Score
Landslide: High Impact: Major infrastructure damage, loss of life, large-scale displacement, severe environmental degradation	Catastrophic	10
Medium Impact: Moderate infrastructure damage, localized displacement, potential injuries	Significant	5
Low Impact: Minor damage to infrastructure, few injuries, no significant displacement	Negligible	1
Flooding: High Impact: Widespread flooding causing large-scale damage to homes, infrastructure, loss of life, and displacement	Catastrophic	10
Medium Impact: Localized flooding with moderate damage to property, limited injuries, some disruption	Significant	5
Low Impact: Minor flooding, temporary inconvenience, limited property damage	Negligible	1
Storm Surge: High Impact: Significant coastal damage, widespread loss of life, destruction of homes, and infrastructure	Catastrophic	10
Medium Impact: Moderate damage to coastal areas, some evacuation, localized disruptions	Significant	5
Low Impact: Minimal coastal damage, brief disruptions, few to no injuries	Negligible	1

UNDRR, 2021: Global Assessment Report on Disaster Risk Reduction 2021.

Table 3: Risk Score

	Impact		
Probability	**Negligible (1)**	**Significant (5)**	**Catastrophic (10)**
High (5)	5	25	50
Medium (4)	4	20	40
Low (1)	1	5	10

Less than 20 is low risks
Between 20 to 39 is medium risks
Between 40 to 50 is high risks

4. Environmental Health and Safety Management

The research used survey and interview among all school disaster risk reduction management coordinator with the schools of Libagon district.

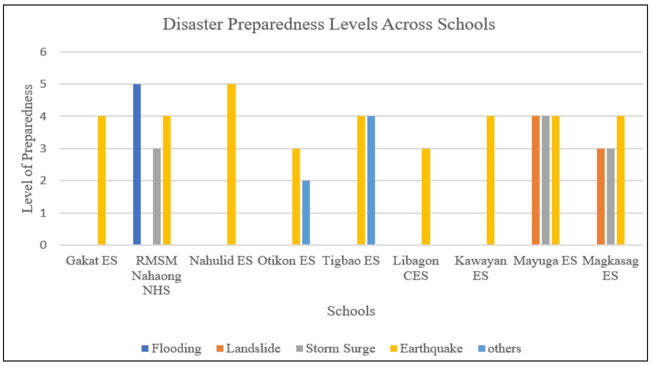
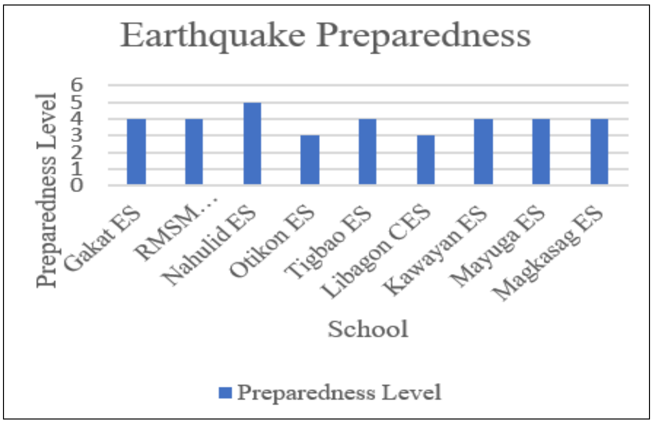
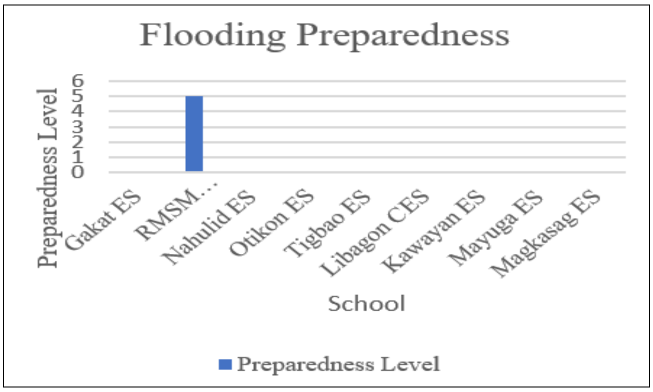


Fig 2: Hazard preparedness levels by school

Fig 2 illustrates the varying levels of disaster preparedness across schools in the Libagon district for different types of hazards, including flooding, landslides, storm surges, earthquakes, and other hazards. Notably, most schools show high preparedness for earthquakes, with several schools such as Nahulid ES reaching the maximum level (5). Flood preparedness is also relatively strong in school RMSM Nahaong NHS. Landslide preparedness, while present, varies across institutions, with Mayuga ES and Magkasag ES demonstrating notable awareness. Storm surge and other hazards receive less emphasis overall, with only a few schools, such as RMSM Nahaong NHS, Mayuga ES and Magkasag ES indicating moderate levels of readiness. This data reflects the prioritization of certain disaster types, possibly based on local risk profiles, and highlights areas where disaster preparedness initiatives may need to be strengthened.





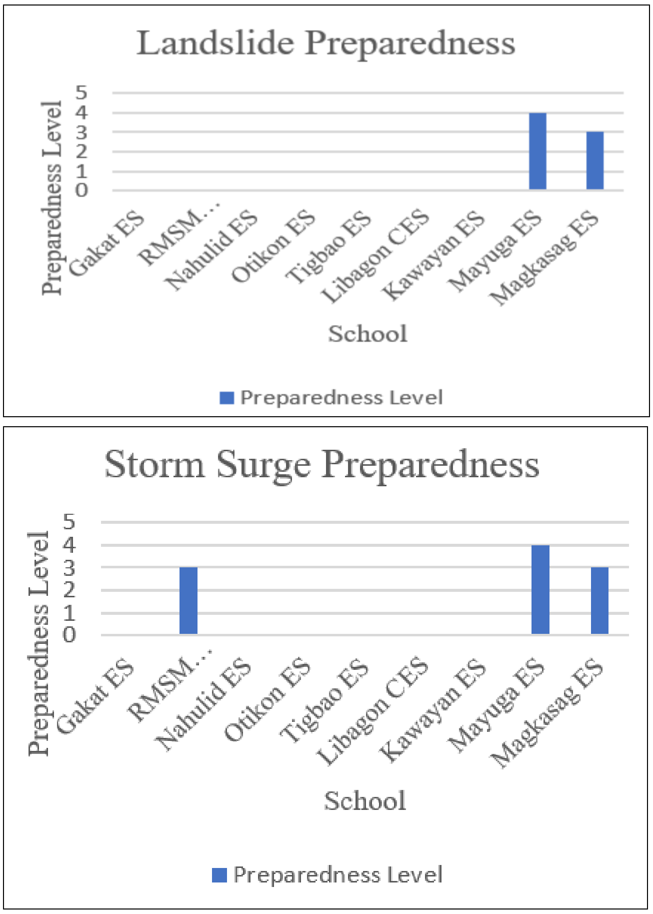


Fig 3: Disaster preparedness levels across schools

Fig 3 presents a breakdown of disaster preparedness levels across schools in the Libagon district, categorized by hazard type. Earthquake preparedness is consistently high, with all schools scoring between levels 3 and 5, highlighting a strong emphasis on seismic risk readiness. In contrast, flooding preparedness is limited, with only RMSM Nahaong NHS registering a preparedness level, indicating a potential area of concern. Landslide preparedness is concentrated in just two schools Mayuga ES and Magkasag ES demonstrating some localized attention to this hazard. Similarly, storm surge preparedness is limited to RMSM Nahaong NHS, Mayuga ES, and Magkasag ES, suggesting that only a few schools perceive or experience significant risk from storm surges. Overall, while earthquake readiness is broadly addressed, other hazards such as flooding, landslides, and storm surges receive uneven attention, pointing to the need for more comprehensive, multi-hazard preparedness planning across all schools.

5. Tools for Environmental Monitoring and Risk Management

This case study will utilize the spatial analysis and Geographic Information System form DOST Project NOAH (Nationwide Operational Assessment of Hazards) the innovation of the country to improve the respond to natural disasters and mitigate its effect to humanity.

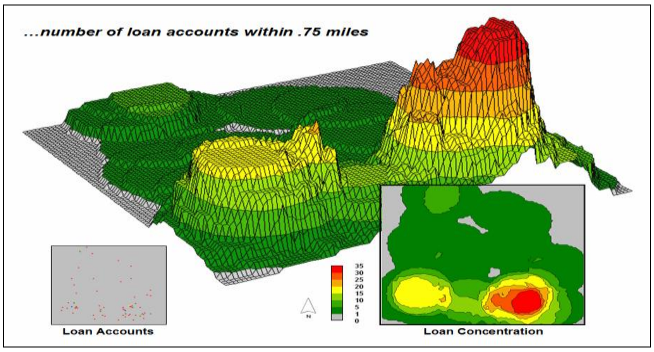


Fig 4: Example of Spatial analysis

Spatial analysis involves a process of looking at the locations, attributes, and relationships of features within spatial data. It's part of the Geographic Information System components that enable the assessment of geographic patterns and trends. Using spatial analysis tools means they can process both raster-based and vector data, which yields insights that are relevant in decision-making in diverse sectors such as urban planning, environmental management, disaster response, public health, and more.

Fig 5: Example of GIS generated map (DOST-Project NOAH)

A Geographic Information System, or GIS, is a very powerful tool in collecting, storing, managing, analyzing, and visualizing spatial and geographic data. GIS combines spatial data with other information types, including demographic, environmental, and infrastructural data, for the purpose of delivering thorough insights. GIS technology is very common in mapping, modeling, and decision-making applications in broad fields, such as environmental management, disaster management, urban planning, and agriculture. This spatial-GIS technology has been used on analyzing the landscape of the surface of the area where a dam or hydropower plant will be constructed and determining if there are hazards on the soon-to-rise powerplant (Torrefranca et. al., 2022) [5]. Based on the study of Lao *et al.* (2022) [2], the healthcare facility development in Tacloban City, Philippines, used GIS-based technology for the site suitability for spatial distribution of facilities among vulnerable communities.

6. Case Study: Environmental Risk Management of Schools in Libagon District using DOST Project NOAH

Eleven (11) schools, both public and private, comprise the Libgaon district: nine (9) elementary schools and three (3) secondary schools. There are only 9 schools that actively responded in the survey conducted by the researcher out of 11 schools. Using the Project NOAH of DOST depicts the hazard level of the following schools within the Libgaon district.

Fig 6: Gakat Elementary School under Project NOAH

Fig 6 show that Gakat Elementary School location is high hazard level of storm surge, little to none in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

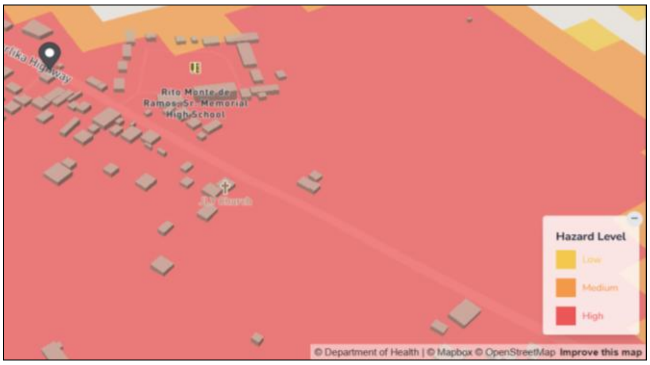


Fig 7: Rito Monte de Ramos Sr. Memorial National High School under Project NOAH

Fig 7 show that Rito Monte de Ramos Sr. Memorial National School location is high risk in storm surge hazard level, little to none in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

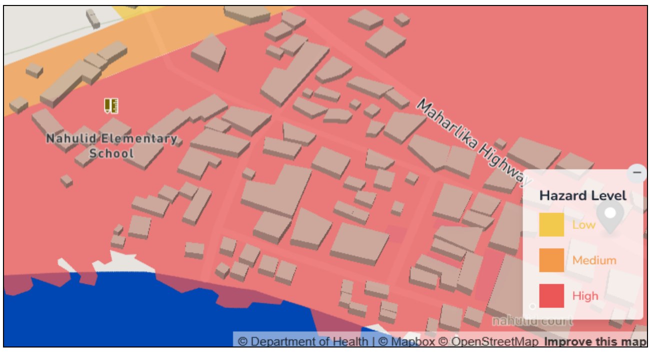


Fig 8: Nahulid Elementary School under Project NOAH

Fig 8 show that Nahulid Elementary School location is high hazard level of storm surge, little to none in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

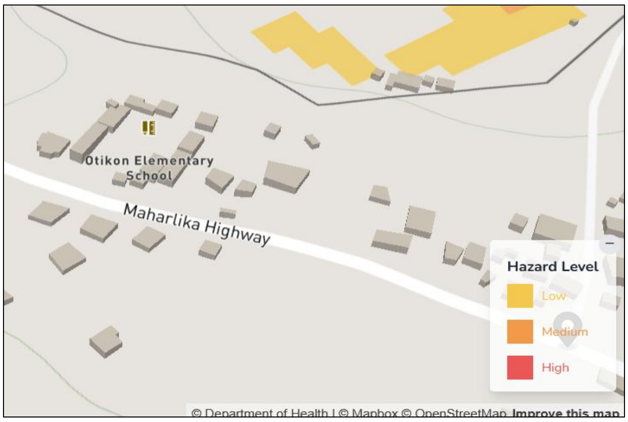


Fig 9: Otikon Elementary School under Project NOAH

Fig 9 show that Otikon Elementary School location is little to none hazard level in storm surge, little to none in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

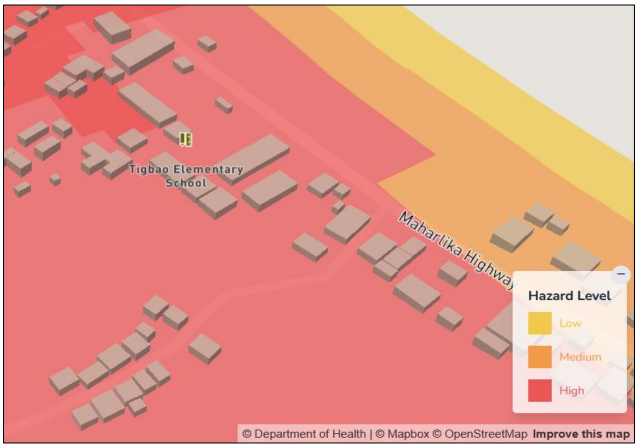


Fig 10: Tigbao Elementary School under Project NOAH

Fig 10 show that Tigbao Elementary School location is medium hazard level in storm surge, little to none in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

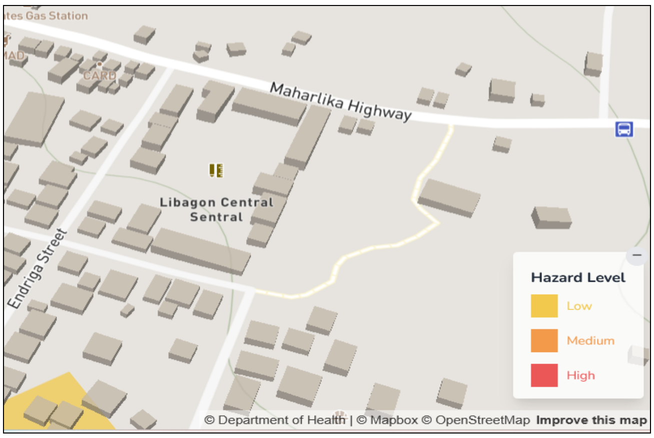


Fig 11: Libagon Central Elementary School under Project NOAH

Fig 11 show that Libagon Central Elementary School location is medium hazard level in storm surge, little to none in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

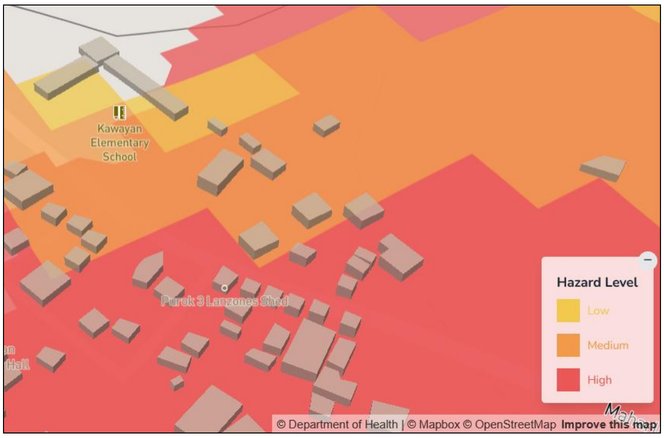


Fig 12: Kawayan Elementary School under Project NOAH

Fig 12 show that Kawayan Elementary School location is little to none hazard level in storm surge, high in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

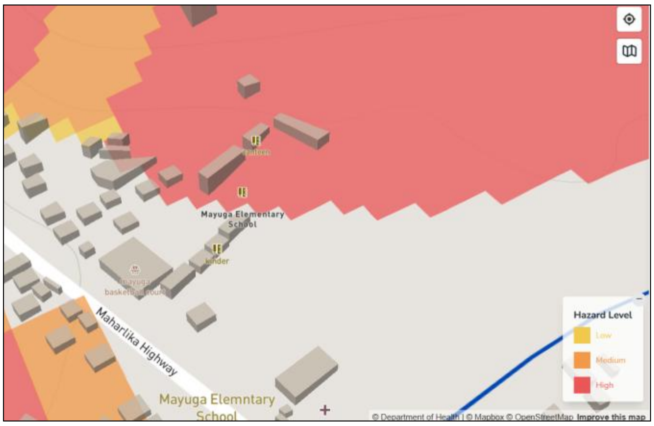


Fig 13: Mayuga Elementary School under Project NOAH

Fig 13 show that Mayuga Elementary School location is little to none hazard level in storm surge, high in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

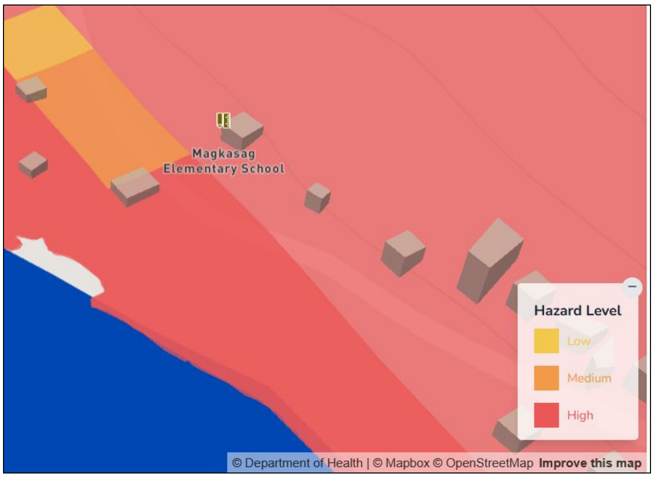


Fig 14: Magkasag Elementary School under Project NOAH

Fig 14 show that Mayuga Elementary School location is little to none hazard level in storm surge, high in landslide hazard level and flooding hazard level is unavailable based on the data from DOST – Project NOAH.

The research adapted the UNDRR 2021: Global Assessment Report on Disaster Risk Reduction 2021 with the data from DOST Project NOAH to assess the risk assessment of the schools in Libagon Ditrict.

Table 4: Risk probability, impact and risk score of the schools in Libagon district

Schools	Risk Score	Kind of Disaster	Natural language expression	Probability value used for calculations	Impact Description
Gakat ES	5	Storm surge	High	84.5%	**Catastrophic** High Impact: Significant coastal damage, widespread loss of life, destruction of homes, and infrastructure
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	1	Landslide	Low	17%	**Negligible** Low Impact: Minor damage to infrastructure, few injuries, no significant displacement
RMSM National High School	5	Storm surge	High	84.5%	**Catastrophic** High Impact: Significant coastal damage, widespread loss of life, destruction of homes, and infrastructure
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	1	Landslide	Low	17%	**Negligible** Low Impact: Minor damage to infrastructure, few injuries, no significant displacement
Nahulid ES	5	Storm surge	High	84.5%	**Catastrophic** High Impact: Significant coastal damage, widespread loss of life, destruction of homes, and infrastructure
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	1	Landslide	Low	17%	**Negligible** Low Impact: Minor damage to infrastructure,

					few injuries, no significant displacement
Otikon ES	1	Storm surge	Low	17%	**Negligible** Low Impact: Minor damage to infrastructure, few injuries, no significant displacement
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	1	Landslide	Low	17%	**Negligible** Low Impact: Minor damage to infrastructure, few injuries, no significant displacement
Tigbao ES	4	Storm surge	Medium	50.5%	**Significant** Medium Impact: Moderate damage to coastal areas, some evacuation, localized disruptions
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	1	Landslide	Low	17%	**Negligible** Low Impact: Minor damage to infrastructure, few injuries, no significant displacement
Libagon Central ES	4	Storm surge	Medium	50.5%	**Significant** Medium Impact: Moderate damage to coastal areas, some evacuation, localized disruptions
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	1	Landslide	Low	17%	**Negligible** Low Impact: Minor damage to infrastructure, few injuries, no significant displacement
Kawayan ES	1	Storm surge	Low	17%	**Negligible** Low Impact: Minimal coastal damage, brief disruptions, few to no injuries
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	5	Landslide	High	84.5%	**Catastrophic** High Impact: Major infrastructure damage, loss of life, large-scale displacement, severe environmental degradation
Mayuga ES	1	Storm surge	Low	17%	**Negligible** Low Impact: Minimal coastal damage, brief disruptions, few to no injuries
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	5	Landslide	High	84.5%	**Catastrophic** High Impact: Major infrastructure damage, loss of life, large-scale displacement, severe environmental degradation
Magkasag ES	1	Storm surge	Low	17%	**Negligible** Low Impact: Minimal coastal damage, brief disruptions, few to no injuries
	1	Flooding	Low	17%	**Negligible** Low Impact: Minor flooding, temporary inconvenience, limited property damage
	5	Landslide	High	84.5%	**Catastrophic** High Impact: Major infrastructure damage, loss of life, large-scale displacement, severe environmental degradation

The table presents a disaster risk assessment of schools in the Libagon District, integrating data from the UNDRR 2021 report and DOST Project NOAH. It evaluates risk scores and the potential impact of three types of natural disasters storm surge, flooding, and landslide across various schools. Gakat ES, RMSM National High School, and Nahulid ES show the highest vulnerability to storm surges, with a high probability (84.5%) and catastrophic impacts. In contrast, Otikon, Kawayan, Mayuga, and Magkasag ES exhibit low risk from storm surges and flooding but face high landslide risks. Tigbao and Libagon Central ES are moderately at risk from storm surges, while all schools experience negligible flooding and landslide impacts except for the last three, which have high landslide risks. The assessment highlights the varying vulnerabilities among schools and underscores the need for targeted disaster preparedness strategies.

7. Conclusion

The environmental risk assessment conducted in the Libagon District using DOST's Project NOAH highlighted significant variations in disaster preparedness among local schools. While earthquake preparedness was notably strong across all institutions, there were clear gaps in readiness for other hazards such as storm surges, landslides, and flooding. Specifically, schools like Gakat Elementary School, RMSM National High School, and Nahulid Elementary School were found to be at high risk for storm surges, while Kawayan, Mayuga, and Magkasag Elementary Schools exhibited high susceptibility to landslides. Although flooding was generally assessed as low risk, the lack of complete data on flood hazards indicates the need for more comprehensive and up-to-date information. Overall, the application of GIS-based spatial analysis proved effective in identifying vulnerabilities and guiding targeted interventions to reduce risk.

8. Recommendations

To address these findings, it is recommended that schools expand their disaster preparedness strategies to cover all potential hazards, rather than focusing primarily on earthquakes. This includes developing specific response plans for storm surges, landslides, and flooding. In addition, improving the availability and accuracy of hazard data—particularly related to flooding—is essential for informed decision-making. Schools should also institutionalize the use of GIS tools in their disaster risk reduction and management (DRRM) plans, supported by regular safety drills and stakeholder consultations. Engaging local authorities, educators, parents, and community members will further strengthen the relevance and sustainability of these efforts.

9. Future Outlook

Looking ahead, the success of this localized environmental risk assessment model suggests that it can be replicated in other disaster-prone areas of the Philippines. Project NOAH, combined with real-time monitoring and predictive analytics, has the potential to significantly enhance early warning systems and adaptive planning. With continued investment in education, capacity building, and inter-agency collaboration, school communities can build long-term resilience to the increasing threats posed by climate change and natural disasters.

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