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GIS-Based Flood Susceptibility Assessment of Cabanatuan City, Nueva Ecija, Philippines

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ABSTRACT: Flooding is a recurrent hazard in Cabanatuan City, Philippines, within the Pampanga River basin. This study assessed flood susceptibility using GIS mapping across all 89 barangays. Flood susceptibility was assessed using weighted GIS-based analysis of elevation, slope, land use/land cover, and proximity to drainage networks. Rainfall was discussed qualitatively as a triggering condition but was excluded from the weighted FSI computation due to the absence of spatially distributed rainfall data. Rainfall is treated only as a triggering condition due to citywide data limitations; this limits the model's ability to represent temporal flood variability. A Flood Susceptibility Index (FSI) was calculated using normalized weights: Distance to River (29%), Elevation (26%), Slope (23%), and Land Use (22%). Results classified 24 barangays (27.0%) as High Susceptibility, 47 (52.8%) as Moderate, and 18 (20.2%) as Low. Valdefuente recorded the highest FSI (2.51) due to developed land use and river proximity within 300 meters. Kalikid Norte, Macatbong, and Patalac recorded the lowest FSI (1.45) due to steeper slopes and agricultural land use. Spatial trend analysis revealed a west-to-east gradient of decreasing susceptibility. Findings show general agreement with documented flood-prone areas. Limitation: The susceptibility map has not been quantitatively validated and is a preliminary assessment. This study provides a replicable framework to guide CDRRMO and LGU in flood mitigation planning.

KEYWORDS: Flood susceptibility, GIS, Cabanatuan City, spatial analysis, flood susceptibility assessment, QGIS, Philippines

I. INTRODUCTION

Flooding is among the most devastating natural hazards globally, causing widespread damage to lives, livelihoods, and infrastructure, particularly in vulnerable river basins and urban areas (National Geographic Society, 2025). As a rapidly urbanizing city in Central Luzon, Cabanatuan City in Nueva Ecija experiences recurring flood events that disrupt daily life, damage properties, and impede local development.

Cabanatuan City is situated within the Pampanga River basin, the fourth largest river basin in the Philippines, which drains water from the Sierra Madre mountain range and several upstream municipalities. The city has a total land area of 282.75 square kilometers and is composed of 89 barangays, with a population density of 1,158 inhabitants per square kilometer (PhilAtlas, 2026). Due to its low-lying topography, with elevations ranging from approximately 20 to 70 meters above sea level, the city receives substantial surface water runoff from surrounding higher elevations during heavy rainfall events. Historically, one of the most significant flood event occurred on October 19, 2015 due to Typhoon Lando (Subia et al., 2019).

To address these challenges, Geographic Information Systems (GIS) have become essential tools in flood susceptibility assessment and management. QGIS (Quantum Geographic Information System), a free and open-source software, allows researchers to analyze spatial data, generate maps, and model environmental hazards. According to Ariyani et al. (2023), flood hazard mapping using QGIS involves analyzing variables such as slope, land cover, elevation, and rainfall to determine areas at risk of flooding.

Although rainfall is a recognized trigger for flooding, it was excluded from the weighted Flood Susceptibility Index (FSI) calculation because only a single annual rainfall value (1,854.9 mm) is available for the entire city from PAGASA (2020-2024). Without spatially distributed rainfall data, rainfall cannot be treated as a spatially varying factor in the susceptibility model. Therefore, rainfall is discussed qualitatively as a general triggering condition rather than as a weighted factor in the FSI. This limits the model's ability to represent temporal flood variability.

This study aims to: (1) describe the existing physical conditions of Cabanatuan City in terms of topography, land use, drainage network, and rainfall patterns; (2) identify flood-susceptible barangays based on these factors; (3) analyze how these factors interact within the weighted GIS model to produce susceptibility scores; and (4) describe the relative weighting structure adopted within the GIS susceptibility model.

II. METHODOLOGY

This section presents the methodological framework employed to assess flood susceptibility in Cabanatuan City, Nueva Ecija. The study adopts a quantitative approach utilizing Geographic Information System (GIS) spatial analysis to evaluate the physical environmental conditions that influence flood susceptibility. These procedures are designed to systematically address the research questions by describing the existing physical conditions of the study area, identifying flood-prone zones, analyzing the individual and combined effects of contributing factors, and determining the most significant reasons for flooding. The use of open-source spatial datasets, including SRTM DEM, Sentinel satellite imagery, OpenStreetMap drainage data, and PAGASA rainfall records, ensures a replicable framework that can be adapted for similar studies in other flood-prone regions.

A. Research Site/Study Area

This study was conducted in Cabanatuan City, located in the province of Nueva Ecija in Central Luzon (Region III), Philippines. The city lies within the catchment area of the Pampanga River system. Its population as determined by the 2020 Census was 327,325, with a population density of 1,158 inhabitants per square kilometer.

B. Data Collection

This study utilized publicly available secondary datasets to assess the physical and environmental factors contributing to flooding in Cabanatuan City. All datasets were obtained from open-source and government repositories to ensure replicability and accessibility.

1. Topographic Data: Elevation and slope were derived from the 30m SRTM DEM, chosen for its global coverage, open license, and reliability in data-scarce regions.
2. Land Use/Land Cover: LULC was interpreted from Sentinel-2 satellite imagery via QGIS using visual interpretation, producing five classes (water, forest, crops, built area, rangeland). Visual cross-checking with Google Earth high-resolution imagery was conducted to verify major land cover patterns. However, no formal supervised classification accuracy assessment was conducted. The absence of formal accuracy assessment introduces potential classification uncertainties, particularly in mixed urban-agricultural transition zones. The LULC classification should be interpreted as a visually validated approximation and may contain classification uncertainties.
3. River/Creek Network: Data extracted from OpenStreetMap; proximity analysis computed distance from each barangay to nearest waterway. Studies confirm that closer proximity increases flood susceptibility due to bank overflow.
4. Rainfall Data: Mean annual rainfall (2020–2024) from PAGASA is 1,854.9 mm. Since only one value applies citywide, rainfall is treated as uniform and excluded from the weighted Flood Susceptibility Index (FSI), mentioned only descriptively as a triggering condition. The authors note this limits the model's ability to capture temporal flood variability.

C. Analysis of Flood Contributing Factors

To systematically assess the flood susceptibility of different areas within Cabanatuan City, each physical factor was classified into susceptibility levels based on established GIS-based flood assessment studies. Elevation and slope classifications followed the criteria set by Hagos et al. (2022), where lower elevations and flatter slopes indicate higher flood susceptibility due to increased water accumulation and reduced runoff velocity. Land use susceptibility was adapted from Amen et al. (2023), with developed areas classified as highly susceptible because impervious surfaces generate greater surface runoff, while agricultural areas were rated moderate and open spaces as low. Distance to river or creek were also derived from Amen et al. (2023), where areas within less than 300 meters of drainage channels and rivers are considered high risk due to potential bank overflow.

Table 1. Flood Susceptibility Factors

Factor	Category	Susceptibility Level	Scoring
Elevation	< 20 m	High	3
	20–50 m	Moderate	2
	> 50 m	Low	1
Slope	0–3%	High	3
	3–8%	Moderate	2
	> 8%	Low	1
Land Use	Developed	High	3
	Agricultural	Moderate	2
	Plain / Open Space	Low	1
Distance to River	< 300 meters	High	3
	300 - 600 meters	Moderate	2
	> 600 meters	Low	1

D. Barangay-Level FSI Aggregation.

To assign a single Flood Susceptibility Index (FSI) value to each of the 89 barangays, zonal statistics were applied using QGIS 4.0. Each factor raster was sampled at the pixel level (30m resolution) across all pixels falling within each barangay polygon boundary. The mean score for each factor was calculated per barangay using the Zonal Statistics tool. These mean scores were then substituted into the FSI formula to produce a single FSI value per barangay. This averaging approach ensures that barangays with mixed land use or variable topography are represented by an aggregate susceptibility score rather than an extreme minimum or maximum value. Barangay boundary shapefiles were obtained from PhilAtlas (2026) and projected to UTM Zone 51N (WGS84) for area-accurate calculations.

E. Ranking of Flood-Contributing Factors

To identify which physical factors appear most influential within the applied GIS-based susceptibility framework, a weighted scoring system was adopted from Gacu et al. (2022). The weights were adapted and utilized because the study was likewise conducted in the Philippines, specifically in the municipality of Odiongan, Romblon, providing a comparable national and environmental context for flood susceptibility assessment. Future studies may apply the Analytical Hierarchy Process (AHP) with local expert validation to refine the weighting scheme specific to Cabanatuan City. However, the use of adapted weights introduces uncertainty, as the relative importance of flood-contributing factors may differ within the local context. Therefore, the assigned weights reflect the assumptions of the adopted model rather than statistically derived factor importance specific to the study area.

Table 2. Normalized Factor Weights Based on Gacu et al. (2022)

Factors	Normalized Weight
Distance to River / Creek	29%
Elevation	26%
Slope	23%
Land Use / Land Cover	22%
Total	100%

Classification criteria adapted from Hagos et al. (2022) for elevation/slope and Amen et al. (2023) for land use/distance to river

Using these normalized weights, a Flood Susceptibility Index (FSI) was calculated for each barangay using the following formula:

$$\mathbf{FSI = (D \times 0.29) + (E \times 0.26) + (S \times 0.23) + (L \times 0.22)}$$

Where:

D = Distance to river score (3 = High, 2 = Moderate, 1 = Low)

E = Elevation score (3 = High, 2 = Moderate, 1 = Low)

S = Slope score (3 = High, 2 = Moderate, 1 = Low)

L = Land use score (3 = High, 2 = Moderate, 1 = Low)

The FSI results will be interpreted using the following scale respectively:

FSI Range: 1.00 - 1.74, 1.75 - 1.99, 2.00 - 3.00. Flood Susceptibility Level: Low, Moderate, High

III. RESULTS AND DISCUSSION

This study assessed flood susceptibility in Cabanatuan City, Nueva Ecija, using Geographic Information System (GIS) mapping and spatial analysis. A total of 89 barangays were analyzed based on four physical factors: elevation, slope, land use, and distance to river or creek. Each factor was classified into three susceptibility levels (High, Moderate, Low) based on established GIS-based flood assessment studies. A weighted scoring system was adopted from Gacu et al. (2022), with weights re-normalized after excluding rainfall due to the availability of only a single annual rainfall value for the entire city (1,854.9 mm). The final normalized weights were: Distance to River (29%), Elevation (26%), Slope (23%), and Land Use (22%). It is noted that these weights were adapted from previous studies and were not derived from local expert judgment specific to Cabanatuan City, which introduces uncertainty in factor importance.

A. Thematic Maps Analysis

1. Land Use and Land Cover Distribution

Land use and land cover (LULC) distribution across Cabanatuan City was classified into five categories. Sentinel-2 satellite imagery with a spatial resolution of 10 meters and land use data for the year 2023 were utilized for the land use and land cover (LULC) classification of Cabanatuan City. The imagery was visually interpreted and digitized using QGIS at an approximate working scale of 1:25,000. Dry season imagery was selected to minimize cloud cover and improve the visibility of land surface features. Land cover categories were classified into water, forest, crops, built-up, and rangeland. Since the classification relied primarily on visual interpretation, no formal accuracy assessment or ground validation was conducted. For flood susceptibility assessment, these were aggregated into three functional classes based on runoff potential: developed (high susceptibility, score 3), agricultural (moderate susceptibility, score 2), and plain/open space (low susceptibility, score 1).

The distribution analysis showed that developed barangays are predominantly clustered in the city center and western portions adjacent to the Pampanga River accounted for 38 of the 89 barangays (42.7%). These developed areas exhibit the highest surface runoff generation due to impervious surfaces which reduce infiltration and accelerate overland flow during intense rainfall. In contrast, agricultural barangays concentrated in the eastern and northern peripheries provide moderate infiltration capacity. Open space and rangeland barangays exhibit the lowest susceptibility due to vegetation cover and soils.

The spatial coincidence of developed land use with low-lying topography and proximity to the Pampanga River corresponds with why barangays such as Valdefuente (developed, elevation 38.6 m, distance 0.20 km) recorded the highest FSI values (2.51). Conversely, agricultural barangays in the eastern sector Kalikid Norte, Macatbong, and Patalac were recorded as the lowest FSI values (1.45) due to the combination of agricultural land use, steeper slopes, and greater distance from drainage networks.

2. Slope Characteristics

The slope map of Cabanatuan City was derived from the SRTM DEM (30m resolution) using the slope analysis tool in QGIS. Slope represents the steepness or grade of the terrain and is a critical factor in flood susceptibility assessment, as it influences surface runoff velocity and water accumulation. Areas with flat slopes tend to slow down surface runoff, allowing water to accumulate and increasing flood susceptibility, while steeper slopes promote rapid drainage and reduce the likelihood of prolonged flooding (Hagos et al., 2022).

The analysis revealed that the majority of barangays in Cabanatuan City have flat to gentle slopes (0-3%), particularly those in the western and central portions of the city. This finding is significant because flat terrain slows surface runoff and allows water to accumulate rather than drain quickly. The eastern and northern peripheries, in contrast, exhibit steeper slopes (>8%), which facilitate rapid surface water runoff and reduce flood susceptibility. Barangays with slope scores of 1 (steep, >8%) including Kalikid Norte, Macatbong, and Patalac are consistently recorded as the lowest FSI values (1.45), confirming the inverse relationship between slope gradient and flood susceptibility within the model.

3. Drainage Network and Proximity Analysis

The drainage network of Cabanatuan City, comprising the Pampanga River main channel and its associated tributaries and creeks, was extracted from OpenStreetMap and analyzed using proximity analysis tools in QGIS. River system interpretation focused on two key aspects: first, the spatial relationship between barangays and the drainage network; second, the identification of a critical distance threshold for flood susceptibility. Barangays located within 300 meters of any waterway were classified as high susceptibility for this factor, consistent with thresholds established by Amen et al. (2023). The proximity analysis revealed that 24 high-susceptibility barangays are predominantly situated along the Pampanga River corridor, particularly in the western and central portions of the city where the drainage network is most dense. Valdefuente recorded the shortest distance to a river (0.20 km) and correspondingly the highest FSI (2.51), followed by San Roque Sur (0.45 km, FSI 2.45) and Sapang (0.25 km, FSI 2.29).

This spatial configuration indicates that the Pampanga River system serves as a primary hydraulic control on flood susceptibility in Cabanatuan City within the adopted model, with bank overflow during intense rainfall events representing the principal flood mechanism.

B. Flood Susceptibility Index Results

1. FSI Calculation and Classification

The Flood Susceptibility Index (FSI) was calculated for all 89 barangays using the formula:

$$\mathbf{FSI = (D \times 0.29) + (E \times 0.26) + (S \times 0.23) + (L \times 0.22)}$$

where D = distance to river score (3 = high, 2 = moderate, 1 = low), E = elevation score, S = slope score, and L = land use score. Barangays were clustered into three flood susceptibility levels using a threshold-based classification scheme. High susceptibility was defined as FSI ≥ 2.00, moderate as FSI 1.75–1.99, and low as FSI ≤ 1.74. The classification thresholds were manually defined after examining the distribution of computed FSI values across the 89 barangays. Threshold selection was guided by previous GIS-based flood susceptibility studies and intended to provide practical differentiation between low, moderate, and high susceptibility zones within the study area.

2. Barangay-Level Results

The FSI results showed that 24 barangays (27.0%) were classified as High Susceptibility, 47 barangays (52.8%) as Moderate Susceptibility, and 18 barangays (20.2%) as Low Susceptibility. This distribution indicates that while the majority of barangays fall under moderate susceptibility, more than one-quarter of the city's barangays exhibit high susceptibility requiring priority attention from disaster management authorities.

3. Top 10 Highest and Lowest Susceptibility Barangays

Table 3-4. Top 10 Highest and Lowest Susceptibility Barangays

Rank	Top 10 Highest Susceptibility Barangays	FSI
1	Valdefuente	2.51
2	San Roque Sur	2.45
3	Sapang	2.29
4	Matadero	2.22
5	Nabao	2.22
6	Pagas	2.22
7	Rizdelis	2.22
8	Sto. Niño	2.22
9	San Roque Norte	2.22
10	Mabini Homesite	2.16

Rank	Bottom 10 Lowest Susceptibility Barangays	FSI
1	Kalikid Norte	1.45
2	Macatbong	1.45
3	Patalac	1.45
4	Kalikid Sur	1.67
5	Bagong Buhay	1.68
6	Bakero	1.68
7	Caudillo	1.71
8	Cinco-Cinco	1.71
9	Mayapyap Norte	1.71
10	Palagay	1.71

Valdefuente recorded the highest FSI (2.51) due to its combination of developed land use (score 3), proximity to rivers within 300 meters (score 3), and low elevation (score 2). The three lowest-risk barangays, Kalikid Norte, Macatbong, and Patalac are all recorded with FSI values of 1.45, characterized by steep slopes (score 1), agricultural land use (score 1), and distances greater than 600 meters from drainage networks (score 1).

C. Spatial Trend Analysis

Visual spatial interpretation of the flood susceptibility map was conducted to identify geographic patterns in flood susceptibility across Cabanatuan City's 89 barangays. Visual interpretation of the Flood Susceptibility Map revealed a distinct west-to-east gradient of decreasing susceptibility. High-susceptibility barangays (red, FSI ≥ 2.00) exhibited clear spatial clustering in the western and central portions of the city, predominantly in low-lying areas adjacent to the Pampanga River main channel and its tributaries. This cluster includes Valdefuente (FSI 2.51), San Roque Sur (2.45), and Sapang (2.29) are barangays characterized by developed land use, flat slopes (0–3%), and proximity to waterways within 300 meters. Conversely, low-susceptibility barangays (green, FSI ≤ 1.74) were concentrated in the eastern and northern sectors, where steeper slopes (>8%) and agricultural land use promote rapid surface water runoff. The intermediate zone of moderate susceptibility (yellow, 52.8%) formed a transitional buffer between these two extremes.

No comparable north-south trend was observed, indicating that east-west proximity to the Pampanga River drainage network is the dominant spatial control on flood susceptibility within the adopted model. This spatial pattern suggests that the Pampanga River floodplain exerts the primary control on barangay-level flood susceptibility, with susceptibility attenuating eastward with increasing distance from the main channel.

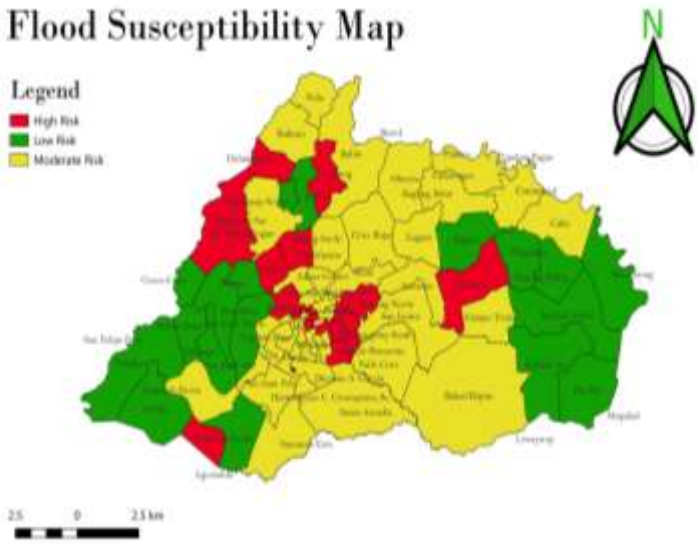

Figure 1. Flood Susceptibility of Cabanatuan City

Figure 1. Flood Susceptibility Map of Cabanatuan City, Nueva Ecija, Philippines. Barangay-level FSI classification: High (FSI 2.00–3.00, red), Moderate (FSI 1.75–1.99, yellow), Low (FSI 1.00–1.74, green). The map reveals a west-to-east decreasing susceptibility gradient, with high-risk barangays clustered along the Pampanga River corridor. Base data: barangay boundaries from PhilAtlas (2026); drainage network from OpenStreetMap (2024); elevation from SRTM DEM (USGS, 2020). Projection: UTM Zone 51N, WGS84. Map produced by the authors using QGIS 4.0.

D. Factor Contributions (Within the Adopted Model)

It is important to note that factor weights were adopted from existing literature (Gacu et al., 2022) and do not represent statistically derived contributions specific to Cabanatuan City. The following discussion of "influence" refers to the model's assigned weights, not empirically measured causal relationships.

Within the adopted weighting framework, distance to river received the highest assigned weight (29%). Barangays located within 300 meters of rivers or creeks are classified as highest risk within the model due to potential bank overflow during intense rainfall events. The FSI results confirm that the 10 highest-risk barangays all have distance scores of 3 (high susceptibility), while the 10 lowest-risk barangays have distance scores of 1 (low susceptibility), suggesting that within the model, Within the adopted weighting framework, proximity to drainage networks shows strong association with higher FSI classifications.

Elevation received the second highest assigned weight (26%). Areas with lower elevations (below 35 m) exhibit higher susceptibility within the model, as low-lying areas act as natural collection points for surface water, leading to prolonged flooding. However, elevation alone does not determine susceptibility, Valdefuente (elevation 38.6 m, FSI 2.51) has higher elevation than some moderate-susceptibility barangays, demonstrating that multiple factors interact to produce the final FSI.

Slope received an assigned weight of 23%. Most barangays in Cabanatuan City have flat to gentle slopes (0-3%), which slow down surface runoff and allow water to accumulate rather than drain quickly. The low-susceptibility barangays in the eastern sector demonstrate that steep slopes (>8%) can offset other risk factors such as agricultural land use.

Land use received an assigned weight of 22%. Developed areas with impervious surfaces generate higher surface runoff compared to agricultural or open spaces, increasing flood susceptibility within the model. The spatial coincidence of developed land use with low-lying topography and proximity to rivers corresponds with why barangays such as Valdefuente recorded the highest FSI values.

E. Comparison with Documented Flood Events (Qualitative Validation)

The FSI results show general agreement with documented flood-prone areas from previous local studies. Subia et al. (2019) identified barangays including Aduas Centro, Aduas Norte, Aduas Sur, Bagong Sikat, Bakero, Bakod Bayan, Bantug Bulalo, Barlis, Barrera, and Balite as among the most physically flood-vulnerable in Cabanatuan City. In the present study, these barangays predominantly fall under Moderate to High susceptibility categories. For example, Aduas Centro (FSI 1.93, Moderate), Aduas Norte (1.89, Moderate), and Aduas Sur (1.95, Moderate) all border the high-susceptibility threshold (FSI ≥ 2.00).

This comparison demonstrates general spatial agreement with historically documented flood-prone areas and should not be interpreted as statistical validation of model accuracy. The general agreement between model results and historically reported flood-prone areas suggests that the FSI methodology captures broad spatial patterns consistent with local experience, even without quantitative validation.

F. Limitations of the Present Study

The following limitations are acknowledged:

- No quantitative validation - The FSI model was not validated against observed flood extent datasets, historical flood inventory points, or field survey data. The qualitative comparison with Subia et al. (2019) should not be interpreted as statistical validation.

- Adopted weights – Factor weights were adopted verbatim from Gacu et al. (2022), a study conducted in Odiongan, Romblon, not calibrated for Cabanatuan City. Local expert judgment was not employed.
- Land use classification – LULC was produced through visual interpretation without formal accuracy assessment. Classification uncertainties may exist, particularly in urban-agricultural transition zones.
- Rainfall exclusion – Only a single annual rainfall value (1,854.9 mm) is available for the entire city. Rainfall was excluded from the FSI and treated qualitatively as a triggering condition. The model does not capture temporal flood variability or differentiate between wet and dry years.
- Drainage network completeness – OpenStreetMap drainage data may not capture all minor creeks, engineered drainage channels, or seasonal waterways. Missing features may underestimate flood susceptibility in certain barangays.
- Resolution limitations – The 30m SRTM DEM may not capture fine-scale topographic variations that influence localized ponding. Higher-resolution (e.g., 5m or LiDAR) data would improve accuracy.
- No field validation – On-site verification of flood-prone areas was not conducted due to time and resource constraints.
- Given these limitations, the flood susceptibility map should be interpreted as a preliminary spatial assessment requiring validation through site-specific hydrological studies and field observation before operational use in disaster management.

G. Implications for Flood Management

The identification of 24 High Susceptibility barangays provides a priority list for the Cabanatuan City Disaster Risk Reduction and Management Office (CDRRMO). Interventions such as early warning systems, evacuation planning, and drainage maintenance may be prioritized for these areas. The top 10 highest-risk barangays were Valdefuente, San Roque Sur, Sapang, Matadero, Nabao, Pagas, Rizdelis, Sto. Niño, San Roque Norte, and Mabini Homesite warrant immediate attention for flood mitigation programs.

For the Local Government Unit (LGU), the flood susceptibility map and findings can be integrated into the Comprehensive Land Use Plan (CLUP) to guide future urban development. Zoning regulations that restrict development in high-risk areas particularly low-lying zones and areas within 300 meters of riverbanks may be considered. Green infrastructure investments in developed areas could reduce surface runoff and improve water infiltration.

IV. CONCLUSIONS

Based on the GIS-based spatial analysis and the calculated Flood Susceptibility Index, the following conclusions are drawn within the adopted weighted model:

- Distribution of susceptibility – Of the 89 barangays, 24 (27.0%) were classified as High Susceptibility, 47 (52.8%) as Moderate Susceptibility, and 18 (20.2%) as Low Susceptibility.
- Highest risk barangay – Valdefuente recorded the highest FSI (2.51) due to its combination of developed land use, proximity to rivers within 300 meters, and low elevation.
- Lowest risk barangays – Kalikid Norte, Macatbong, and Patalac recorded the lowest FSI (1.45) due to steep slopes (>8%), agricultural land use, and distance greater than 600 meters from drainage networks.
- Spatial pattern – A distinct west-to-east gradient of decreasing flood susceptibility was identified, with high-risk barangays clustering along the Pampanga River corridor and low-risk areas concentrated in the eastern and northern sectors.
- Within-model factor influence – Distance to river received the highest assigned weight (29%) in the FSI model, followed by elevation (26%), slope (23%), and land use (22%). However, these weights were adopted from literature and do not represent empirically measured causal relationships specific to Cabanatuan City.
- Compound risk – The highest flood susceptibility occurs when multiple high-susceptibility factors coincide. Barangays that combine low elevation, flat slopes, developed land use, and proximity to rivers exhibit the highest overall susceptibility within the model.

V. RECOMMENDATIONS

Based on the findings and limitations of this study, the following recommendations are provided. These recommendations are based on model-derived susceptibility and should be validated through detailed hydrological and field studies.

For the City Disaster Risk Reduction and Management Office (CDRRMO):

- Prioritize the 24 High Susceptibility barangays identified in this study for flood mitigation programs, early warning systems, and evacuation planning.
- Develop and implement barangay-level flood response plans for the top 10 highest-risk barangays.

- Conduct regular clearing and maintenance of rivers, creeks, and drainage channels, particularly in barangays within 300 meters of water bodies.

For the Local Government Unit (LGU):

- Integrate the flood susceptibility maps and findings into the Comprehensive Land Use Plan (CLUP) of Cabanatuan City.
- Consider enforcing zoning regulations that restrict development in high-risk areas, especially low-lying zones and areas within 300 meters of riverbanks.
- Consider investing in green infrastructure in developed areas to reduce surface runoff.

For Future Researchers:

- Obtain high-resolution, spatially distributed rainfall data to enable per-barangay rainfall variation and allow rainfall to be properly weighted in the FSI calculation.
- Incorporate additional factors such as soil type, drainage density, and flood depth data to improve model completeness.
- Conduct on-site validation of flood-prone areas through field surveys and interviews with local residents to verify and refine the FSI results.
- Apply the same methodological framework to other flood-prone cities and municipalities in the Philippines to further assess its replicability and scalability.

SUPPLEMENTARY MATERIALS

High-resolution flood susceptibility maps, GIS outputs, and supplementary figures used in this study are available through the following Google Drive link:
Click here to access map

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