Technologique | 2026, Vol. 8, No.1, 65 – 77 | ISSN Online: 3028-1415 | ISSN Print: 3028-1407
DOI: https://doi.org/10.62718/vmca.tech-gjtdsi.8.1.SC-1225-007

OPEN ACCESS

Effectiveness and Community Satisfaction of Flood Control Infrastructure in the 4th District of Quezon Province

Article History:

Initial submission:	11 December 2025
First decision:	15 December 2025
Revision received:	20 May 2026
Accepted for publication:	30 May 2026
Online release:	05 June 2026

Engr. Jomar B. Alcantara, ORCID No. 0009-0007-5802-0206
Master of Science in Construction Management, Polytechnic University of the Philippines, Sta. Mesa, Manila, Philippines

Abstract

Flooding is one of the most pressing hazards in the Philippines, causing widespread damage to lives, property, and livelihoods. To address this, the Department of Public Works and Highways (DPWH) has implemented numerous flood control projects in the Philippines, including the Quezon Province. Despite ongoing infrastructure investments, few studies have evaluated the effectiveness of these flood control projects from both technical and community perspectives. Thus, this study assessed the effectiveness of selected projects in the 4th District of Quezon Province, focusing on their impacts on lives, property, the environment, and the economy, as well as residents' satisfaction. Using a mixed-methods design, data were collected from 280 residents living near flood control structures, supplemented by interviews with municipal engineers and planning officers. Results indicated that the projects were effective in reducing flooding and improving community safety, with respondents reporting high satisfaction regarding safety and moderate satisfaction regarding maintenance. However, qualitative findings revealed critical concerns, including river overflow in certain areas, siltation of waterways, and budget constraints that limit regular maintenance and monitoring. These findings highlight a discrepancy between high perceived effectiveness and underlying technical and sustainability challenges. The study concludes that while flood control projects strengthen community resilience, long-term effectiveness requires consistent maintenance, ecological integration, and stronger institutional support.

Keywords: community satisfaction, disaster resilience, flood control, Quezon Province, structural integrity

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INTRODUCTION

Flooding is one of the most destructive and recurring natural hazards worldwide, causing significant damage to lives, infrastructure, agriculture, and local economies. The increasing intensity and frequency of flooding events have been linked to climate change, rapid urbanization, environmental degradation, and inadequate land-use planning. Across many countries, governments have invested heavily in flood control infrastructure such as levees, dikes, floodwalls, drainage systems, and river improvement projects as primary strategies for disaster risk reduction and climate adaptation. Previous studies have shown that these structural interventions can significantly reduce vulnerability and improve community resilience when properly designed and maintained (Tan et al., 2023; Sun et al., 2023). However, the long-term effectiveness of flood control projects remains a continuing concern due to issues related to maintenance, sustainability, ecological impacts, and institutional capacity (Chen et al., 2024; Khan, 2023).

In the Philippines, flooding is a persistent environmental and socio-economic problem due to the country's geographic location along the typhoon belt and its exposure to heavy monsoons, tropical cyclones, rising sea levels, and extreme rainfall events (PAGASA, 2023). Severe flooding continues to affect both urban and rural communities, resulting in displacement, property destruction, economic disruption, and threats to public safety. In response, the Department of Public Works and Highways (DPWH) has implemented numerous flood mitigation and river control projects

nationwide, including drainage systems, levees, floodwalls, and river rehabilitation programs (DPWH, 2024). While these interventions have contributed to reducing flood impacts in many communities, recurring flood events continue to expose concerns regarding infrastructure adequacy, sustainability, and long-term maintenance.

At the provincial level, Quezon Province remains highly vulnerable to flooding because of its multiple river systems, low-lying settlements, coastal exposure, and increasing rainfall intensity during typhoon seasons. In particular, the 4th District of Quezon Province experiences recurring flooding associated with rivers such as Maling, Pipisik, Talolong, Bocboc, and Pandanan. Unlike flood studies commonly conducted in highly urbanized areas such as Metro Manila, where flood management systems are largely engineered and centralized, the flooding conditions in Quezon Province involve complex interactions between riverine overflow, coastal dynamics, and dispersed rural communities. These localized conditions make the district a critical and serious but underexplored area for assessing flood control effectiveness and community resilience.

Although several studies have evaluated the technical performance of flood control infrastructure, many have focused primarily on engineering efficiency and hydrological outcomes. Existing literature frequently measures effectiveness through structural integrity, drainage capacity, and floodwater reduction while giving limited attention to community perception and public satisfaction. In the Philippine setting, Garcia (2021) and Santos (2024) emphasized the importance of local participation, awareness, and community engagement in disaster risk reduction; however, integrated assessments that combine technical effectiveness and community satisfaction remain limited. Moreover, many existing studies are concentrated in metropolitan areas, leaving rural and semi-rural flood-prone communities insufficiently examined.

Another significant gap in the literature involves the sustainability and long-term management of flood control infrastructure. While infrastructure investments continue to increase, limited research has examined the effects of maintenance systems, ecological integration, siltation, budget constraints, and institutional coordination on project effectiveness. Flood control systems may initially reduce flood risks, yet their long-term performance can deteriorate without regular maintenance, environmental management, and community participation. Consequently, there remains a need for localized and integrated evaluations that examine not only the technical outcomes of flood control projects but also the perceptions, experiences, and satisfaction of affected communities.

This study is anchored on Resilience Theory, which emphasizes the capacity of communities to adapt to, withstand, and recover from hazards and environmental disturbances. The study is also guided by Systems Theory, which views flood control infrastructure as interconnected systems requiring coordination among technical, environmental, institutional, and social components. These theoretical perspectives provide a framework for understanding whether existing flood control projects contribute to long-term resilience or merely offer temporary protection against flooding events.

Specifically, this study aimed to evaluate the effectiveness of selected flood control projects in the 4th District of Quezon Province by examining their impacts on lives, property, the environment, and the local economy, as well as the level of community satisfaction with these infrastructures. The study also sought to determine whether a significant relationship exists between perceived effectiveness and community satisfaction and to identify the technical and institutional challenges affecting long-term sustainability.

The study specifically sought to answer the following research questions:

1. How do the respondents' demographic profile be described in terms of age, sex, civil status, and employment status?

2. How effective are the flood control projects in the 4th District of Quezon Province in terms of reducing flooding and protecting lives, property, the environment, and the local economy?

3. What is the level of community satisfaction regarding the implemented flood control infrastructure?

4. Do demographic characteristics of respondents significantly influence perceptions of flood control project effectiveness and community satisfaction?

5. Is there a significant relationship between perceived effectiveness and community satisfaction?

6. What technical, environmental, and institutional challenges affect the sustainability of flood control projects?

7. How do residents and local officials describe the strengths and limitations of existing flood control systems?

The findings of this study are significant to local government units, the Department of Public Works and Highways (DPWH), disaster risk reduction practitioners, infrastructure planners, and policymakers involved in climate adaptation and flood management. By integrating technical assessments and community perspectives, the study contributes to a more comprehensive understanding of infrastructure effectiveness and public trust. Furthermore, the study provides evidence-based insights that may guide the development of more sustainable, inclusive, and community-responsive flood management strategies. The study also contributes to the broader discourse on resilience and disaster governance by demonstrating how maintenance systems, ecological sustainability, and community satisfaction influence the long-term success of flood control infrastructure.

LITERATURE REVIEW

Flood Hazards and Community Vulnerability in the Philippines. Flooding remains one of the most frequent and destructive natural hazards in the Philippines due to the country's geographic location along the Pacific typhoon belt and its exposure to intense monsoon rains, tropical cyclones, storm surges, and rising sea levels. According to the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA, 2023), the increasing intensity of extreme weather events has heightened the vulnerability of both urban and rural communities to flooding. Flood disasters continue to result in casualties, displacement, infrastructure damage, agricultural losses, and economic disruption, particularly in low-lying and riverine areas.

Community vulnerability to flooding is influenced not only by environmental exposure but also by socio-economic and institutional factors. Rural communities often face greater vulnerability due to limited infrastructure, inadequate drainage systems, and restricted access to disaster preparedness resources. Garcia (2021) explained that socio-demographic conditions such as income level, occupation, and access to public services significantly affect community participation and resilience in flood-prone areas. Similarly, Santos (2024) emphasized that public awareness, preparedness education, and local participation play critical roles in improving disaster response and reducing community vulnerability. In Quezon Province, flooding is aggravated by the presence of multiple river systems, coastal exposure, and geographically dispersed settlements. Communities located near rivers such as Maling, Pipisik, Talolong, Bocboc, and Pandanan frequently experience overflow during heavy rainfall events. These conditions highlight the importance of localized flood management strategies that consider both environmental and community-specific conditions.

Infrastructure-Based Flood Control Strategies. Flood control infrastructure has long been

recognized as an essential component of disaster risk reduction and climate adaptation. Governments worldwide have invested in levees, dikes, floodwalls, drainage systems, pumping stations, and river improvement projects to reduce flood risks and protect communities from disaster impacts. Structural flood mitigation measures are designed to control water flow, reduce overflow, and minimize damage to lives and property during extreme weather events.

Studies have shown that properly designed flood control structures can significantly improve public safety and reduce economic losses. Tan et al. (2023) found that levee and dike systems in flood-prone communities contributed to improved safety outcomes and reduced property damage during flooding incidents. Similarly, Sun et al. (2023) reported that visible flood control infrastructure positively influenced community confidence and resilience by reducing fear and increasing perceptions of preparedness.

Despite these benefits, several scholars have noted that the effectiveness of flood control infrastructure depends heavily on maintenance, sustainability, and ecological integration. Chen et al. (2024) emphasized that inadequate maintenance, sediment accumulation, and poor institutional coordination can reduce the long-term functionality of flood control systems. Structural interventions may also create environmental consequences such as riverbank degradation, altered water flow patterns, and vegetation loss if ecological considerations are not integrated into project planning and implementation.

In the Philippine context, flood control projects implemented by the Department of Public Works and Highways (DPWH) have contributed to reducing flood risks in several provinces; however, recurring flood events continue to reveal limitations in infrastructure capacity and maintenance systems. This suggests that flood management should not rely solely on engineering interventions but should also incorporate sustainability measures and community participation.

Community Satisfaction and Perceived Effectiveness. Community satisfaction is an important indicator in evaluating the success and social acceptance of public infrastructure projects. In disaster risk reduction, residents' perceptions of effectiveness influence public trust, cooperation, and long-term support for government interventions. Perceived effectiveness refers to the extent to which communities believe that flood control projects successfully reduce flooding, improve safety, and minimize disruption to daily life.

Previous studies have demonstrated a strong relationship between perceived effectiveness and public satisfaction. Sun et al. (2023) found that communities living near flood control structures often report increased confidence and psychological security when visible protective infrastructure is present. However, public perception may not always reflect actual technical performance, especially when underlying issues such as poor maintenance or structural deterioration remain unresolved.

Khan (2023) explained that public trust in disaster infrastructure is strongly influenced by continued maintenance, transparency, and institutional responsiveness. Communities are more likely to support flood mitigation programs when they observe consistent government action and infrastructure upkeep. Conversely, dissatisfaction may emerge when drainage systems become clogged, river channels silt up, or maintenance activities are delayed.

In the Philippine setting, Garcia (2021) emphasized that active community engagement improves residents' willingness to participate in disaster risk reduction initiatives. This highlights the importance of integrating community perspectives into infrastructure assessment to ensure that flood control projects remain responsive to local needs and expectations.

Sustainability, Maintenance, and Ecological Integration. The long-term effectiveness of flood control infrastructure depends not only on initial construction quality but also on sustainability and regular maintenance. Structural systems may deteriorate over time due to sediment accumulation, erosion, waste blockage, and changing environmental conditions. Without consistent monitoring and maintenance, flood control projects may lose effectiveness and create a false sense of security among residents.

Chen et al. (2024) emphasized that maintenance systems are critical in sustaining infrastructure performance under climate-related stress. Budget limitations, weak institutional coordination, and insufficient technical monitoring often reduce the operational lifespan of flood control systems. In many developing communities, maintenance activities are reactive rather than preventive, resulting in recurring infrastructure failure during severe weather events.

Ecological integration has also become increasingly important in flood management planning. Modern flood mitigation approaches encourage the use of eco-engineering strategies such as vegetative buffers, watershed rehabilitation, riverbank stabilization, and sediment management systems to improve environmental sustainability. These approaches recognize that purely structural interventions may not fully address the complexity of flooding problems, particularly in riverine and coastal communities.

Theoretical and Conceptual Foundations. This study is anchored on Resilience Theory and Systems Theory. Resilience Theory explains the ability of individuals and communities to adapt to, recover from, and withstand environmental hazards and disasters. In the context of flood management, resilience involves not only the presence of protective infrastructure but also the capacity of institutions and communities to sustain preparedness, adaptation, and recovery mechanisms over time.

Systems Theory, on the other hand, views flood control projects as interconnected systems involving technical, environmental, institutional, and social components. Effective flood management requires coordination among infrastructure planning, ecological protection, government support, and community participation. Weakness in one component may reduce the overall effectiveness of the entire system.

These theoretical perspectives support the present study by emphasizing that flood control effectiveness should not be evaluated solely through engineering performance. Instead, infrastructure success must also consider sustainability, maintenance capacity, environmental impacts, and community satisfaction. Through the integration of quantitative and qualitative approaches, the study seeks to provide a more comprehensive assessment of flood control infrastructure in the 4th District of Quezon Province.

METHODOLOGY

Research Design. This study employed a convergent parallel mixed-methods research design to assess the effectiveness of flood control projects in the 4th District of Quezon Province. This design was used because the study sought to examine both measurable community perceptions and qualitative insights from local officials involved in flood management. Quantitative and qualitative data were collected during the same phase, analyzed separately, and integrated during interpretation to provide a more complete understanding of the research problem (Creswell & Creswell, 2018).

The quantitative strand focused on residents perceived effectiveness of flood control infrastructure and their level of community satisfaction. The qualitative strand explored maintenance challenges, ecological concerns, institutional limitations, and technical issues experienced in the implementation and monitoring of flood control projects. This approach directly addressed the research gap

by combining community-based evaluation with technical and institutional perspectives.

Research Locale. The study was conducted in four municipalities under the jurisdiction of the DPWH Quezon 4th District Engineering Office: Atimonan, Gumaca, Lopez, and Calauag. These areas were selected because they are exposed to recurring flooding and have existing flood control structures along major waterways, including Maling River, Pipisik River, Talolong River, Bocboc Creek, and Pandanan River.

Respondents and Key Participants. For the quantitative component, 280 residents participated in the survey, with 70 respondents from each municipality. Respondents were purposively selected based on their direct exposure to flood control structures and flooding conditions in their communities (Etikan et al., 2016). For the qualitative component, 12 key informants were included, with 3 participants from each municipality. Included were municipal engineers, planning officers, and disaster risk reduction personnel. These participants were selected because of their technical knowledge and direct involvement in flood control planning, implementation, monitoring, and maintenance.

Research Instruments. A structured survey questionnaire was used to gather quantitative data on respondents' demographic profile, perceived impacts of flood control projects, perceived effectiveness of flood control structures, and level of community satisfaction. The instrument underwent expert validation and pilot testing. Reliability testing yielded a Cronbach's alpha coefficient above 0.70, indicating acceptable internal consistency (Taber, 2018).

A semi-structured interview guide was used for the qualitative component. The interview questions focused on technical performance, maintenance practices, river overflow, siltation, ecological concerns, budget limitations, and institutional support.

Data Collection Procedure. Data collection was conducted over a three-month period in 2024. Survey questionnaires were administered face-to-face to residents living near flood control structures. At the same time, key informant interviews were conducted with municipal engineers, planning officers, and disaster risk reduction personnel. This simultaneous collection of quantitative and qualitative data was consistent with the convergent parallel mixed-methods design. It allowed the study to compare residents' perceptions with the technical and institutional insights of local officials.

Data Analysis. Quantitative data were analyzed using descriptive statistics, including frequency, percentage, mean, and standard deviation, to describe respondents' demographic profile, perceived effectiveness, and satisfaction levels. Inferential statistics, including Chi-square tests and Pearson correlation analysis, were used to examine relationships between demographic variables, perceived effectiveness, and community satisfaction (Field, 2018).

Qualitative data from interviews were transcribed, coded, and analyzed using thematic analysis. Following Braun and Clarke (2019), recurring themes were identified, including maintenance challenges, siltation, ecological concerns, river overflow, budget constraints, and institutional support.

After separate analysis, the quantitative and qualitative results were integrated during interpretation. Quantitative findings were first presented through descriptive and inferential statistics, followed by qualitative themes from interviews. The two strands were then compared to identify areas of convergence, divergence, and complementarity.

This integration allowed the study to determine whether residents' satisfaction and perceived effectiveness aligned with the technical observations of local officials. For example, high satisfaction ratings were compared with qualitative reports on maintenance issues, siltation, and river overflow. This process

strengthened the validity of the findings and ensured that the evaluation considered both social acceptance and technical sustainability.

To enhance clarity of the research process, Figure 1 presents the methodological flow and integration of quantitative and qualitative components across the four study sites.

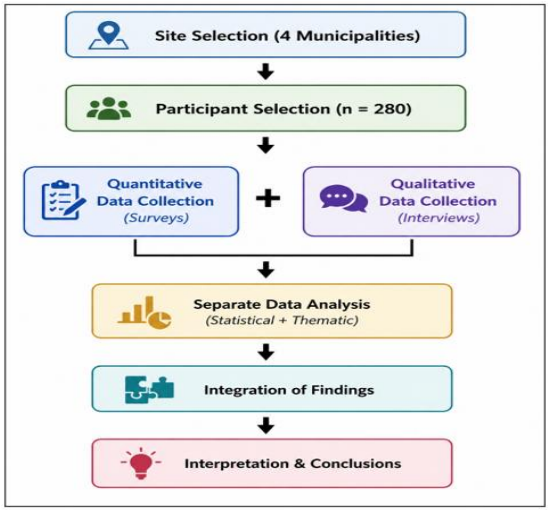

Figure 1

Mixed-Methods Research Process: From Site and Participant Selection to Integrated Analysis and Conclusions

Ethical Considerations. Ethical considerations were strictly observed throughout the study. Participants were informed about the purpose of the research and provided informed consent prior to participation. Confidentiality and anonymity of responses were ensured, and all information gathered was used solely for academic purposes.

RESULTS

The following results are organized in direct alignment with the stated research questions, ensuring that each inquiry is systematically addressed. Quantitative findings derived from survey data are presented alongside qualitative insights obtained from interviews with local officials, with both strands analyzed independently and subsequently integrated. This integration highlights points of convergence, divergence, and complementarity, thereby providing a comprehensive understanding of the effectiveness and community satisfaction with flood control infrastructure in the 4th District of Quezon Province.

Demographic Profile of the Respondents. The demographic profile of the 280 respondents is presented in Table 1. The respondents were evenly distributed across the four municipalities, with 70 participants each from Atimonan, Gumaca, Lopez, and Calauag. The profile shows a balanced representation of community members directly exposed to flood control structures. Most respondents belonged to the economically active age group, were married, employed, and engaged in skilled or professional occupations. These characteristics indicate that the respondents were directly affected by flooding and were therefore capable of assessing the local impacts of flood control projects.

Table 1

Demographic Profile of Respondents (n = 280)

Variable	Frequency	Percentage
Sex		
Male	136	48.6
Female	144	51.4
Age		
18–30 years old	68	24.3
31–50 years old	149	53.2
51 years old and above	63	22.5
Civil Status		
Single	79	28.2
Married	171	61.1
Others	30	10.7
Employment Status		
Employed	184	65.7
Unemployed	96	34.3

Effectiveness of Flood Control Projects in Reducing Flooding and Protecting Lives, Property, the Environment, and the Local Economy. As shown in Table 2, flood control projects were perceived to have a strong positive impact on the protection of lives and property, with a mean score of 4.30 and a standard deviation of 0.52. The projects were also rated positively in terms of economic impact, with a mean score of 4.10 and a standard deviation of 0.60. However, the environmental impact received a lower mean score of 3.60 and a standard deviation of 0.75. This suggests that while respondents recognized the contribution of flood control

structures to safety and economic stability, they had more moderate perceptions regarding environmental outcomes.

Table 2
Perceived Impacts of Flood Control Projects

Indicators	Mean	Standard Deviation	Interpretation
Protection of lives and property	4.30	0.52	Highly Effective
Economic benefits	4.10	0.60	Effective
Environmental impact	3.60	0.75	Moderately Effective
Overall Mean	4.00	0.62	Effective

The results in Table 3 indicate that flood control structures are effective in reducing flooding (M = 4.20, SD = 0.55) and maintaining structural integrity (M = 4.10, SD = 0.58). However, sustainability received a lower rating (M = 3.70, SD = 0.80), suggesting concerns about long-term effectiveness. This is supported by qualitative findings, where engineers identified siltation and budget constraints as ongoing challenges. These findings align with Chen et al., (2024), who emphasized that inadequate maintenance could reduce the long-term performance of flood control infrastructure.

Table 3
Effectiveness of Flood Control Structures

Indicators	Mean	Standard Deviation	Interpretation
Flood reduction	4.20	0.55	Effective
Structural integrity	4.10	0.58	Effective
Long-term sustainability	3.70	0.80	Moderately Effective
Overall Mean	4.00	0.64	Effective

Level of Community Satisfaction Regarding the Implemented Flood Control Infrastructure. As shown in Table 4, Community satisfaction was highest in terms of safety (M = 4.30, SD = 0.50), indicating that residents feel more secure during flooding events. Satisfaction with daily life improvements was moderate (M = 4.00, SD = 0.65), while maintenance received the lowest rating (M = 3.60, SD = 0.85).

This suggests a gap between initial infrastructure benefits and ongoing upkeep. The findings highlight a maintenance disconnect, where insufficient follow-up and clogged drainage systems reduce confidence in long-term effectiveness. As noted by Khan (2023) and Garcia (2021), sustained maintenance is critical for maintaining public trust in disaster infrastructure.

Table 4
Community Satisfaction

Indicators	Mean	Standard Deviation	Interpretation
Safety during flooding events	4.30	0.50	Highly Satisfied
Improvement in daily life	4.00	0.65	Satisfied
Maintenance of infrastructure	3.60	0.85	Moderately Satisfied
Overall Mean	3.97	0.67	Satisfied

To address these maintenance gaps, community-based approaches such as cash-for-work programs may be considered, allowing residents to participate in routine clearing, monitoring, and minor repairs while also providing supplemental livelihood opportunities. This approach can help bridge resource limitations while strengthening community ownership of flood control infrastructure.

Influence of Demographic Characteristics on Perceptions of Flood Control Project Effectiveness and Community Satisfaction. The statistical analysis in Table 5 revealed that demographic variables did not significantly influence perceptions of project effectiveness (χ^2 (3) = 2.15, p = 0.34).

Table 5
Inferential Statistical Tests on Demographic Variables and the Relationship Between Perceived Effectiveness and Community Satisfaction

Statistical Test	Computed Value	p-value	Interpretation
Chi-square Test	χ^2 (3) = 2.15	0.34	Not Significant

This suggests that flooding impacts were broadly experienced across different social groups, resulting in similar perceptions

regardless of age, gender, or employment status. This finding is notable, as many disaster studies report variations among vulnerable populations. In this case, the widespread nature of flooding may have created a shared experience among residents.

Relationship Between Perceived Effectiveness and Community Satisfaction. In contrast, a significant positive correlation was found, as shown in Table 6, between perceived effectiveness and community satisfaction ($r = 0.62$, $p < 0.01$), indicating that higher perceived effectiveness leads to higher satisfaction. However, qualitative findings suggest that this satisfaction may be delicate and fragile. Despite high safety ratings, engineers reported persistent issues such as river overflow, suggesting a perceived security effect, where residents feel safer due to visible infrastructure even when technical limitations remain. This highlights the importance of aligning perceived and actual effectiveness to ensure long-term resilience.

Table 6

Pearson Correlation Between Perceived Effectiveness and Community Satisfaction

Statistical Test	Computed Value	p-value	Interpretation
Pearson Correlation	r = 0.62	<0.01	Significant Positive Relationship

Descriptions of Strengths and Limitations of Flood Control Systems by Residents and Local Officials. The qualitative findings from interviews with municipal engineers, planning officers, and disaster risk reduction personnel revealed several recurring themes.

Theme 1: Maintenance Challenges. Key informants emphasized that maintenance remains one of the main issues affecting the long-term effectiveness of flood control projects. They noted that while structures were initially effective, their performance may decline when regular clearing, inspection, and repair are not sustained. Concerns were raised regarding clogged drainage channels, accumulated debris, and limited manpower for routine maintenance.

Theme 2: Siltation and River Overflow. Interview participants identified siltation as a recurring problem in rivers and waterways. Sediment accumulation reduces water-carrying capacity, increasing the likelihood of overflow during heavy rainfall. This concern was particularly relevant in river systems such as Maling, Pipisik, Talolong, Bocboc, and Pandanan, where flood control structures are exposed to continuous river flow and sediment movement.

Theme 3: Budget and Institutional Constraints. Local officials reported that budget limitations affect the regular monitoring and maintenance of flood control infrastructure. Although flood control structures are considered necessary for public safety, available funds are often insufficient for continuous inspection, desilting, and repair. These financial constraints limit the ability of local agencies to sustain the intended performance of the projects.

Theme 4: Environmental and Ecological Concerns. The interviews also revealed concerns regarding environmental impacts. Some informants observed changes in riverbank conditions, reduced vegetation, and altered natural water flow. These concerns suggest the need to integrate ecological considerations in future flood control planning and implementation.

Theme 5: Improved Community Safety and Confidence. Despite technical and maintenance concerns, key informants acknowledged that flood control projects improved residents' sense of safety. The presence of visible infrastructure gave communities greater confidence during rainy seasons and flooding events. However, officials also noted that this perceived safety must be supported by continuous maintenance and monitoring to ensure long-term protection.

Integrated Findings. Quantitative findings showed that residents rated the flood control projects highly in terms of safety, flood reduction, and protection of lives and property.

These results converged with qualitative findings indicating that the structures improved community confidence and reduced fear during flooding events.

However, the two strands also revealed important sustainability concerns. Although residents reported high satisfaction with safety, maintenance received the lowest satisfaction rating. This finding was supported by qualitative interviews, where local officials identified siltation, river overflow, limited budgets, and insufficient maintenance as major challenges. Thus, while the projects were perceived as effective in the short term, their long-term performance may be affected by technical, environmental, and institutional limitations.

The integrated findings show that flood control projects in the 4th District of Quezon Province have contributed to improved safety and community satisfaction. However, sustained effectiveness requires regular maintenance, ecological integration, adequate funding, and stronger institutional support.

DISCUSSION

The study found that flood control projects in the 4th District of Quezon Province were generally perceived as effective in reducing flooding, protecting lives and property, and improving community safety. Quantitative findings showed high ratings for flood reduction, structural integrity, and safety satisfaction, indicating that residents recognized the immediate benefits of the implemented infrastructure projects. The significant positive relationship between perceived effectiveness and community satisfaction further suggests that residents who viewed the projects as effective were more likely to express confidence and satisfaction with the flood control systems.

These findings are consistent with previous studies emphasizing the importance of structural flood mitigation measures in strengthening community resilience. Tan et al. (2023) reported that levee and dike systems improved safety outcomes and reduced property damage in flood-prone communities, while Sun et al. (2023) found that visible flood control infrastructure increased public confidence and perceptions of preparedness. The present study similarly demonstrates that flood control structures contribute not only to physical protection but also to psychological security among residents exposed to recurring flooding.

Despite these positive findings, the study also revealed concerns regarding maintenance, sustainability, and environmental impacts. Quantitative results showed that maintenance and sustainability received lower ratings compared to safety and flood reduction indicators. These findings were reinforced by qualitative interviews, where local officials identified siltation, river overflow, limited maintenance systems, and insufficient budgets as continuing challenges. This suggests that while the infrastructure projects are effective in the short term, their long-term performance may be threatened by operational and institutional limitations.

The findings support the observations of Chen et al. (2024), who emphasized that inadequate maintenance and weak institutional coordination reduce the long-term effectiveness of flood control infrastructure under climate-related stress. Similarly, Khan (2023) highlighted that public trust in disaster infrastructure depends heavily on transparency, responsiveness, and sustained maintenance. In the context of the present study, residents generally expressed confidence in the flood control projects; however, qualitative findings suggest that this confidence may weaken if maintenance concerns remain unresolved.

Another important finding of the study is that demographic variables did not significantly influence perceptions of project effectiveness. This indicates that flooding was experienced broadly across the study communities regardless of age, sex, or employment status. The shared exposure to flood risks may have contributed to relatively similar perceptions among respondents. This finding contrasts with

some disaster studies that report varying levels of vulnerability across demographic groups, but it may reflect the widespread nature of flooding in the selected municipalities.

The integration of quantitative and qualitative findings demonstrates the value of the convergent parallel mixed-methods design. While survey results showed high levels of satisfaction and perceived effectiveness, interviews provided deeper insight into technical and institutional issues that may not be immediately visible in quantitative data alone. The integration of both strands therefore provided a more comprehensive assessment of flood control effectiveness by combining statistical findings with community experiences and technical observations.

From a theoretical perspective, the findings support Resilience Theory by showing that flood control infrastructure enhances the adaptive capacity and sense of security of flood-prone communities. However, resilience extends beyond physical infrastructure and requires sustained maintenance, institutional support, and environmental management. The findings also support Systems Theory, which emphasizes that flood control effectiveness depends on the interaction among technical, ecological, institutional, and social components. Weaknesses in maintenance systems, funding, or environmental management may reduce the effectiveness of the entire flood control system. The findings have important implications for policy and practice. Local government units and the Department of Public Works and Highways should strengthen maintenance and monitoring systems to sustain the effectiveness of flood control infrastructure. Regular desilting, drainage clearing, structural inspections, and rapid repair mechanisms should be institutionalized and supported by dedicated funding. Furthermore, future flood management initiatives should integrate ecological approaches such as riverbank stabilization, vegetative buffers, and sediment management systems to improve environmental sustainability.

Community participation should also be strengthened through local monitoring programs, awareness campaigns, and maintenance partnerships. Engaging residents in flood management activities may improve accountability, strengthen public trust, and enhance long-term sustainability. The findings likewise highlight the need for evidence-based planning and feasibility studies that consider local environmental and socio-economic conditions in designing future flood control projects.

The study has several limitations. First, the research was limited to four municipalities in the 4th District of Quezon Province, which may affect the generalizability of the findings to other flood-prone areas. Second, the study relied partly on residents' perceptions, which may differ from technical hydrological assessments of flood control performance. Third, budgetary and logistical limitations constrained the scope of field validation and long-term observation of infrastructure conditions.

Future studies may expand the geographic scope by comparing flood control projects across multiple districts or provinces. Further research may also incorporate engineering assessments, hydrological modeling, and long-term ecological monitoring to evaluate the sustainability of flood control systems more comprehensively. Comparative studies examining the relationship between technical effectiveness and community satisfaction in different environmental settings may likewise provide additional insights for disaster risk reduction planning and infrastructure policy.

Conclusions. The study revealed that flood control projects in the 4th District of Quezon Province are generally effective in reducing flood risks, protecting lives and property, and improving community safety. Residents reported high levels of satisfaction, particularly in terms of safety, indicating increased confidence during flooding events. However, concerns were raised regarding long-term

sustainability, particularly in relation to maintenance and environmental impacts.

The findings also showed that demographic factors did not significantly influence perceptions of project effectiveness, suggesting that flooding impacts were broadly experienced across different social groups. In contrast, a strong positive correlation between perceived effectiveness and community satisfaction underscores the importance of both technical performance and public confidence in evaluating infrastructure success.

Importantly, qualitative insights from municipal engineers and planning officers revealed critical challenges, particularly budget constraints, siltation, and insufficient maintenance systems, which threaten the long-term effectiveness of these projects. These findings highlight the value of the mixed-methods approach, as they provide deeper context to the quantitative results and reveal underlying issues that may not be immediately visible through survey data alone.

Based on these findings, it is recommended that future flood control initiatives prioritize evidence-based planning through comprehensive feasibility studies and the development of flood control master plans to ensure context-specific and community-responsive designs. Local governments and the Department of Public Works and Highways (DPWH) should institutionalize regular maintenance and monitoring systems, supported by dedicated funding. This recommendation is strongly grounded in the qualitative findings, which identified the lack of sustained financial support as a major barrier to effective maintenance.

Furthermore, strengthening partnerships with civil society and integrating eco-engineering approaches, such as vegetative buffers and silt management systems, can enhance both sustainability and environmental balance. Programs that encourage community participation such as local monitoring initiatives and maintenance support should also be promoted to improve accountability and long-term project performance.

By combining technical soundness, sustained maintenance, ecological sensitivity, and community engagement, flood control projects can move beyond short-term protection and contribute to long-term resilience and increased public trust.

Author contributions. This paper was solely authored by the researcher, who independently conceptualized the study, collected and analyzed the data, interpreted the findings, and prepared the manuscript for publication.

Conflict of interest. The author declares no conflict of interest.

Funding source. This research received no external funding.

Artificial intelligence use. No AI tools were used in the preparation of this manuscript.

Ethics approval statement. Ethics approval was acquired from the Chief of the Center for Research and Extension at the Polytechnic University of the Philippines - Open University System (PUP-OUS).

Data availability statement. All data supporting the findings of this study are included within the manuscript and its supplementary materials.

Acknowledgement. The researcher sincerely extends gratitude to the residents and local officials of Atimonan, Gumaca, Lopez, and Calauag for their participation and cooperation in this study. Special thanks are given to the Department of Public Works and Highways (DPWH) Quezon 4th District Engineering Office for providing technical insights, and to colleagues and mentors whose guidance enriched the research process. Above all, heartfelt appreciation is offered to family and friends for their unwavering encouragement and support throughout this endeavor.

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