



Construction Management Perspectives on Flood Control Infrastructure Efficiency: A Case Study of Bay, Laguna

Article History:

Initial submission:	30 July 2026
First decision:	08 August 2026
Revision received:	14 October 2026
Accepted for publication:	20 October 2026
Online release:	23 October 2026

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Abstract

Flooding remains a recurring problem in the Municipality of Bay, Laguna despite the presence of flood-control infrastructure. This study assessed the efficiency of existing flood-control infrastructure from a construction management perspective, focusing on current condition and performance; structural and functional performance; planning and design quality; construction and execution; construction management performance; operation, maintenance, and community involvement; and implementation and management challenges. A quantitative case study design was employed using a five-point Likert-scale questionnaire administered to 15 purposively selected respondents. Field observations and document review were also conducted to provide supporting information on the physical condition and management of existing flood-control infrastructure. Quantitative data were analyzed using frequency, percentage, weighted mean, and ranking. The current condition and performance dimension received the lowest weighted mean (2.20, Disagree), while operation, maintenance, and community involvement received the highest weighted mean (3.00, Somewhat Agree), followed by construction management performance (2.80), construction and execution (2.78), structural and functional performance (2.76), and planning and design quality and challenges encountered (2.73 each). The findings indicate that existing flood-control infrastructure provides some level of functionality but remains subject to limitations in condition, capacity, and maintenance, particularly during periods of heavy rainfall. The study recommends lifecycle-oriented construction management, infrastructure rehabilitation and upgrading, preventive maintenance, stronger quality assurance and monitoring, and improved stakeholder coordination to support more sustainable and climate-resilient flood-control infrastructure management in Bay, Laguna.

Keywords: flood control infrastructure, construction management, flood mitigation, infrastructure management, climate resilience, Bay, Laguna



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INTRODUCTION

Flooding is one of the most frequent and damaging natural hazards affecting communities, particularly in areas exposed to intense rainfall, river overflow, inadequate drainage, and changing environmental conditions. The impacts of flooding extend beyond immediate damage to property and infrastructure, affecting transportation, livelihoods, public services, and community safety. Climate change further increases the need for effective and resilient flood-risk management because changes in rainfall patterns and the occurrence of extreme weather events can place additional pressure on existing infrastructure systems (Asian

Development Bank [ADB], 2013; Intergovernmental Panel on Climate Change [IPCC], 2023).

In the Philippines, flood management remains an important concern because many communities are exposed to recurring flooding associated with intense rainfall, river systems, coastal and lakeshore conditions, urban development, and limitations in drainage and flood-control infrastructure. Government agencies have implemented structural measures such as drainage systems, canals, dikes, floodways, and river walls to reduce flood risks and protect communities and economic assets. The effectiveness of these facilities, however, depends not only on their physical

design and hydraulic capacity but also on the quality of planning, construction, supervision, maintenance, monitoring, and risk management throughout their service life (Department of Public Works and Highways [DPWH], 2005, 2019, 2023).

From a construction management perspective, the effectiveness of flood-control infrastructure should therefore be considered beyond the completion of construction. Project planning and scheduling, cost control, quality assurance, procurement, stakeholder coordination, risk management, and monitoring are interconnected processes that influence whether infrastructure can achieve its intended performance (Project Management Institute [PMI], 2021). Similarly, asset-management principles emphasize that infrastructure performance should be managed throughout its lifecycle, including operation, maintenance, rehabilitation, and eventual replacement (International Organization for Standardization [ISO], 2014). Risk-management principles further support the systematic identification, assessment, treatment, and monitoring of risks that may affect infrastructure performance (International Organization for Standardization [ISO], 2018).

The Municipality of Bay, Laguna, experiences recurring flooding, particularly during periods of moderate to heavy rainfall. The municipality has existing flood-control interventions, including drainage systems, canals, dikes, and river walls intended to reduce the effects of flooding in vulnerable communities. Despite these interventions, recurring flood events raise concerns regarding the condition, functionality, capacity, and long-term management of existing flood-control infrastructure. Within the Laguna de Bay context, integrated water-resource and community-oriented approaches have also been recognized as important considerations in addressing flood-related concerns and managing environmental risks (Santos-Borja & Nepomuceno, 2018, 2019).

The conditions observed in the study area indicate that the presence of flood-control structures does not necessarily guarantee adequate flood protection. Infrastructure may continue to function while simultaneously experiencing deterioration, sediment accumulation, drainage congestion, or capacity limitations. In addition, urban development and changes in runoff characteristics can increase pressure on existing drainage and flood-control systems. These concerns highlight the importance of evaluating not only the engineering characteristics of flood-control facilities but also the management processes governing their planning, construction, operation, maintenance, and improvement.

Existing flood-related studies and practices have frequently emphasized hydrological conditions, hydraulic performance, engineering design, hazard assessment, and structural mitigation. These perspectives are essential for determining the technical adequacy of flood-control systems. However, infrastructure performance is also influenced by construction-management processes, including project planning, construction execution, quality control, supervision, maintenance management, stakeholder coordination, and lifecycle asset management. A construction management perspective can therefore provide an additional way of understanding why infrastructure may perform below its intended level even when structural interventions are already present.

The need for resilient infrastructure is particularly important under changing climatic conditions. The IPCC (2023) emphasizes the importance of adaptation and resilience in infrastructure systems exposed to increasing climate-related risks. In the Philippine setting, climate and flood information provided by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA, 2023), together with national flood-control and infrastructure-management programs, provides an important basis for risk-informed planning and decision-making (DPWH, 2019, 2023). These considerations suggest that

flood-control projects should be managed as long-term infrastructure assets rather than as isolated construction activities.

Despite the importance of these considerations, there remains a need for more localized assessment of how construction management practices relate to the observed efficiency of flood-control infrastructure, particularly at the municipal level. Examining planning, design, construction, quality management, maintenance, stakeholder participation, and implementation challenges together can provide a more comprehensive understanding of infrastructure performance. This is especially relevant in Bay, Laguna, where recurring flooding persists despite the presence of flood-control facilities.

Therefore, this study evaluated the efficiency of flood-control infrastructure in Bay, Laguna from a construction management perspective. Specifically, it assessed: (1) the current condition and performance of existing flood-control infrastructure; (2) structural and functional performance; (3) planning and design quality; (4) construction and execution; (5) construction management performance; (6) operation, maintenance, and community involvement; and (7) challenges encountered in the implementation and management of flood-control infrastructure. The study also used field observations and document review to provide supporting contextual information for interpreting the quantitative assessment of existing flood-control infrastructure.

By examining flood-control infrastructure through a construction management lens, the study seeks to contribute a practical perspective to flood-risk and infrastructure-management research. The findings are intended to support local government units, project managers, engineers, and other stakeholders in identifying management and infrastructure priorities that can improve the durability, functionality, maintainability, and long-term resilience of flood-control facilities in Bay, Laguna.

LITERATURE REVIEW

Flood Control Infrastructure and Infrastructure Performance. Flood control infrastructure is essential for reducing communities' exposure to flooding and protecting lives, property, and economic activities. Structural measures such as drainage systems, canals, dikes, floodways, river walls, pumping facilities, and other hydraulic structures are designed to regulate water movement and reduce flood impacts. However, the existence of these structures does not automatically guarantee effective flood protection. Their performance depends on appropriate design, construction quality, operational capacity, maintenance, environmental conditions, and the ability of responsible institutions to manage them throughout their service life.

In the Philippine context, flood-control infrastructure is particularly important because many communities experience recurrent flooding associated with intense rainfall, river overflow, urban development, drainage limitations, and the country's exposure to tropical cyclones. The Department of Public Works and Highways (DPWH) provides technical and implementation guidance for flood-control and drainage infrastructure, emphasizing appropriate planning, design, construction, and maintenance practices (DPWH, 2005, 2019, 2023). These requirements indicate that flood-control infrastructure should be viewed as a continuing management responsibility rather than as a project that ends upon physical completion.

The Laguna de Bay setting presents additional challenges because the lake functions as an important receiving and detention system for floodwaters while simultaneously supporting settlements, fisheries, agriculture, and other economic activities. Recent hydrodynamic research has emphasized the complex interaction among lake storage, river discharge, flood-control structures, sedimentation, and competing uses in the Laguna Lake system (Herrera & Naito, 2024). These conditions reinforce the importance of considering flood-

control infrastructure within its broader environmental and institutional context.

Construction Management in Infrastructure Projects. Construction management provides a framework for coordinating the technical, financial, organizational, and human dimensions of infrastructure delivery. The Project Management Institute (PMI, 2021) identifies project scope, schedule, cost, quality, procurement, risk, communication, and stakeholder management as interconnected areas that influence project performance. For flood-control infrastructure, these dimensions are relevant because construction projects often involve multiple agencies, contractors, technical personnel, local government units, and affected communities.

Planning and scheduling are particularly important because delays in infrastructure projects can affect project costs, resource allocation, community protection, and the timing of flood-risk reduction. Evidence from Laguna demonstrates the relevance of construction-management factors specifically to flood-control projects. Namo (2020) examined delays in flood-control construction projects in Laguna and identified slow decision-making as a leading cause of delay, while expert interviews highlighted the importance of technical capacity, timely decision-making, coordination meetings, and clearly defined responsibilities. These findings support the need to examine construction management not only as an administrative function but also as a factor that can influence the delivery and eventual performance of flood-control infrastructure.

Quality management is another critical construction-management consideration. Flood-control facilities must be constructed according to approved designs, technical specifications, material requirements, and applicable standards. Effective quality assurance and quality control can reduce defects, premature deterioration, and costly corrective work. PMI (2021) emphasizes that quality should be incorporated throughout

project planning and execution rather than treated solely as a final inspection activity.

For flood-control projects, quality management is especially important because deficiencies in construction may become apparent only when infrastructure is exposed to heavy rainfall, high water levels, hydraulic pressure, or repeated loading. Consequently, construction supervision, inspection, materials control, workmanship monitoring, and documentation are important components of infrastructure performance.

Asset Management, Operation, and Maintenance. Flood-control infrastructure is a long-term public asset requiring continuous operation, inspection, maintenance, rehabilitation, and eventual replacement. ISO 55000 (2014) emphasizes lifecycle asset management, which involves coordinating asset performance, risk, cost, and service objectives throughout the asset's life. Applying this principle to flood-control infrastructure means that decisions should not focus solely on initial construction costs but should also consider long-term operation, maintenance, deterioration, rehabilitation, and replacement.

Maintenance is particularly important for drainage and flood-control facilities because sediment accumulation, debris, vegetation, structural deterioration, and blockage can reduce hydraulic capacity. A structurally sound drainage channel can nevertheless perform poorly when its flow path is obstructed. Similarly, river walls and other protective structures may require periodic inspection and rehabilitation as their condition changes.

Recent Philippine evidence reinforces the importance of maintenance. A 2026 assessment of flood-control infrastructure in Quezon Province found that communities generally perceived flood-control projects as effective but identified river overflow, siltation, budget constraints, and limitations in regular maintenance and monitoring as continuing concerns. This suggests that perceived

effectiveness and long-term sustainability are related but distinct considerations.

The relationship between infrastructure condition and maintenance is therefore important to the present study. Evaluating current infrastructure performance together with operation and maintenance practices can reveal whether existing management arrangements are sufficient to preserve infrastructure functionality over time.

Risk Management and Climate Resilience. Flood-control infrastructure operates in an environment characterized by uncertainty. Extreme rainfall, river overflow, sedimentation, changes in land use, infrastructure deterioration, construction delays, resource limitations, and changing climate conditions can affect infrastructure performance. ISO 31000 (2018) provides a systematic framework for identifying, assessing, treating, and monitoring risks. Incorporating these principles into flood-control project management can improve preparedness and support more informed decisions regarding infrastructure investment and maintenance.

Climate change further strengthens the need for risk-informed infrastructure management. The IPCC (2023) emphasizes the importance of adaptation and resilience in infrastructure systems exposed to climate-related hazards. In the Philippines, climate information and projections provided by PAGASA can support climate-risk assessment and planning (PAGASA, 2023).

Research in the Philippine setting also demonstrates the value of combining structural interventions with broader resilience measures. In Davao City, co-design approaches involving stakeholders have been used to connect hydrological modeling, disaster literacy, risk communication, and community participation in strengthening flood resilience. The study demonstrates that structural measures can be strengthened when technical knowledge and community-level capacities are developed together.

Thus, flood-control infrastructure efficiency should not be interpreted only as the ability of a structure to withstand floodwater. It also involves the capacity of institutions and communities to anticipate risks, maintain infrastructure, coordinate interventions, and adapt management practices as flood conditions change.

Community Participation and Stakeholder Coordination. Flood management involves multiple stakeholders, including national government agencies, local government units, engineers, contractors, community organizations, and residents. Coordination among these groups is important because infrastructure planning and implementation often affect communities directly. Residents also possess local knowledge concerning flood depth, drainage behavior, recurring blockages, and infrastructure weaknesses that may not be fully captured by technical assessments.

Philippine research supports the importance of community involvement in flood mitigation. De Vera, Gonzales, and Evangelista (2020), in a comparative case study of Malabon City and Candaba, Pampanga, found that flood management involved community stakeholders and local government actors and highlighted the importance of preparedness systems, reporting mechanisms, sustainability measures, and community involvement.

More recent Philippine research similarly indicates that community participation can contribute to flood resilience when combined with institutional support. A 2024 mixed-methods study in Zamboanga City reported substantial community involvement in flood-mitigation activities and emphasized the contribution of collective action to flood-risk reduction. Research on climate-disaster interventions in the Philippines has likewise identified participatory governance, community empowerment, and collaborative resource mobilization as important to sustaining climate-responsive infrastructure, while funding, technical capacity, and maintenance remain continuing challenges.

These findings are relevant to construction management because stakeholder coordination extends across the entire infrastructure lifecycle. Community participation can contribute to planning and monitoring, while government agencies and technical personnel remain responsible for ensuring that infrastructure is properly designed, constructed, maintained, and managed.

Flood-Control Governance and Institutional Coordination. Infrastructure performance is also influenced by institutional arrangements. Flood-control projects commonly involve multiple organizations with different responsibilities for planning, financing, construction, operation, maintenance, and emergency response. Weak coordination can result in delays, unclear responsibilities, and inadequate information sharing between construction and long-term maintenance.

Research on flood-control programs in the Philippines has highlighted the importance of inter-agency coordination and systematic planning. A qualitative study of flood-control programs in Region XII found that comprehensive planning, consistent monitoring, and collaboration among government agencies and local government units were associated with more effective implementation, while limited funding, weather-related delays, and maintenance constraints remained challenges.

Similarly, recent flood-risk governance research in Zamboanga City found that flooding was associated with river overflow, heavy rainfall, clogged waterways, poor drainage, and waste-management problems, while institutional coordination and routine maintenance remained important areas for improvement. These findings demonstrate that infrastructure performance cannot be separated completely from governance and management processes.

For construction management, this means that coordination should be considered a performance factor rather than simply an

administrative requirement. Effective communication among project owners, technical personnel, contractors, local authorities, and communities can facilitate timely decisions, improve quality control, and support the transition from construction to operation and maintenance.

Construction Management and Flood-Control Infrastructure Efficiency. Although flood-control research commonly emphasizes hydrology, hydraulic modeling, structural design, disaster risk reduction, and climate adaptation, a construction-management perspective provides an additional framework for understanding infrastructure performance. Construction management connects planning and design with procurement, construction execution, quality assurance, cost and schedule control, stakeholder coordination, risk management, operation, maintenance, and asset management.

The available Philippine evidence demonstrates that these management dimensions can have direct implications for flood-control outcomes. The Laguna study by Namo (2020), for example, identified decision-making and coordination as important factors affecting flood-control construction delays. More recent studies have similarly identified maintenance, funding, institutional coordination, and community participation as factors affecting the sustainability and effectiveness of flood-related interventions.

However, relatively fewer studies have evaluated flood-control infrastructure at the municipal level by integrating infrastructure condition with planning, design, construction execution, construction management, maintenance, community involvement, and implementation challenges within a single assessment framework. Much of the existing literature addresses these dimensions separately or focuses primarily on engineering and disaster-risk perspectives.

The present study addresses this gap by examining flood-control infrastructure through

a construction-management lens and connecting infrastructure condition with planning, design, construction execution, construction management, operation and maintenance, community involvement, and implementation challenges. Field observations and documentary evidence provide additional contextual information for interpreting the quantitative assessment of infrastructure performance.

Synthesis and Research Gap. The literature indicates that effective flood-control infrastructure depends on several interconnected factors: appropriate planning and design, sound construction practices, quality assurance, effective project management, systematic risk management, lifecycle asset management, regular maintenance, institutional coordination, and meaningful community participation. These factors are particularly important in the Philippine context, where recurrent flooding, climate-related risks, infrastructure limitations, and resource constraints create continuing challenges for local governments and implementing agencies.

Existing studies provide evidence concerning flood-control effectiveness, community participation, construction delays, climate resilience, and institutional coordination. However, there remains a need for localized studies that integrate these dimensions from a construction management perspective. There is limited evidence on how the condition and functional performance of flood-control infrastructure in a municipality relate to planning and design, construction execution, construction management, operation and maintenance, community involvement, and implementation challenges.

The present study addresses this gap by examining flood-control infrastructure in Bay, Laguna using a quantitative case study approach. The quantitative assessment provides weighted measures of infrastructure and construction-management performance, while field observations and document review

provide supporting contextual information concerning the observed physical conditions and management of existing flood-control infrastructure. This approach allows the study to assess the perceived performance of flood-control infrastructure while relating the results to observed physical conditions and documented management practices.

METHODS

Research Design. A quantitative case study design was used to evaluate the efficiency of flood-control infrastructure in Bay, Laguna from a construction management perspective. The quantitative component assessed respondents' perceptions of existing flood-control infrastructure using a structured questionnaire covering current condition and performance, structural and functional performance, planning and design quality, construction and execution, construction management performance, operation and maintenance, community involvement, and implementation challenges.

The case study design was selected because the study focused on a specific municipality and examined existing flood-control infrastructure within its actual local context. Field observations and document review were used as supporting sources of information concerning the physical condition and management of the infrastructure. The findings are interpreted as a case-specific assessment because of the localized study area and purposive sampling approach and are not intended to represent all municipalities or flood-control infrastructure systems.

Study Area. The study was conducted in the Municipality of Bay, Laguna, Philippines, a first-class municipality located along the eastern portion of Laguna Province and adjacent to Laguna de Bay. The municipality experiences recurring flooding during periods of moderate to heavy rainfall because of its proximity to rivers, drainage systems, and the lake. Existing flood control measures within the municipality include drainage systems, drainage canals,

dikes, and river walls constructed to reduce flood risks and protect communities.

Eight flood-prone barangays, namely Tagumpay, San Isidro, Dila, San Antonio, San Agustin, Maitim, Calo, and San Nicolas were selected as the study sites. These barangays were chosen because they have experienced recurring flooding and contain existing flood control infrastructures relevant to the objectives of the study. Their varying levels of flood exposure provided an appropriate setting for evaluating the effectiveness of flood control infrastructure from a construction management perspective.

Participants and Sampling. Purposive sampling was employed to select respondents with firsthand experience and technical knowledge relevant to flood control infrastructure. A total of fifteen (15) respondents participated in the study, consisting of eight (8) residents, four (4) engineers, two (2) project managers, and one (1) architect. The resident respondents were selected from flood-prone barangays based on their experiences with recurring flooding and their familiarity with the existing flood control infrastructure. The engineers, project managers, and architect were included as professional respondents because of their relevant technical and project-management knowledge concerning infrastructure planning, design, construction, quality assurance, operation and maintenance, and project implementation. Their professional perspectives complemented the residents' firsthand community experiences by providing informed assessments of the technical and management aspects of flood-control infrastructure. Their inclusion was intended to provide professional contextualization of the conditions observed in the study area rather than to imply that they served as official representatives of all eight barangays.

The use of purposive sampling was appropriate because the study sought detailed information from participants possessing specialized knowledge rather than generating statistically generalizable findings. The combination of

community-based and professional respondents enabled the study to examine flood control infrastructure from both technical and user perspectives, thereby strengthening the comprehensiveness of the evaluation.

Research Instrument. The primary research instrument used in this study was a researcher-developed survey questionnaire designed to assess flood-control infrastructure efficiency from a construction management perspective in Bay, Laguna. The questionnaire was developed in accordance with the objectives of the study and covered seven assessment dimensions: (1) current condition and performance; (2) structural and functional performance; (3) planning and design quality; (4) construction and execution; (5) construction management performance; (6) operation, maintenance, and community involvement; and (7) challenges encountered in the implementation and management of flood-control infrastructure.

The questionnaire consisted of statements intended to obtain respondents' assessments of the condition, functionality, planning, construction, management, operation, and maintenance of flood-control infrastructure, as well as the challenges encountered in its implementation and management. Responses were measured using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The collected responses were analyzed using frequency, percentage, weighted mean, and ranking, as appropriate to the objectives of the study.

Research Instrument Validation. The research instrument was not subjected to formal expert validation prior to data collection. Although the instrument was developed based on a review of relevant literature and aligned with the study objectives, its validity was not independently established. Therefore, the findings should be interpreted with appropriate caution, considering that the extent to which the instrument accurately measured the intended constructs was not formally established before data collection.

A field observation checklist was also used to document the visible physical conditions of flood-control infrastructure in the eight selected barangays of Bay, Laguna: Tagumpay, San Isidro, Dila, San Antonio, San Agustin, Maitim, Calo, and San Nicolas. The observations covered drainage systems, drainage canals, dikes, and river walls, focusing on visible obstructions, sediment or silt accumulation, and the relative height and condition of river walls in relation to adjacent road levels. Observations were recorded through direct field inspection and field notes. The recorded observations were described and compared with the survey findings to provide contextual information about the infrastructure's condition and possible performance concerns. They were not subjected to a separate thematic qualitative analysis or qualitative coding procedure.

Document review was also used to examine available records relevant to flood-control infrastructure in the study area. The information obtained from the documents provided supplementary context for interpreting the survey findings and understanding the construction management of flood-control infrastructure. The specific documents reviewed should be identified in the manuscript based on the records examined.

The researcher also conducted interviews with the Municipal Engineer and a DPWH Engineer to obtain supplementary information relevant to flood-control infrastructure and construction management in Bay, Laguna. The survey questionnaire served as the primary instrument for collecting the quantitative data used in the statistical analysis.

Five-Point Likert Scale. The survey questionnaire used a five-point Likert scale to assess respondents' perceptions of the condition, performance, and management of flood-control infrastructure. The scale ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). The numerical ranges and corresponding verbal interpretations presented in Table 1 were used to interpret the weighted mean scores.

The weighted mean scores obtained from the survey responses were interpreted according to the established verbal interpretation ranges. Higher weighted mean scores indicate stronger agreement with the statements presented in the questionnaire.

Table 1

Scale	Range	Verbal interpretation
5	4.21–5.00	Strongly Agree
4	3.41–4.20	Agree
3	2.61–3.40	Somewhat Agree
2	1.81–2.60	Disagree
1	1.00–1.80	Strongly Disagree

Data Collection. Prior to data collection, the researcher secured the necessary permissions from the concerned municipal and barangay authorities and obtained informed consent from all participants. The survey questionnaires were personally administered to the selected respondents. The accomplished questionnaires were collected and checked for completeness before the responses were encoded and subjected to statistical analysis.

Field Observation Procedure. Field observations were conducted in the identified flood-prone barangays of Bay, Laguna, specifically Tagumpay, San Isidro, Dila, San Antonio, San Agustin, Maitim, Calo, and San Nicolas. The observations focused on existing flood-control infrastructure, including drainage systems, drainage canals, dikes, and river walls.

The observation indicators were based on the study dimensions concerning current physical condition, structural and functional performance, drainage and floodwater capacity, visible signs of deterioration, maintenance conditions, and factors that could affect infrastructure performance during rainfall and flooding. Attention was given to visible obstructions, sediment and silt accumulation, drainage congestion, structural deterioration, the condition of river walls, and the relationship of flood-control structures to adjacent roads and surrounding areas.

The observations were documented through field notes and direct visual assessment of the identified infrastructure. Relevant municipal reports and planning documents available to the researcher were also reviewed to provide supporting contextual information. The observational findings were subsequently compared with the quantitative survey results to provide physical context for interpreting respondents' assessments of infrastructure condition, capacity, maintenance, and overall flood-control performance.

Data Analysis. The quantitative data obtained from the survey questionnaires were organized, tabulated, and analyzed using frequency, percentage, weighted mean, and ranking. Frequency and percentage were used to summarize the demographic and professional characteristics of the respondents. Weighted mean was used to determine the respondents' level of agreement with statements describing the condition and performance, planning and design, construction and execution, construction management, operation and maintenance, community involvement, and implementation and management challenges associated with flood-control infrastructure.

The weighted mean results were interpreted using the five-point verbal interpretation scale presented in Table 1. The indicators within each assessment dimension were compared based on their weighted mean values to identify areas where respondents expressed relatively higher or lower levels of agreement.

Field observations and relevant documentary information were used as supporting contextual evidence in interpreting the quantitative findings. These sources were not subjected to thematic qualitative analysis but were used to describe observed physical conditions and documented management considerations relevant to the assessment. The field observations and documentary information were therefore treated as supplementary evidence and were not assigned separate quantitative scores or included in the computation of the weighted means.

Ethical Considerations. The study adhered to established ethical principles throughout the research process. Participation was voluntary, and informed consent was obtained from all respondents before data collection. Participants were informed of the objectives of the study and assured that the information they provided would be treated with strict confidentiality and used solely for academic purposes. Personal identities were kept anonymous, and all collected data were accurately reported and interpreted without fabrication, falsification, or misrepresentation.

RESULTS

Evaluation of the Current Condition and Performance of Flood Control Infrastructure.

Table 2 presents the respondents' evaluation of the current condition and performance of flood control infrastructure in Bay, Laguna. All five indicators obtained a weighted mean of 2.20, corresponding to the verbal interpretation of Disagree. The uniform ratings indicate that the respondents generally perceived the existing flood control infrastructure as insufficient to effectively reduce flooding within the municipality. The findings suggest that concerns exist regarding the condition, structural integrity, consistency of performance, and overall effectiveness of the existing flood control measures.

Table 2
Evaluation of the Current Condition and Performance of Flood Control Infrastructure

Indicator	WM	Interpretation
Flood control infrastructure is generally in good condition.	2.20	Disagree
Infrastructures such as drainage systems and dikes maintain integrity.	2.20	Disagree
Flood control measures effectively reduce flood frequency.	2.20	Disagree
Different flood control measures perform consistently well.	2.20	Disagree
The infrastructure positively impacts the community during floods.	2.20	Disagree

Evaluation of the Structural and Functional Performance of Flood Control Infrastructure.

Table 3 presents the respondents' assessment of the structural and functional performance of flood control infrastructure. The highest weighted mean of 3.00 (Somewhat Agree) was

obtained by the indicator stating that functional improvements are regularly implemented. Meanwhile, infrastructure durability over time received the lowest weighted mean of 2.20 (Disagree). The remaining indicators obtained weighted means ranging from 2.73 to 2.93, all interpreted as Somewhat Agree. Overall, the findings indicate that although the infrastructure demonstrates acceptable structural and operational performance, respondents perceived limitations in its long-term durability.

Table 3

Evaluation of the Structural and Functional Performance of Flood Control Infrastructure

Indicator	WM	Interpretation
Flood control infrastructures withstand heavy rainfall and typhoons.	2.93	Somewhat Agree
Infrastructure functions effectively to control floodwater.	2.73	Somewhat Agree
There are minimal signs of wear or damage on infrastructure.	2.93	Somewhat Agree
Infrastructure durability is satisfactory over time.	2.20	Disagree
Functional improvements are regularly implemented.	3.00	Somewhat Agree

Evaluation of the Planning and Design Quality of Flood Control Projects. Table 4 presents the respondents' evaluation of the planning and design quality of flood control projects in Bay, Laguna. All indicators received an identical weighted mean of 2.73, corresponding to the interpretation of Somewhat Agree. The results indicate that respondents considered stakeholder involvement, consideration of local environmental conditions, flood-risk assessment, community participation, and overall planning practices to be moderately satisfactory. However, the uniform ratings also suggest opportunities for further improvement in project planning and design.

Table 4

Evaluation of the Planning and Design Quality of Flood Control Projects

Indicator	WM	Interpretation
Stakeholders are involved in planning and design processes.	2.73	Somewhat Agree
Planning considers local geography and environmental risks.	2.73	Somewhat Agree
Flood risk assessments inform project designs adequately.	2.73	Somewhat Agree
Community feedback is integrated into design.	2.73	Somewhat Agree
Planning and design processes meet project requirements.	2.73	Somewhat Agree

Evaluation of the Construction and Execution of Flood Control Projects. Table 5 presents the respondents' assessment of the construction and execution of flood control projects. The highest weighted mean of 3.00 (Somewhat Agree) was obtained by the indicator stating that construction projects adhere to schedules and budgets. The remaining indicators; including construction quality, compliance with engineering standards, quality control, and management of construction challenges received weighted means of 2.73, also interpreted as Somewhat Agree. Overall, the findings indicate that the implementation of flood control projects is moderately effective but still requires improvement in several aspects of project execution.

Table 5

Evaluation of the Construction and Execution of Flood Control Projects

Indicator	WM	Interpretation
Construction materials and workmanship are of high quality.	2.73	Somewhat Agree
Construction projects adhere to schedules and budgets.	3.00	Somewhat Agree
Construction standards and regulations are consistently followed.	2.73	Somewhat Agree
Quality control measures are effective during construction.	2.73	Somewhat Agree
Construction challenges are promptly addressed.	2.73	Somewhat Agree

Evaluation of Construction Management Performance. Table 6 presents the respondents' assessment of construction management performance. All indicators obtained an identical weighted mean of 2.80, corresponding to the verbal interpretation of Somewhat Agree. The findings indicate that respondents generally viewed project planning, scheduling, budget management, stakeholder coordination, quality assurance, and management of construction challenges as moderately effective. The consistency of the ratings suggests that construction management practices contribute positively to project implementation while still requiring further enhancement.

Table 6
Evaluation of Construction Management Performance

Indicator	WM	Interpretation
Construction projects are well planned and scheduled.	2.80	Somewhat Agree
Budget management and cost control are effectively applied.	2.80	Somewhat Agree
Stakeholders coordinate effectively throughout the project.	2.80	Somewhat Agree
Quality assurance practices are consistently implemented.	2.80	Somewhat Agree
Construction management challenges are managed successfully.	2.80	Somewhat Agree

Evaluation of Operation, Maintenance, and Community Involvement. Table 7 presents the respondents' evaluation of operation, maintenance, and community involvement in flood control infrastructure management. All indicators obtained a weighted mean of 3.00, corresponding to the verbal interpretation of Somewhat Agree. The findings indicate that respondents perceived maintenance activities, infrastructure inspections, operational responsibilities, and community participation to be implemented at a moderate level. Among the evaluated themes, this category obtained the highest overall weighted mean, suggesting relatively stronger performance compared with the other dimensions assessed in the study.

Table 7
Evaluation of the Efficiency of Operation, Maintenance, and Community Involvement

Indicator	WM	Interpretation
Infrastructure inspections and maintenance are regular.	3.00	Somewhat Agree
Maintenance issues are promptly and effectively addressed.	3.00	Somewhat Agree
Responsibilities for operation and maintenance are clear.	3.00	Somewhat Agree
Community members are aware of and participate in flood management.	3.00	Somewhat Agree
Community involvement contributes positively to infrastructure upkeep.	3.00	Somewhat Agree

Challenges Encountered in the Implementation and Management of Flood Control Infrastructure. Table 8 presents the respondents' assessment of the challenges encountered in the implementation and maintenance of flood control infrastructure. All indicators obtained a weighted mean of 2.73, interpreted as Somewhat Agree. The results indicate that respondents recognized the

presence of challenges related to construction management, stakeholder coordination, project implementation, and infrastructure improvement. The consistent ratings suggest that these issues continue to influence the effectiveness of flood control infrastructure within the municipality.

Table 8
Evaluation of the Challenges Encountered in Flood Control Infrastructure Management

Indicator	WM	Interpretation
Major challenges in flood control infrastructure management are recognized.	2.73	Somewhat Agree
Performance of infrastructure is impacted by inadequacies in construction management.	2.73	Somewhat Agree
Recommended improvements are practical and actionable.	2.73	Somewhat Agree
Coordination between government and stakeholders can improve.	2.73	Somewhat Agree
Flood control efforts show continuous improvement.	2.73	Somewhat Agree

Field Observation Findings. Field observations were conducted to assess the physical condition and observable performance of existing flood-control infrastructure in selected areas of Bay, Laguna. The observations focused on drainage systems, canals, dikes, and river walls, particularly conditions that may affect the capacity and effectiveness of these structures in managing stormwater and floodwater.

Table 9
Field Observation Findings on Existing Flood-Control Infrastructure

Infrastructure/Condition Observed	Field Observation	Possible Implication
Drainage systems and canals	Accumulated materials and visible obstructions were observed in some drainage sections.	These conditions may restrict water flow and reduce drainage efficiency, particularly during heavy rainfall.
Drainage canals and waterways	Sediment and silt accumulation were observed in some sections.	These conditions may reduce the effective flow area and limit drainage capacity.
River walls	Some sections of the river walls were observed to have elevations that were relatively low or nearly level with adjacent roadways.	This condition may limit the ability of the river-wall system to contain rising water levels when river flows increase during heavy rainfall.
Drainage and flood-control infrastructure	The observed conditions highlighted the need for regular cleaning, desilting, inspection, and maintenance.	Continued monitoring and maintenance may help identify and address physical conditions that may affect infrastructure performance.

The field observations documented several physical conditions that may affect flood-control performance. Accumulated materials and visible obstructions were observed in some drainage sections, while sediment and silt accumulation were noted in some drainage and waterway sections. These conditions may reduce the effective flow area and limit drainage capacity, particularly during periods of heavy rainfall.

In addition, some sections of the river walls were observed to have elevations that were relatively low or nearly level with adjacent roadways. This condition may limit the ability of the river-wall system to contain rising water levels when river flows increase during periods of heavy rainfall. These observations indicate that the performance of flood-control infrastructure depends not only on the presence of physical structures but also on their condition, capacity, and relationship to surrounding site conditions.

The observations also highlight the importance of regular cleaning, desilting, inspection, and maintenance of drainage channels and other flood-control structures. Continuous monitoring may help identify obstructions, sediment accumulation, deterioration, and other physical conditions that may affect infrastructure performance.

Overall, the field observations provide supporting physical evidence for interpreting the quantitative findings. The observed drainage obstructions, sediment accumulation, and relatively low sections of river walls indicate physical conditions that may affect flood-control effectiveness during periods of heavy rainfall. These findings further emphasize the need for continued maintenance, improvement of drainage capacity, and appropriate upgrading of existing flood-control structures.

DISCUSSION

The quantitative findings show a contrast between respondents' assessment of existing infrastructure condition and their assessment

of operation, maintenance, and community involvement. Current condition and performance received the lowest weighted mean of 2.20, interpreted as Disagree, whereas operation, maintenance, and community involvement received the highest weighted mean of 3.00, interpreted as Somewhat Agree. The field observations provide physical context for this result. Accumulated materials and visible obstructions were observed in some drainage sections, while sediment and silt accumulation were noted in some drainage and waterway sections. These conditions may affect drainage capacity and help explain the relatively low assessment of current infrastructure condition and performance.

The structural and functional performance dimension received a weighted mean of 2.76, interpreted as Somewhat Agree, although durability over time received a lower assessment. The field observations documented sediment accumulation, drainage obstructions, and relatively low sections of river walls. These conditions suggest that while existing structures may continue to provide some level of functionality, their physical condition and capacity may limit their performance during periods of heavy rainfall. The observations therefore provide supporting physical evidence for interpreting the quantitative assessment of structural and functional performance.

Planning and design quality received a weighted mean of 2.73, interpreted as Somewhat Agree, indicating moderate perceptions of stakeholder involvement, environmental consideration, flood-risk assessment, and community feedback. The field observations further demonstrate the importance of considering site-specific conditions, drainage capacity, and the physical relationship between flood-control structures and adjacent areas during planning and design. In particular, the presence of drainage obstructions, sediment accumulation, and relatively low river-wall sections highlights the need for planning and design approaches that consider both existing site conditions and long-term infrastructure performance.

Construction and execution received a weighted mean of 2.78, while construction management performance received 2.80, both interpreted as Somewhat Agree. These results indicate that respondents generally perceived construction and management practices as moderately satisfactory. However, the physical conditions observed in some flood-control facilities indicate the need for continued inspection, quality monitoring, maintenance, and rehabilitation to preserve infrastructure functionality throughout its service life.

Operation, maintenance, and community involvement received the highest weighted mean of 3.00, interpreted as Somewhat Agree. This relatively higher assessment indicates that maintenance and community-related practices were perceived more positively than the current physical condition and performance of the infrastructure. Nevertheless, the field observations identified accumulated materials, sediment, and other conditions that may affect drainage performance. This suggests that maintenance activities should be sustained and strengthened through regular cleaning, desilting, inspection, and monitoring to help preserve drainage capacity and flood-control functionality.

Overall, the quantitative findings and field observations indicate that the flood-control infrastructure in Bay, Laguna provides some level of functionality but continues to face physical and maintenance-related limitations. The lowest assessment for current condition and performance, together with the observed drainage obstructions, sediment accumulation, and relatively low river-wall sections, emphasizes the need for continued maintenance, infrastructure assessment, drainage-capacity improvement, and appropriate upgrading. From a construction management perspective, these measures should be integrated throughout the infrastructure life cycle to support sustained flood-control performance.

Conclusion. This study evaluated the efficiency of flood-control infrastructure in Bay, Laguna

using a construction management approach by examining its current condition and performance, structural and functional performance, planning and design quality, construction and execution, construction management performance, operation, maintenance, and community involvement, as well as the challenges encountered during implementation and management.

The findings indicate that the existing flood-control infrastructure provides some level of functionality but continues to have limitations in its current condition and performance. Among the evaluated dimensions, current condition and performance received the lowest weighted mean of 2.20, interpreted as Disagree, indicating concerns regarding the condition and performance of existing flood-control facilities. Field observations documented accumulated materials and visible obstructions in some drainage sections, sediment and silt accumulation in some drainage and waterway sections, and relatively low sections of river walls. These observed conditions may contribute to reduced flood-control effectiveness during periods of heavy rainfall.

The study further revealed that structural and functional performance, planning and design quality, construction and execution, and construction management performance were generally assessed as Somewhat Agree, with weighted means of 2.76, 2.73, 2.78, and 2.80, respectively. These findings indicate that although the existing infrastructure and associated management practices provide some level of functionality, continued improvement is needed in engineering design, project planning, quality assurance, construction supervision, maintenance management, and infrastructure monitoring.

Operation, maintenance, and community involvement received the highest weighted mean of 3.00, interpreted as Somewhat Agree, among the assessed dimensions. This indicates relatively stronger perceptions of maintenance and community-related practices. However, the field observations of drainage obstructions,

sediment accumulation, and relatively low river-wall sections indicate that continued maintenance and monitoring remain necessary to preserve infrastructure functionality and capacity.

Overall, the study indicates that the efficiency of flood-control infrastructure depends not only on the presence and design of physical structures but also on effective construction management practices throughout the infrastructure life cycle. Regular inspection, cleaning and desilting, preventive maintenance, quality monitoring, rehabilitation of inadequate or deteriorated structures, and improvement of drainage capacity should be considered in managing existing flood-control infrastructure. From a construction management perspective, these measures can support more sustainable and resilient flood-control infrastructure in Bay, Laguna and provide useful considerations for similar flood-prone municipalities.

Practical Implications. The findings of this study provide practical guidance for local government units, engineers, project managers, contractors, and policymakers responsible for flood control infrastructure planning, implementation, and maintenance. The results suggest that rehabilitation and upgrading of existing flood control structures should be prioritized to improve hydraulic capacity and structural performance. Regular inspections, preventive maintenance, desilting, dredging, and timely infrastructure rehabilitation should be institutionalized to preserve the operational efficiency of drainage systems, canals, dikes, and river walls.

From a construction management perspective, implementing comprehensive asset management programs, Geographic Information System (GIS)-based infrastructure monitoring, early warning systems, and digital maintenance databases can improve infrastructure planning, maintenance scheduling, and decision-making. Strengthening project monitoring, quality assurance, contractor performance evaluation, and stakeholder coordination throughout the

infrastructure life cycle may further improve project outcomes and reduce long-term maintenance costs.

The study also highlights the importance of community participation in supporting flood control initiatives. Encouraging residents to report drainage blockages, participate in environmental programs, and practice proper waste disposal can complement government maintenance activities and contribute to the long-term sustainability of flood control infrastructure. Collectively, these measures may improve infrastructure resilience, optimize public investment, and strengthen flood risk management in municipalities experiencing similar flooding conditions.

Limitations of the Study. A key limitation of this study is the absence of formal instrument validation before the administration of the researcher-developed questionnaire. Without formal expert validation or other appropriate validation procedures, the extent to which the instrument accurately measured the intended constructs cannot be fully established. This limitation may affect the precision of the findings and the extent to which the results can be generalized beyond the selected respondents and study area. Future studies are encouraged to conduct comprehensive validity assessments, including formal expert validation and pilot testing, before administering the instrument to larger populations. Appropriate statistical reliability analysis may also be considered, where applicable, to further assess the instrument's consistency.

Future Research. Future studies may expand this research by including a larger sample size and additional municipalities to improve the generalizability of the findings and enable comparative analyses of different flood control systems. Researchers may also investigate the effectiveness of specific construction management strategies in improving the planning, implementation, operation, and maintenance of flood control infrastructure across different geographic settings.

Further investigations may incorporate advanced technologies such as Building Information Modeling (BIM), Geographic Information Systems (GIS), remote sensing, unmanned aerial vehicle (UAV)-based infrastructure inspection, Internet of Things (IoT)-enabled monitoring systems, artificial intelligence, and predictive asset management to support infrastructure monitoring and maintenance planning. Integrating hydraulic modeling, climate projections, and lifecycle cost analysis may likewise provide a more comprehensive evaluation of flood control infrastructure performance under future climate scenarios.

Finally, longitudinal studies examining the long-term effectiveness of maintenance programs, rehabilitation projects, and construction management interventions would contribute to the development of more sustainable, resilient, and adaptive flood control infrastructure management practices in the Philippines.

Author contributions. Wincess Zyrach A. League: Conceptualization, Methodology, Investigation, Data Curation, Formal analysis, Validation, Visualization, Writing-Original draft, Writing-Review & editing, and Project administration.

Conflict of interest. The author declares that the research was conducted without commercial or financial relationships that could be construed as a potential conflict of interest.

Funding source. This study did not receive any external financial support or grant funding. The research was self-funded by the author.

Artificial intelligence use. AI-assisted language editing was performed using ChatGPT; the author reviewed and approved all content.

Ethics approval statement. This study received ethics approval from Aileen Camille B. Dimatatac, MC under Ethics Clearance No. OUSREC 625-0042. The study was conducted in accordance with applicable ethical guidelines. Informed consent was obtained from all

participants prior to their participation in the study.

Data availability statement. The datasets generated and analyzed during the current study are not publicly available due to ethical and confidentiality considerations involving the research participants but are available from the corresponding author upon reasonable request.

Acknowledgement. (Not available)

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