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FLOODMAP: FLOOD LOCATION AND OVERLAY-ORIENTED DIGITAL MAPPING FOR HIGHLIGHTING AT-RISK BARANGAYS IN TANJAY CITY THROUGH GIS-BASED HAZARD ASSESSMENT

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Abstract

Flooding is a common hazard in the Philippines, particularly in Tanjay City, where low-lying areas, rivers, and tidal flow create dangerous conditions within the municipality. In response to these risks, this study aims to strengthen local disaster readiness by developing a GIS based tool for identifying susceptible flood areas using spatial, hydrological and historical flood data. Data were gathered from Provincial Disaster Risk Reduction and Management Office and Planning and Development Office and these various data types from .csv files whereby attributes of datasets were tailored to closely align with their appropriate field within the shapefiles from igismap.com and were utilized within QGIS and then streamed as layered maps with risk scores based on municipal barangays. Barangays that were designated as high risk were Luca, Manipis, Polo and San Jose. Azagra. Bahian, Pal-ew, Sta. Cruz Nuevo and Sto. Niño were considered low risk. Novallas, Obogon, barangay 1, barangay 2, barangay 8, San Jose, and Sta, Cruz Viejo was at a moderate risk level. There was a close match between historical flood incidents and the GIS-generated flood risk scores. The maps generated were validated with barangay officials and DRR personnel to ensure its accuracy and validity. FLOODMAP is a fact-based and trustworthy decision-support tool for disaster preparedness and public awareness. Ethical standards were upheld throughout the project's research process, securing reliability, accurate records, good practice, and avoiding misconduct such as fraudulent misrepresentation or plagiarism, thus ensuring FLOODMAP as a reliable tool to enhance flood resilience within Tanjay City.

Keywords: Flooding, FloodMap, GIS based tool, Disaster Risk Reduction and Management

Introduction

Flooding is one of the most common and destructive hazards in the Philippines. The country is highly susceptible to typhoons, heavy rainfall, and rising sea levels, resulting in the inundation of hundreds of low-lying communities. Rivera (2025). One of the causes of flooding relates to river systems, including that of Negros Oriental, which additionally has diverse topography, with Tanjay City being the most severely affected by flooding. Places most at risk of flooding are barangays located along riverbanks, estuaries, and low-lying plains, which not only result in property being lost, but also livelihoods lost, public health risks, and, in some cases, a risk of death.

Currently, flood risk assessment strategies in numerous localities take the form of observation, anecdotal evidence, and disaster response logic derived from interviewees, which are prone to errors and uncertainties introduced by these methods. While it is beneficial in producing insights, it is often limited by a lack of accuracy and is unable to sufficiently illustrate the risk distribution of impacts in locations. With increased computational capacity, geographic information systems (GIS) have proven to be a useful method of spatial data analysis, combining different elements and producing detailed maps with the purpose of assisting decision-making related to disaster preparedness and risk reduction. Oyedotun (2025)

GIS application in this mapping of flood hazard enables researchers, planners, decision-makers, and even municipal government units to overlay different data about a given area, including elevation, slope, land use, soil permeability, probable sea/tidal level, distance from the river, and historical flooding events. This is done to determine the most vulnerable barangays, visualize the potential extent of flooding, and make site-specific recommendations. Rezvani (2024)

This study aims to strengthen local disaster readiness. Many barangays in Tanjay City have historically been impacted by floods triggered by overflowing rivers, blocked drainage, and storm surges after typhoons. Yet some cities and towns are at greater risk than others. Identifying the areas most vulnerable to flooding will allow local government to prepare a plan of action to prioritize evacuations, determine where to build infrastructure, and allocate resources. Further, the map can serve as an educational tool, empowering citizens with data to help them stay resilient in the face of flooding's damaging effects.

The primary goal of this research FLOODMAP - Flood Location Overlay-Oriented Digital Mapping for Highlighting At-Risk Barangays in Tanjay City, Negros Oriental, is to create a flood risk area map of the city. The research aims to collect, collate, and analyze spatial data on flood risk variables and combine the data using GIS tools to present the areas vulnerable to flooding issues at localized levels. The proposed mapping product will function as a basic planning tool for disaster risk reduction, for small community capacity-building awareness, and serve as a local 2 policymaking resource.

Literature Review

Integrating spatial hydrological data for disaster risk reduction requires the proper use of Geographic Information Systems (GIS), which have proven algorithmic support to tally all topographic, hydrological, and human data to map malaria, and have turned out other advantages with regard to using GIS. Puno et al. (2019) identified flash flood zones in Bukang Liwayway, Bukidnon, at risk, using GIS integrated with the Frequency Ratio (FR) method. The authors considered uphillness, slope, land use/landcover, rainfall, distance from river or lake, and incorporated models for other environmental variables, and assigned statistical weights according to their correlation with past regularity of frequency of factors inundating. Findings suggested that in flood-prone zones, low elevation and a higher density of town had moved downstream. Puno et al. (2019) suggested that GIS maps of flood hazards are analytics of real use to evacuation planning, zoning codes, and mapping agricultural and residential land. Puno et al., (2019), Nguyen et al., (2021).

The accuracy of flood maps has improved dramatically over the past few years due to improved hydrodynamic modeling. In one example, Nguyen et al. (2021), incorporated synthetic aperture radar (SAR) data from Sentinel-1 into a two-dimensional flood model in Vietnam, and demonstrated that adding SAR-derived flood extents to the hydrodynamic simulations in GIS produced better flood predictions than either technique alone. This type of hybrid modeling technique would be highly applicable in the Philippines where floods occur commonly from typhoons, and flood-modeled predictions need to capture both riverine and coastal dynamics. These measures were utilized to outline areas appropriate for harvesting rainwater. Here, an approach is proposed that, while less cogent than hydrodynamic modelling, works in information-scarce conditions as well. That is what is intriguing about the approach. It shows the way that with information available at any place GIS can also provide flood maps. It is an easy way out for even small municipalities.

Additionally, the National Mapping and Resource Information Authority, which offers base geographical information data, encompasses resources such as topographical maps, elevation models, and water for the future. Even Project Geographic, which has utilized these datasets provided by NAMRIA, has served as the basis for pilot studies being pursued by academic researchers employing GIS technology for real-life applications (NAMRIA, 2022). It was primarily through this open-disclosure rule that academic researchers and LGUs were able to conduct flood mapping without paying a fortune for images and data from commercial companies, such as Ikonos or SPOT. Senior

Administrative Officer Ricky Abaya states, "LGUs and the flood mapping open access is part of how academics have been able to do flood mapping with no access to expensive proprietary datasets.

Participatory Geographic Information Systems (PGIS) represent another technical principal development that can be used in full conjunction with technical flood mapping. PGIS, as defined by Chambers (2006), is a process in which communities create maps themselves using participatory approaches and spatial tools. This, in principle, ensures the flood hazard maps reflect local conditions. In Calamba City, Ordinario et al. (2017) conducted a PGIS workshop in Barangay Pansol where community members provided their own flood histories and experiences with hazards. The result was a community-based flood map, which had much higher acceptance from those involved, because it represented their experience and knowledge of their environment. Their study clearly demonstrated that community participation improved the accuracy and utility of flood maps.

Finally, the results of the research by Soriano and colleagues (2018) in Zambales clearly demonstrated the benefits of using GIS-generated flood mapping in addition to community-based disaster prevention. The authors manipulated GIS through analytic hierarchy procedure to develop flood vulnerability assessments for communities affected by Typhoons Labuyo and Ompong. The flood maps were then tested in community workshops and during field trips and eventually used for planning development to revise contingency plans and emergency actions with local disaster risk reduction and management offices in the province. Their work shows that the combination of geospatial technology and local knowledge can help improve flood preparedness coordination. In addition to a technical tool developed through methods such as GPS systems, GIS needs to involve local government agencies and communities to become truly democratic, the authors emphasize.

Methodology

This employs a quantitative, descriptive, and spatial research design with the application of GIS that maps out the affected towns of flooding in Tanjay City, Negros Oriental. Quantifying spatial and hydrological parameters such as elevation, slope, soil permeability, land use/cover type, sea level, distance from the river, and historical flooding information, it will provide numbers for the application of systematic numbers to produce reliable or accurate flood hazard classes that will translate into government disaster prevention policy. The researchers adopt Tanjay City, Negros Oriental, as the study area and gather thorough community-based accounts along with official records to determine which barangays are flood-prone. The entire area is full of constantly changing natural features like lowland riverbanks and coastal lowlands.

The compiled datasets were organized and formatted for use in GIS. The Tanjay City shapefile was acquired and verified to have map, the same attribute data of the CSV files that had barangay-level information, encoded particulars such as, elevation, slope, soil permeability, land use, sea level, distance from the river and event from past flood events, while ensuring that all fields and data types in the shapefile and CSV remained the same to guarantee the join in GIS would work correctly.

The following formula is used to calculate the Compute Flood Risk Index (FRI):

$$X_{\text{normalized}} = \frac{X - X_{\min}}{X_{\max} - X_{\min}}$$

Value 1 → 0
Value 2 → 0.5
Value 3 → 1

Assign Weight

Factor	Weight
Flood History	0.22
Distance from the river	0.18
Elevation	0.18
Sea level/tidal	0.15
Slope	0.12
Land Use	0.08
Soil Permeability	0.07

The composite score or Flood Risk Index (FRI) combines normalized values and weights:

$$\mathrm{FRI} = \sum_{i=1} w_i . X_{\mathrm{normalized}}, i$$

$$FRI = \sum(\text{Normalized Value} \times \text{Weight})$$

Classify Risk Levels
Define thresholds for low, moderate, high risk. For example:
Low: 0-0.33
Moderate: 0.34-0.66
High: 0.67-1.0
Total possible FRI range = 1.00
Divide the range into 3 equal sections: 1 ÷ 3 = 0.3333 So, the categories become:

Category	Range	Explanation
Low	0.00 – 0.33	Lowest third of risk values
Moderate	0.34 – 0.66	Middle third
High	0.67 – 1.00	Highest third

This is called Equal Interval Classification, commonly used in GIS and risk mapping.

Conceptual Framework

The study is framed with the assumption that Geographic Information Systems (GIS) can effectively integrate spatial and hydrological information to develop a reliable, verifiable, and trusted map of flood-prone areas for disaster preparedness. The framework follows the Input-Process-Output (IPO) Model.

The Input consists of the calibration study that facilitate application of the following necessary input data:
Elevation Data – to find out how high the vulnerable and low-lying places are.
Slope-to measure the steepness of the area
Tidal/sea level- changes in the tidal range itself contribute to high tide flooding by increasing the baseline water level.
Land Use Information – for the quantification of the exposure of residential, agricultural and commercial areas.
Soil permeability data – to assess run-off and water absorption rate.
Distance from the river- to quantify the distance of each barangay from the river
Historical Flooding – to confirm and verify whether flood areas are genuine.

Process

The inputs will be transformed into outputs by passing through the following stages through GIS tool:
1. Data sourced from authoritative agencies, including Negros Oriental DRRMO and Provincial Planning for the figures presented from verified sources above.
2. Data encoding is necessary for GIS applications, as well as for cleaning and formatting data.
3. Overlap analysis and spatial analysis of maps on elevation, slope, tidal/sea level, land use, soil permeability, distance from the river and past flooding experience.
4. Once the outputs of GIS are established, it will then compare them with historical flooding records and local knowledge to verify accuracy.

Output

The final output will be:
1. A GIS-Generated Flood-Prone Map at barangays level of Tanjay City, Negros Oriental to which:
2. Accurate – provides an honest portrayal of actual flood risks by combining data sources.
3. Factual- consistent with proven history and disaster reports.

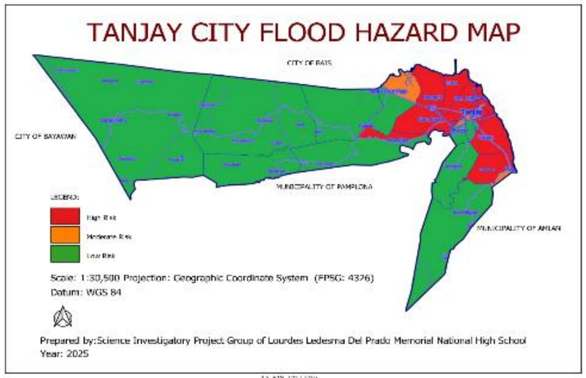
The research framework shows the stepwise progression of study procedures in sequence. The initial step is validating input data such as topography, hydrology and socio-economic variables. These include the location of elevation, slope, soil permeability, land use, sea-level, flood history and in a table format. The datasets are then processed in GIS using reclassification, weighting and overlay. The processed data is combined in various formats to create a flood hazard map that classifies areas in terms of low, moderate or high risk of flooding. To verify reliability, the map created is confirmed with historical flood records, field data on flooded communities and certified by the DRRMO. The end outputs are hazard maps and recommendations for use by local government units, disaster risk reduction offices and community planning steps.

Results

The results obtained from the formulated equation are presented below.

Barangay	Elevation	Slope	Soil	Land Use	Sea Level	River	Flood History	FRI	Risk
Azagra	0.18	0.06	0	0.04	0	0	0	0.1	Low
Bahian	0	0	0	0.04	0	0	0	0.04	Low
Luca	0.18	0.12	0.07	0.04	0.15	0.09	0.22	0.87	High
Manipis	0.18	0.12	0.07	0.04	0.15	0.09	0.22	0.87	High
Novallas	0	0	0.07	0.04	0	0.18	0	0.29	Low
Obogon	0.09	0.06	0.035	0	0.075	0	0	0.26	Low

Pal-ew	0	0	0	0.04	0	0	0	0.04	Low
Poblacion 1	0.09	0.06	0.07	0.08	0.75	0.18	0.11	0.66	Moderate
Poblacion 2	0.09	0.06	0.07	0.08	0.75	0.18	0	0.56	Moderate
Poblacion 3	0.18	0.06	0.07	0.08	0.15	0.18	0.11	0.83	High
Poblacion 4	0.18	0.06	0.07	0.08	0.15	0.18	0.22	0.94	High
Poblacion 5	0.18	0.06	0.07	0.08	0.15	0.18	0.11	0.83	High
Poblacion 6	0.18	0.06	0.07	0.08	0.15	0.18	0.22	0.94	High
Poblacion 7	0.18	0.06	0.07	0.08	0.15	0.18	0.22	0.94	High
Poblacion 8	0.09	0.06	0.07	0.08	0.075	0.15	0	0.52	Moderate
Poblacion 9	0.18	0.12	0.07	0.08	0.15	0.15	0.22	0.97	High
Polo	0.18	0.12	0.07	0.08	0.15	0.15	0.22	0.97	High
San Isidro	0.18	0.12	0.07	0.04	0.15	0.15	0.22	0.93	High
San Jose	0	0.06	0.07	0.04	0	0.15	0	0.32	Low
San Miguel	0	0.06	0	0.04	0	0	0	0.1	Low
Sta. Cruz Nuevo	0	0.06	0	0.04	0	0	0	0.1	Low
Sta. Cruz Viejo	0	0.06	0.035	0.04	0	0	0.11	0.25	Low
Sto. Niño	0	0	0.035	0.04	0	0	0	0.075	Low
Tugas	0.18	0.06	0.07	0.04	0.15	0.15	0.22	0.87	Low



GIS Based Hazard Map of the flood prone barangays in Tanjay City

Discussion

The flood risk assessment for the barangays in Tanjay City accounted for seven essential properties contributing to flood risk: elevation, slope, soil permeability, land use, tidal/sea level, river distance, and flood history. It shows the different patterns of vulnerability in the city. Many of these barangays Bahian, Pal-ew, San Miguel, Sta. Cruz Nuevo, Sto. Niño, Sta. Cruz Viejo and Obogon usually provide low-risk indicators. Their positive elevation, good draining permeability, slope presence, or remoteness to flood plains limit likely flooding contributions. Moderately risked areas include the barangays Novallas, Barangay 1, Barangay 2, Barangay 3, Barangay 5, Barangay 8, San Jose, and Tugas. These sites usually show slow to moderate soil permeability, are moderately used for agricultural or mixed development, and have low flood history sites. Whereas it is least likely to be the most at risk, and those would assuredly not be the least at risk to floods. Barangay Luca, Manipis, Polo, San Isidro, San Jose, Barangays 4, 6, 7, 9, and some portions of the Poblacion are perennially considered high-risk areas. These areas are low-lying and generally flat, exhibit a slow rate of soil drainage, and are predominantly residential or close to tidal/sea level. For both, the past flooding experience reveals more than five episodes showing strong exposure. Residential areas, particularly the Poblacion barangays, are generally classified as high-risk areas due to population densities, impervious surfaces, and have the highest history of uptick in floods. Agricultural barangays, on the other hand, continue to be at risk but overall see moderate risk, which may not be as drastic, but are still issues as well. Residential areas, particularly the Poblacion barangays, are generally classified as high-risk areas due to population densities, impervious surfaces, and have the highest history of uptick in floods. Agricultural barangays, on the other hand, continue to be at risk but overall see moderate risk, which may not be as drastic, but are still issues as well. The findings of the current study reject the null hypothesis (H_0) and substantiate the alternative hypothesis (H_1). Utilizing GIS to combine spatial and hydrologic data resulted in flood-prone maps that are scientifically based and align with historical flooding in Tanjay City, Negros Oriental. Thus, it can be concluded that GIS-based integration of spatial and hydrologic variables improves the accuracy, credibility, and reliability of barangay-level flood hazard maps. This supports the research hypothesis (H_1) and demonstrates FLOODMAP as an asset for disaster risk reduction in Tanjay City.

Conclusion

A flood risk assessment conducted in Tanjay City based on elevation, slope, soil infiltration, land use, tidal/sea level, river distance, and flood history showed that flooding represents the central issue of most of the barangays, especially in the lower barangays. Barangays Luca, Manipis, Polo, San Isidro, and San Jose, in addition to barangays 4, 6, 7, and 9, were rated as high-risk areas due to physical exposure and land use history of past flooding that made them susceptible to flooding. It is important that these areas receive attention to disaster risk reduction and disaster response. Those requiring greater elevations with well-draining, good slope soils like Bahian, Pal-ew, Sta. Cruz Nuevo, Sta. Cruz Viejo, San Miguel, and Sto. Niño, consistently rated as low risk. These findings imply that using topography and soil property is crucial in diminishing flood risk. The moderate-risk barangays are mostly agricultural at risk to major flood events with minor resolute events for particularly heavy rainfall events of typhoons.

Hence, results indicate a disparity in the allocation of flood risk across Tanjay City, particularly between high urbanized and low urbanized barangays. Improving the adaptive capacity will require improved drainage systems, more solid land-use planning, community preparedness programs, and green infrastructure programs that will direct specific targeted investments in flood mitigation to lessen disaster severity while enhancing resiliency in the most vulnerable neighborhoods.

Hence, FLOODMAP: Flood Location and Overlay-Oriented Digital Mapping for At-Risk Barangays in Tanjay City, was successfully developed as part of the study, which incorporated spatial and hydrological data using GIS technology. Once these datasets were overlain, researchers calibrated the results using verified disaster reports, producing accurate, dependable, and scientifically strong maps of flood-prone areas. Feedback from stakeholders verified the FLOODMAP and the value as a decision-support and awareness-raising framework to inform disaster preparedness, evacuation planning, and risk messaging. Apart from being validated and manually updated yearly, FLOODMAP can be a support system for local governments (LGUs), barangays, and citizen residents to build long-term resilience against recurring floods.

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