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Spatial Distribution of DPWH Flood Control Projects Along Selected Pampanga River Sections in Cabanatuan City and San Isidro, Nueva Ecija Using GIS (2016–2025)

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ABSTRACT: Flooding is a recurring problem in areas near the Pampanga River, particularly in Cabanatuan City and nearby municipalities in Nueva Ecija. To address this issue, the Department of Public Works and Highways (DPWH) implemented several flood control projects from 2016 to 2025. This study analyzed the spatial distribution of these projects along selected sections of the Pampanga River in Cabanatuan City and San Isidro using Geographic Information Systems (GIS). Project data were obtained from the DPWH Transparency Portal and analyzed through QGIS and descriptive statistical methods. The study identified project locations and examined their characteristics in terms of contractor, project cost, implementation year, and geographic distribution. It also determined areas with high concentrations of flood control projects and analyzed yearly trends in project implementation and spending. Results showed that projects were concentrated in selected sections of the river and in several barangays with relatively higher levels of recorded flood control implementation, while implementation and project costs varied across the study period. The study highlights the usefulness of GIS in visualizing and analyzing infrastructure distribution patterns that may support future flood management planning and spatial analysis studies. However, the study does not assess hydraulic performance, structural adequacy, or the actual flood reduction effectiveness of the flood control projects.

KEYWORDS: Flood Control Projects, Geographic Information System (GIS), Spatial Distribution, Pampanga River, DPWH

I. INTRODUCTION

1.1 Background of the Study

Flooding is a natural phenomenon characterized by the overflow of water into areas that are normally dry due to the rise in water levels in rivers, streams, and other bodies of water (PAGASA, n.d.). In the Philippines, flooding is commonly caused by heavy rainfall brought by monsoons, tropical cyclones, thunderstorms, and the Intertropical Convergence Zone (ITCZ).

In Nueva Ecija, especially in Cabanatuan City and nearby municipalities, flooding has been a common concern during periods of intense rainfall. Communities located near the Pampanga River are often affected due to rising water levels and overflow.

Recurrent flooding in Cabanatuan City and nearby areas indicates the continuing need for effective flood management interventions. To address this, the Department of Public Works and Highways (DPWH) has implemented several flood control projects along different sections of the river. These projects aim to reduce flood risks and improve water flow management. However, there is limited analysis on how these projects are distributed across locations and whether they are concentrated in specific areas.

In this context, Geographic Information Systems (GIS) provide a useful tool for analyzing spatial patterns of infrastructure projects. GIS allows the visualization and assessment of where projects are located and how they are distributed across the study area. This study applies GIS to analyze the spatial and temporal distribution of DPWH flood control projects along selected sections of the Pampanga River in Cabanatuan City and San Isidro from 2016 to 2025.

Research Gap

Most studies on flooding in the Philippines focus on flood hazards, rainfall patterns, and vulnerability assessment. While these are important, limited research has examined the spatial distribution of actual flood control projects implemented by government agencies using GIS.

In the Pampanga River context, existing studies mainly focus on flood risk and environmental conditions rather than infrastructure allocation patterns over time.

Furthermore, although DPWH project data are publicly available, they are rarely analyzed using GIS at a localized river-section scale. This creates a gap in understanding how flood control projects are geographically distributed across selected river sections over time. This study addresses this gap by examining the spatial and temporal distribution of DPWH flood control projects using GIS-based analysis.

1.2 Statement of the Problem

The study aims to answer the following:

1. What are the spatial locations of DPWH flood control projects in selected sections of Pampanga River in Cabanatuan City and San Isidro?
2. What are the key characteristics of these flood control projects in terms of contractors, cost, implementation year and location?
3. Which area shows concentration of flood control projects?
4. Which contractors received the highest frequency of awarded projects during the study period?
5. How do project implementation and total cost vary across the years 2016–2025?

1.3 Objectives of the Study

The study aims to find the following objectives:

1. Geospatially map the locations of DPWH flood control projects implemented from 2016–2025 in selected Pampanga River sections of Cabanatuan City and San Isidro.
2. To describe the flood control projects in terms of contractor, contract cost, implementation year, and location.
3. To identify barangays or river reaches with high concentrations of flood control projects.
4. To determine the frequency distribution of contractors awarded flood control projects during the study period.
5. To analyze yearly trends in project implementation and total spending.

1.4 Significance of the Study

The results of the study will be beneficial to:

-The result of the study may support government agencies and policy makers in improving planning, prioritization, and decision-making related to flood control infrastructure. By identifying spatial distribution patterns, the study provides useful insights into how projects are allocated across different areas.

-For local communities, the findings may contribute to improved awareness of flood mitigation efforts and support better planning at the local level. However, the study does not assess the structural effectiveness of the projects.

-For the academic community, this research serves as a reference for future GIS-based studies involving infrastructure planning, spatial analysis, and flood mitigation.

1.5 Scope and Limitations

This study focused on DPWH flood control projects implemented from 2016 to 2025 in Cabanatuan City and selected parts of San Isidro along the Pampanga River. The study utilized Geographic Information System (GIS) tools for spatial analysis and DPWH portal data to examine project characteristics such as contractor, project cost, implementation year, and geographic location.

Because exact coordinates were unavailable for several DPWH records, some project locations were approximated using barangay descriptions, river alignment, nearby roads, bridges, and visible flood control structures in Google Earth. Therefore, mapped locations should be interpreted as approximate project positions rather than surveyed coordinates.

Theanalysis was limited to available DPWH project records and focused only on the descriptive spatial distribution of flood control projects. The study did not include hydraulic modeling, flood hazard mapping, rainfall analysis, structural performance evaluation, hydraulic efficiency assessment, or sub-surface investigation. Flood control projects not implemented by DPWH or not located along the selected river sections were excluded from the study

1.6 Conceptual Framework

This figure presents how the study is carried out, starting from the data gathered, the methods used, and the result expected.

Figure 1.7 Conceptual Framework

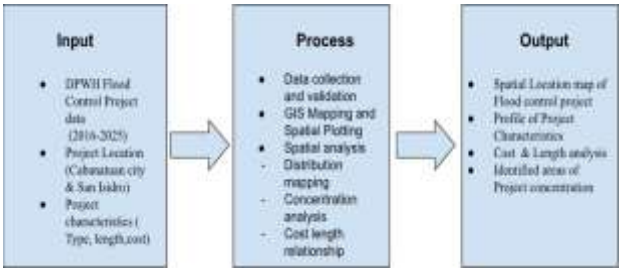


Figure 1 illustrates how DPWH flood control project records were collected, processed, mapped, and analyzed using GIS tools, processed, mapped, and analyzed using GIS tools. The inputs included project data such as location, contractor, year of implementation, and project cost. These data were processed through GIS mapping, descriptive statistical analysis, and spatial visualization techniques to identify geographic distribution patterns and project concentration areas along selected Pampanga River sections. The output of

the study consisted of thematic maps, tabular summaries, and descriptive interpretations of project distribution from 2016 to 2025.

II. REVIEW OF RELATED LITERATURE

Flooding is a common problem in many areas, especially in places near rivers like the Pampanga River. Based on different studies, several factors affect flooding such as land use, population, and environmental conditions. According to Dela Torre et al. (2019), the use of geospatial analysis and the Analytic Hierarchy Process (AHP) helps identify areas that are more vulnerable to flooding. Their study showed that areas with high agricultural activity and limited resources are more prone to flood impacts.

Some studies also focus on how flooding affects structures. Singh et al. (2024) used Geographic Information Systems (GIS) along with AHP and TOPSIS to assess flood risk in buildings. The results showed that many structures fall under moderate to high risk, especially in areas with poor planning and environmental conditions.

In addition, modern technologies like satellite data and flood monitoring systems play an important role in flood management. Revilla-Romero et al. (2015) explained that systems such as GFDS and GloFAS can provide near real-time data that is useful for disaster response and preparedness, although there are still some limitations in accuracy.

Overall, the reviewed studies highlight the importance of Geographic Information Systems (GIS) in analyzing spatial patterns related to flood management and infrastructure planning. While previous studies focused on flood hazard mapping and risk assessment, this study differs by examining the spatial and temporal distribution of government-implemented flood control projects using publicly available data. This gap emphasizes the need to understand how flood mitigation resources are geographically allocated, which this study aims to address.

III. METHODOLOGY

This chapter presents the methods and procedures employed in this study using Geographic Information System (GIS) analysis. It includes the research design, study area description, data collection procedures, GIS software and mapping methods, geolocation verification, and data analysis techniques used to assess the spatial distribution of DPWH flood control projects along selected Pampanga River sections in Cabanatuan City and San Isidro from 2016 to 2025.

3.1 Research Design

This study employed a **descriptive research design** combined with **geospatial analysis** to examine the distribution of flood control projects along selected sections of the Pampanga River.

The descriptive approach was used to summarize project characteristics such as cost, contractor, year of implementation, and location, while geospatial analysis was applied to visualize and assess spatial distribution patterns using GIS.

3.2 Spatial Analysis Approach

This study adopted a descriptive spatial analysis approach to examine the geographic distribution of flood control projects along selected sections of the Pampanga River.

The approach focused on identifying spatial distribution patterns and project concentration areas across selected barangays using GIS-based visualization techniques. By mapping project locations and analyzing their proximity to river sections, the study described how flood control projects were geographically distributed within the study area.

The analysis emphasized:

- Geographic distribution of projects
- variation in project distribution across barangays
- spatial relationship between project locations and river sections

The spatial analysis conducted in this study is descriptive and visualization-based and does not include predictive, hydrologic, hydraulic, or statistical spatial modeling.

3.3 Study Area Description

This study focused on selected Pampanga River sections located in Cabanatuan City and San Isidro, Nueva Ecija. These areas were selected due to the presence of multiple DPWH flood control projects implemented from 2016 to 2025 and their vulnerability to flooding during periods of heavy rainfall and river overflow. The presence of several flood control structures along these river sections makes the area suitable for spatial distribution analysis using GIS.

Data Collection

- Project title
- Contractor name
- Contract amount / total cost
- Year of implementation
- Project location / barangay

Flood control project records were collected from the DPWH Transparency Portal covering the years 2016 to 2025. Search keywords such as "flood control," "river improvement," "slope protection," "revetment," and "flood mitigation" were used to identify relevant projects within the study area.

Projects were included if they were officially classified as flood control or river protection projects and were located along selected sections of the Pampanga River in Cabanatuan City and San Isidro. Projects unrelated to flood control infrastructure or located outside the study area were excluded.

Duplicate entries were reviewed based on project title, contractor, cost, and implementation year. Incomplete records with unclear locations were validated using Google Earth imagery, nearby roads, bridges, and river alignment references.

The collected data were encoded and organized into tabular form using spreadsheet software to facilitate sorting, filtering, and analysis. Duplicate or incomplete records were reviewed and validated based on available descriptions.

This study did not involve field surveys or direct structural inspections. Furthermore, the research does not evaluate hydraulic performance, flood reduction efficiency, or structural integrity of the projects. Instead, it focuses solely on the spatial and temporal distribution of flood control interventions.

3.4 GIS Software and Mapping Methods

The primary GIS software used in this study was QGIS, an open-source geographic information system used for storing, editing, visualizing, and analyzing spatial data. QGIS was selected because it is capable of handling coordinate plotting, layer creation, thematic mapping, and spatial analysis without requiring expensive licensing. It is suitable for descriptive and spatial studies involving public infrastructure projects.

Google Earth was also used to verify river alignment, nearby roads, bridges, barangays, and visible flood control structures through satellite imagery.

The study utilized:

QGIS – for spatial mapping and analysis

Google Earth – for location verification

3.5 Coordinate Validation

The locations of flood control projects were validated using project descriptions from DPWH records, including barangay names, nearby bridges, roads, river sections, and visible flood control structures. Google Earth and QGIS were used to cross-check whether the identified project locations matched the physical features shown on satellite imagery. When exact coordinates were unavailable, approximate locations were determined using barangay boundaries, river alignment references, and visible flood control structures along the Pampanga River.

- Project locations were validated using:
- Barangay names
- Nearby landmarks (bridges, roads)
- River alignment

When exact coordinates were unavailable, approximate locations were determined using satellite imagery and spatial references in QGIS and Google Earth.

3.6 Geospatial Analysis

Geographic Information System (GIS) tools were used to map and analyze the spatial distribution of flood control projects. The data were processed using QGIS software, where project locations were plotted to visualize their geographic distribution.

The following GIS techniques were applied:

- Point Mapping – to plot the geographic locations of flood control projects.
- Spatial distribution of projects by barangay or river reach Relationship of project locations to selected river sections
- Visual Concentration Analysis – to identify areas with relatively higher concentrations of projects.
- Overlay Analysis (Basic) – to relate project locations to river sections.

These techniques helped identify spatial distribution patterns, visualize areas with relatively higher project concentrations, and examine the relationship between project locations and selected river sections.

Statistical Treatment

Descriptive statistics such as frequency counts, totals, percentages, and tabular comparisons were used to analyze the number of projects per year, contractor frequency distribution, project cost trends, and project concentration per barangay. This helped in identifying implementation patterns and funding distribution during the study period from 2016 to 2025.

3.7 Data Analysis

The collected data were analyzed using both tabular and spatial techniques.

Frequency counts, totals, and comparisons were used to analyze:

- Number of projects per year
- Total cost per year
- Number of projects per contractor
- Total value awarded per contractor
- Number of projects per barangay

Spatial Analysis

GIS tools were used to determine:

- Areas with high concentrations of projects
- Distribution of projects along selected Pampanga River sections
- Spatial clustering by barangay or river reach

Relationship of project locations to flood-prone river sections

Presentation of Results

The results of the analysis were presented through:

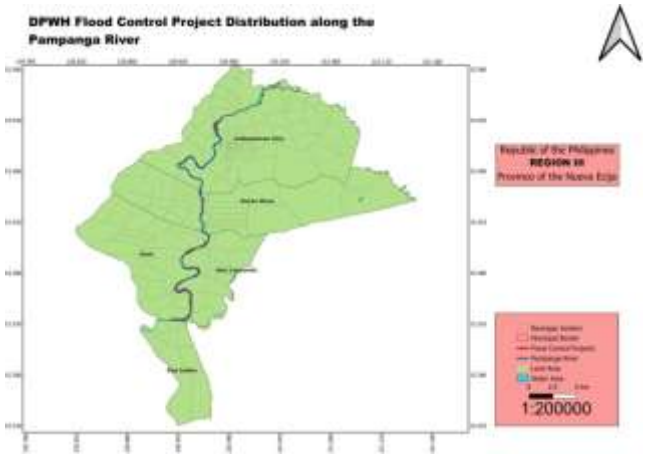
- Statistical tables
- Thematic Map
- Comparative summaries
- Narrative interpretation

These methods helped explain how DPWH flood control projects were distributed geographically and financially from 2016 to 2025.

IV. RESULTS AND DISCUSSIONS

This chapter presents the results of the geospatial and statistical analysis of Department of Public Works and Highways (DPWH) flood control projects implemented from 2016 to 2025 along selected sections of the Pampanga River in Cabanatuan City and San Isidro. The analysis integrates Geographic Information System (GIS) mapping with descriptive and statistical techniques to examine spatial distribution, project characteristics, contractor involvement, and temporal trends in implementation and cost.

Figure 4.1 GIS Map of Project Location



Source Link: CLICK HERE

The GIS-based mapping of flood control projects shows that project implementation is unevenly distributed across selected sections of the Pampanga River. Several barangays, including San Anton, San Roque, Sto. Tomas South, and Tambo Adorable, exhibit relatively higher

concentrations of recorded projects based on available DPWH data.

The observed concentration of projects may represent areas with relatively higher levels of DPWH flood control implementation along the river sections included in the study. However, the study does not confirm whether these locations correspond to the highest flood-risk zones because no flood hazard maps, hydraulic analysis, rainfall analysis, or flood inventory validation were conducted.

Other barangays recorded fewer or no mapped projects. This may reflect differences in project allocation priorities, available records, river section characteristics, or limitations in the dataset used in the study

4.1 Project Characteristics

The analyzed flood control projects vary in terms of contractor, cost, year of implementation, and geographic location. These variations reflect differences in project scale, complexity, and funding allocation.

Project costs show significant variation, with some projects involving relatively small expenditures while others require substantial investment. This suggests that certain projects involve more complex engineering interventions or are located in areas requiring stronger flood protection measures.

The participation of multiple contractors indicates competitive involvement in public infrastructure development. However, variations in project frequency among contractors suggest that some firms are more actively engaged in flood control implementation than others.

Overall, the diversity in project characteristics highlights the dynamic nature of flood control planning and the influence of both technical and administrative factors.

Table 4.2 Yearly Distribution of Projects and Cost (2016-2025)

Year	No. of Projects	Total Cost
2016	**2**	**₱46,746,797.25**
2017	**8**	**₱205,042,017.6**
2018	**6**	**₱182,154,668.6**
2019	**3**	**₱96,655,903.77**
2020	**8**	**₱408,598,767.2**
2022	**6**	**₱415,048,529.1**
2023	**1**	**₱72,374,624.95**
2024	**2**	**₱173,699,871.9**
2025	**3**	**₱311,083,058.8**

Table 4.2 shows that the yearly distribution of flood control projects shows fluctuations in both project frequency and total cost from 2016 to 2025. Some years recorded more projects with lower overall expenditures, while other years recorded fewer but higher-cost infrastructure projects.

The year 2022 recorded the highest total project expenditure despite having only six projects, suggesting the implementation of relatively larger-scale infrastructure interventions during that period. Similarly, 2020 recorded both a high number of projects and high overall expenditure.

These variations indicate that implementation patterns were influenced by funding allocation, project scope, infrastructure priorities, and administrative scheduling rather than a fixed yearly trend

Table 4.3 Distribution of Flood Control Projects by Contractor Based on Frequency and Total Cost

Contractor	Number of Projects	Total Cost
Framecon Builders	**14**	**516,241,040.00**
R.D Talens Construction	**7**	**184,402,431.60**
AMP 723 Construction Corp.	**5**	**229,165,930.24**
E.D Libunao Construction	**5**	**250,656,361.90**
Celso C. Ferrer Construction	**4**	**319,886,788.00**

Others (combined)	Remaining Contractors	Combined total (see dataset)

Table 4.2 presents the distribution of flood control projects by contractor based on project frequency and total cost from 2016 to 2025.

The results show that Framecon Builders recorded the highest number of projects with 14, followed by R.D. Talens Construction and Trading with 7 projects. AMP 723 Construction Corporation and E.D. Libunao Construction & Trading each handled 5 projects, while Celso C. Ferrer Construction Corporation completed 4 projects.

In terms of project cost, Framecon Builders recorded the highest total value at ₱516.24 million, followed by Celso C. Ferrer Construction Corporation with ₱319.89 million. Although some contractors handled fewer projects, they were associated with relatively high project costs, indicating differences in project scale and implementation complexity.

The findings indicate that flood control projects were not evenly distributed among contractors, with a small number of contractors accounting for most project implementation. This suggests a concentration of infrastructure contracts among established contractors involved in flood mitigation projects along the selected Pampanga River sections.

Table 4.4 Distribution of Flood Control Projects Across Barangays Based on Number of Projects and Total Cost.

Barangay	No. of projects	Total Cost (₱)
San Anton	6	229,243,057.30
San Roque	4	141,424,982.92
Sto. Tomas South	3	197,849,337.70
Tambo Adorable	3	165,131,643.00
Pagas	2	181,902,278.20
Ibabao Bana	2	104,653,760.60
Magpapalayok	2	158,588,563.10
Others	2	No available data

The distribution of projects across barangays is uneven. San Anton recorded the highest number of projects and total cost, followed by San Roque and Sto. Tomas South. **Z**

The concentration of projects in these barangays may reflect relatively higher levels of recorded flood control implementation within the study area. However, further validation using flood hazard maps, rainfall data, and hydraulic analysis is needed to confirm whether these areas correspond to the highest flood-risk zones.

The variation in total cost also suggests differences in project scale, with some barangays receiving larger or more complex interventions. Meanwhile, other barangays received fewer and lower-cost projects, reflecting differences in project scale and infrastructure priority.

The findings indicate that flood control projects were concentrated in selected barangays along the Pampanga River. Variations in project counts and total cost may reflect differences in project allocation priorities, river section characteristics, infrastructure requirements, and project scale within the study area.

4.4 Contractor Distribution

The distribution of flood control projects among contractors indicates that a limited number of firms handled a large portion of the recorded projects. Framecon Builders recorded the highest number of projects, followed by R.D. Talens Construction and Trading.

Variations in total project cost among contractors suggest differences in project scope, infrastructure scale, and implementation complexity. Contractors with fewer projects may still record relatively high total contract values due to larger individual project costs.

The findings reflect implementation patterns based on available DPWH project records and do not evaluate contractor performance or construction effectiveness

4.5 Barangay-Level Distribution of Projects

The distribution of flood control projects across barangays is uneven. San Anton recorded the highest number of projects and total project cost, followed by San Roque, Sto. Tomas South, and Tambo Adorable.

These barangays may represent areas with relatively

higher concentrations of DPWH flood control implementation based on available project records. However, the study does not confirm actual flood-risk conditions because no flood hazard assessment or hydraulic validation was conducted.

Variations in project counts and total cost may reflect differences in project allocation priorities, river section characteristics, infrastructure requirements, and project scale within the study area.

4.5 Summary of findings

Based on the results of the study, the following key findings were identified:

- Flood control projects are unevenly distributed across the study area, with clustering observed in specific barangays.
- Certain locations, such as San Anton, San Roque, Sto. Tomas South, and Tambo Adorable, show higher concentrations of projects.
- Project characteristics vary in terms of cost, contractor, and year of implementation, indicating differences in project scale and complexity.
- Contractor participation is not evenly distributed, with a small number of contractors handling a larger share of projects.
- Yearly trends in project implementation and cost show fluctuations, reflecting variations in funding allocation and project priorities.

The findings highlight spatial variations in the implementation of DPWH flood control projects along selected sections of the Pampanga River. GIS-based mapping and descriptive analysis provided useful visualization of project distribution patterns, contractor participation, and yearly implementation trends. However, the results are limited to descriptive spatial analysis and do not confirm flood hazard levels, infrastructure effectiveness, or actual flood mitigation performance.

V. SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Summary

This study examined the spatial distribution of DPWH flood control projects implemented from 2016 to 2025 along selected sections of the Pampanga River in Cabanatuan City and San Isidro. The primary objective was to analyze how these projects are distributed geographically, how they vary in terms of characteristics and cost, and how implementation trends change over time. Using secondary data obtained from the DPWH Transparency Portal, the study applied Geographic Information System (GIS) tools and descriptive statistical methods to map project locations and analyze spatial and temporal patterns.

Based on the findings presented in Chapter 4, the following summaries were drawn:

1. The geospatial mapping of flood control projects revealed that projects were unevenly distributed along the selected Pampanga River sections. Several barangays showed clusters of projects, while other areas had few or no recorded projects.
2. In terms of project characteristics, the flood control projects varied according to contractor, total contract cost, year of implementation, and geographic location. This indicates differences in project size, complexity, and funding allocation.
3. Barangays such as San Anton, San Roque, Sto. Tomas South, and Tambo Adorable recorded higher concentrations of projects, suggesting these locations as priority areas for flood mitigation due to their exposure to flood risks or proximity to critical river sections.
4. Contractor participation was not evenly distributed. A small number of contractors handled the majority of projects. Framecon Builders recorded the highest number of awarded projects, followed by R.D. Talens Construction and Trading and AMP 723 Construction Corporation.
5. Yearly trends in implementation showed fluctuations in both project frequency and total spending. Some years had more projects but lower expenditures, while others had fewer projects with higher costs. The year 2022 recorded the highest total spending, while 2017 and 2020 had the highest number of implemented projects.

Overall, the results show that flood control projects were distributed across multiple barangays along the Pampanga River, with noticeable concentration in selected areas. The spatial patterns observed through GIS mapping suggest targeted implementation of projects over time. Variations in yearly distribution, contractor participation, and project cost were also identified. However, the findings are limited to descriptive and spatial analysis and do not confirm flood risk levels or project effectiveness.

5.2 Conclusion

Based on the results of the study, the following conclusions were drawn:

1. GIS-based spatial analysis proved effective in identifying distribution patterns of flood control projects and highlighting areas of concentration.
2. Flood control projects were concentrated in selected barangays along the Pampanga River, indicating uneven spatial distribution of project implementation based on available DPWH records rather than uniform allocation across all locations.
3. The variation in project costs suggests that financial allocation is influenced by multiple factors, including project type, design, and site conditions, rather than project size alone.
4. The distribution of projects among contractors shows that a limited number of firms are frequently awarded projects, although project value does not always correspond to frequency.
5. Annual trends in project implementation and cost do not follow a consistent pattern, indicating that infrastructure development is influenced by budget availability, planning priorities, and project complexity.
6. The integration of spatial mapping and project data provides spatial and temporal insights that can support more informed decision-making in flood control planning and resource allocation.

The study shows that flood control project implementation along the Pampanga River is shaped by both spatial and financial considerations, and that GIS serves as a useful tool in analyzing these patterns.

5.3 Recommendations

Based on the findings of the study, the researchers recommend that DPWH and local government units strengthen the management and updating of flood control project records through a centralized GIS-based database containing accurate project locations and details. Second, flood control data should be integrated with flood hazard maps, rainfall information, and river conditions to improve planning and the identification of priority intervention areas.

Third, barangays with limited or no recorded flood control projects should be reassessed to determine whether additional interventions are necessary based on current flood risk conditions. Fourth, future planning efforts should promote a more balanced distribution of flood control projects, particularly in vulnerable areas. Lastly, future studies may apply advanced GIS techniques and include field validation, flood hazard data, and river capacity analysis to improve the accuracy and depth of spatial assessments in Nueva Ecija and other nearby river systems.

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REFERENCES

1. Cabrera, J. S., & Lee, H. S. (2019). Flood-prone area assessment using GIS-based multi-criteria analysis: A case study in Davao Oriental, Philippines. *Water*, *11*(11), 2203. https://doi.org/10.3390/w1111220
2. Dela Torre, D. M. G. D., Cruz, P. K. A. D., Jose, R. P., Gatdula, N. B., & Blanco, A. C. (2019). Geospatial assessment ofvulnerabilities of croplands to flooding risks: A case study of Philippine river basins. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-4/W19*, 173–180. https://doi.org/10.5194/isprs-archives-xlii-4-w19-173-2019
3. Department of Public Works and Highways. (n.d.). DPWH infrastructure projects portal: Real-time government transparency.https://transparency.dpwh.gov.ph/
4. Gacu, J. G., Monjardin, C. E. F., Senoro, D. B., & Tan, F. J. (2022). Flood risk assessment using GIS-based analytical hierarchy process in the municipality of Odiongan, Romblon, Philippines. *Applied Sciences*, *12*(19), 9456. https://doi.org/10.3390/app12199456
5. Hosonuma, K., Aida, K., Ballaran, V., Jr., Nagumo, N., Sanchez, P. A. J., Sumita, T., & Homma, K. (2024). Evaluation of geographical and annual changes in rice planting patterns using satellite images in the flood-prone area of the Pampanga River Basin, the Philippines. *Remote Sensing*, *16*(3), 499. https://doi.org/10.3390/rs16030499
6. Pang, Z., Ohara, M., Nagumo, N., Tanaka, T., & Jaranilla-Sanchez, P. A. (2026). *Social impacts of floods in the Pampanga River Basin: An analysis from the perspective of the SDGs*. Journal of Disaster Research, 21(2), 369–384. https://doi.org/10.20965/jdr.2026.p0369
7. Singh, S. R., Harirchian, E., Monjardin, C. E. F., & Lahmer, T. (2024). GIS-based risk assessment of building vulnerability in flood zones of Naic, Cavite, Philippines using AHP and TOPSIS. *GeoHazards*, *5*(4), 1040–1073. https://doi.org/10.3390/geohazards5040050

8. Johnson, B. A., Estoque, R. C., Li, X., Kumar, P., Dasgupta, R., Avtar, R., & Maccale-Macandog, D. B. (2021). High-resolution urban change modeling and flood exposure estimation at a national scale using open geospatial data: A case study of the Philippines. Computers, Environment and Urban Systems, 90 101704. https://doi.org/10.1016/j.compenvurbsys.2021.101704
9. Kefi, M., Mishra, B. K., Masago, Y., & Fukushi, K. (2020). Analysis of flood damage and influencing factors in urban catchments: Case studies in Manila, Philippines, and Jakarta, Indonesia. Natural Hazards, 104, 2461–2487. https://doi.org/10.1007/s11069-020-04237-5
10. Khattak, M. S., Anwar, F., Saeed, T. U., Sharif, M., Sheraz, K., & Ahmed, A. (2016). Floodplain mapping using HEC-RAS and ArcGIS: A case study of Kabul River. *Arabian Journal for Science and Engineering, 41*(4), 1375–1390. https://doi.org/10.1007/s13369-015-1915-3
11. Lagmay, A. M. F. A., Racoma, B. A., Aracan, K. A., Alconis-Ayco, J., & Saddi, I. L. (2017). Disseminating near-real-time hazards information and flood maps in the Philippines through Web-GIS. Journal of Environmental Sciences, 59, 13–23. https://doi.org/10.1016/j.jes.2017.03.014
Liu, W., Chen, W., & Peng, C. (2014). Assessing the effectiveness of green infrastructures on urban flooding reduction: A community scale study. *Ecological Modelling, 291*, 6–14. https://doi.org/10.1016/j.ecolmodel.2014.07.012
12. Park, J., & Hong, I. (2020). Innovative solutions for climate-resilient flood management in the poorer and vulnerable province of Leyte, the Philippines. In *Springer Water* (pp. 593–605). https://doi.org/10.1007/978-981-15-5436-0_46
13. Philippine Atmospheric, Geophysical and Astronomical Services Administration. (n.d.). Floods. https://www.pagasa.dost.gov.ph/learning-tools/floods
14. Poff, N. L., Allan, J. D., Bain, M. B., Karr, J. R., Prestegaard, K. L., Richter, B. D., Sparks, R. E., & Stromberg, J. C. (1997). The natural flow regime: A paradigm for river conservation and restoration. *River Research and Applications, 13*(2), 97–114. https://doi.org/10.1002/rra.867
15. Qi, H., Qi, P., & Altinakar, M. S. (2013). GIS-based spatial Monte Carlo analysis for integrated flood management with two-dimensional flood simulation. *Water Resources Management, 27*(10), 3631–3645. https://doi.org/10.1007/s11269-013-0370-8
16. Rincón, D., Khan, U. T., & Armenakis, C. (2018). Flood risk mapping using GIS and multi-criteria analysis: A Greater Toronto Area case study. *Geosciences,8*(8), 275. https://doi.org/10.3390/geosciences8080275
17. Wang, X., & Xie, H. (2018). A review on applications of remote sensing and geographic information systems (GIS) in water resources and flood risk management. *Water, 10*(5), 608. https://doi.org/10.3390/w10050608