Research Paper

DIT.ADS International Multidisciplinary Research Journal
Volume 1; Issue 3; July 2025; pp: 19-35; No.: 07-2025-19
Website: https://ditadsresearchcenter.com
E-ISSN: 3082-5148; P-ISSN: 3082-513X

Evaluating Green Infrastructure for Urban Flood Control: A Sustainable Approach to Environmental Protection in Barangay Lorega, Cebu City

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Received 18th May 2025; Accepted 23rd June 2025; Published Online 31st July 2025
DOI: 10.63941/DIT.ADSimrj.2025.1.3.1.19

ABSTRACT

Urban flooding presents a persistent environmental threat in rapidly urbanizing cities like Cebu City, Philippines. The increase in impervious surfaces has disrupted natural water infiltration, heightening flood vulnerability during extreme rainfall events. Traditional flood control infrastructures, such as concrete barriers and drainage systems, have proven insufficient against intensifying climate challenges. This study explores the role of green infrastructure (GI)—including permeable pavements, green roofs, rain gardens, and constructed wetlands—in enhancing flood resilience in a tropical, densely populated urban setting. Using a descriptive-quantitative approach, data were collected through surveys and interviews with 200 respondents to assess the community's awareness and perception of GI's effectiveness. Results indicate a high level of community awareness and strong agreement on the potential of GI to support flood control, particularly through well-maintained, localized designs and community engagement. Moreover, GI was viewed as highly effective in reducing flood risks, offering environmental benefits, promoting economic sustainability, and strengthening community resilience. While the statistical impact of GI on flood control was modest (adjusted $R^2 = 2.1\%$), its perceived value underscores its relevance as a supplementary strategy within a broader sustainable urban planning framework. Findings support Ecological Modernization and Green Infrastructure theories, advocating for integrated, nature-based approaches. Recommendations emphasize policy integration, stakeholder collaboration, and public education to scale GI solutions. This study contributes localized insights into sustainable flood management and provides a model for similar tropical urban centers.

Keywords: *Green Infrastructure, Urban Flooding, Sustainability, Community Engagement, Cebu City*

INTRODUCTION

Urban flooding is a growing environmental concern, particularly in densely populated cities like Cebu City, Philippines. With rapid urbanization, impervious surfaces have increased, limiting natural infiltration and exacerbating flood risks during heavy rainfall. Traditional infrastructure solutions, such as drainage systems and concrete flood barriers, are often inadequate in the face of increasingly intense weather events, further compounded by climate change. This necessitates a shift toward sustainable flood management practices, with green infrastructure emerging as a promising alternative. Green infrastructure, which includes solutions like permeable pavements, green roofs, rain gardens, and urban wetlands, provides both environmental and social benefits by enhancing flood resilience while promoting biodiversity and improving urban aesthetics.

Cebu City faces significant flooding issues during the rainy season, affecting communities, disrupting local businesses, and straining government resources. To address these challenges, sustainable solutions are crucial to achieving long-term environmental resilience and mitigating climate impacts. Green infrastructure represents a shift from traditional flood control practices, emphasizing ecological

design and resilience by mimicking natural hydrological processes. This study aims to evaluate the effectiveness of green infrastructure for urban flood control in Cebu City, exploring its potential to reduce flood risks while contributing to broader environmental protection goals. In doing so, the study will examine how green infrastructure can serve as a sustainable model that benefits both the environment and urban populations.

While several studies highlight the benefits of green infrastructure for urban flood management, limited research specifically examines its applicability and effectiveness in tropical, high-density urban areas like Cebu City. Much of the existing literature on green infrastructure focuses on temperate climates and developed countries, where environmental and social conditions differ significantly from those in Philippine cities. Furthermore, few studies have analyzed the role of green infrastructure within the specific context of Cebu City's unique urban landscape, which includes both highly developed and flood-prone low-lying areas.

This research addresses this gap by providing localized data and analysis on green infrastructure's impact on flood control in Cebu City, assessing its sustainability, cost-effectiveness, and potential for integration with existing urban planning frameworks. By evaluating green infrastructure's performance in a tropical setting, this study seeks to contribute to a growing body of knowledge on sustainable urban flood management solutions, offering insights that may guide policymakers, urban planners, and environmental advocates in Cebu City and other similar urban centers..

MATERIALS & METHODS

This study adopts a descriptive-quantitative approach, combining quantitative and interview research techniques to evaluate the effectiveness of green infrastructure (GI) in urban flood control. The quantitative aspect involves collecting data on flood reduction rates, environmental quality measures, and economic sustainability metrics. The qualitative component includes interviews with urban planners, community leaders, and residents to gather insights into their perceptions of GI and its social impact. This dual approach ensures a comprehensive analysis of both the measurable outcomes and the community's experiences with GI.

RESULTS AND DISCUSSION

The Demographic Profile of the Respondents

Table 1 shows the frequency and percentage distribution of respondents in terms of sex. The data revealed that male has 52.0 percent and female has 48.0 percent. This means that the majority of the respondents are male, offering insights into the demographic dynamics that may shape perceptions of urban flood control. Men often play significant roles in activities such as construction, maintenance, and emergency response, which could influence their views on the effectiveness of flood management measures (Gaisie et al., 2021). Understanding these gender dynamics is essential for developing inclusive and equitable flood control strategies that address the needs and perspectives of all community members.

Table 1
The Frequency and Percentage Distribution of Respondents in terms of Sex

Profile	Characteristics	Frequency	Percentage
Sex	Male	104	52.0
	Female	96	48.0
	Total	**200**	**100.0**

Table 2 shows the frequency and percentage distribution of respondents in terms of age. The data revealed that 18-22 has 7.5 percent, 22-37 has 13.5 percent, 28-32 has 22.0 percent, 33-47 has 30.5 percent, and 38 and older has 26.5 percent. This means that the majority of the respondents aged 33 to 47 years old, suggesting that individuals in this demographic are particularly engaged with or impacted by issues such as urban flood control. This age group often includes people actively involved in decision-making, community leadership, or property ownership—roles that typically align with a greater interest in addressing environmental and infrastructural challenges (Tellman et al., 2020). Moreover, rapid and uncontrolled urbanization has been identified as a significant factor exacerbating urban flooding. Contributing issues include the development of informal settlements on floodplains, inadequate household waste management, and poorly maintained drainage systems, all of which compound the challenges of flood control (Amoako & Boamah, 2020).

Table 2
The Frequency and Percentage Distribution of Respondents in terms of Age

Profile	Characteristics	Frequency	Percentage
Age	18-22	15	7.5
	23-27	27	13.5
	28-32	44	22.0
	33-47	61	30.5
	38 and Older	53	26.5
	Total	**200**	**100.0**

Table 3 shows the frequency and percentage distribution of respondents in terms of civil status. The data revealed that single has 38.0 percent, married has 61.0 percent, and widow has 1.0 percent. This means that the majority of the respondents aged are married, offering valuable insights into the demographic characteristics of those engaging with urban flood control issues. Married individuals often prioritize community safety, infrastructure resilience, and long-term planning, likely driven by family responsibilities and property ownership (Rainey et al., 2021). This demographics' vested interest in protecting their households and investments underscores the importance of considering their perspectives in flood management initiatives and planning efforts.

Table 3
The Frequency and Percentage Distribution of Respondents in terms of Civil Status

Profile	Characteristics	Frequency	Percentage
Civil Status	Single	76	38.0
	Married	122	61.0
	Widow	2	1.0
	Total	**200**	**100.0**

Table 4 shows the frequency and percentage distribution of respondents in terms of education. The data revealed that high school has 53.5 percent, college degree has 27.5 percent, master's degree has 17.5 percent, and doctorate degree has 1.5 percent. This means that the majority of the respondents are high school, offering valuable insights into the educational background of those engaging with urban flood control issues. This demographic is more likely to benefit from accessible, community-focused communication and straightforward educational materials to effectively understand and participate in flood management initiatives. Reaching this group is particularly important given the increasing threat of urban flooding, which poses significant economic and social challenges worldwide and within the United States (Rainey et al., 2021). Recognizing this educational distribution can help inform how information and resources are tailored to ensure inclusivity and effectiveness. For instance, using clear

and practical messaging in public awareness campaigns or community engagement activities can help bridge gaps in understanding and empower individuals across different educational levels to participate meaningfully in urban flood control efforts.

Table 4
The Frequency and Percentage Distribution of Respondents in terms of Education

Profile	Characteristics	Frequency	Percentage
Education	High School	107	53.5
	College Degree	55	27.5
	Master's Degree	35	17.5
	Doctorate Degree	3	1.5
	Total	**200**	**100.0**

Assessment of Green Infrastructure for Urban Flood Control

Table 5 shows the distribution of respondents' assessment in the green infrastructure for urban control in terms of types of green infrastructure. The overall mean is 3.15 (SD=0.59) indicates a description **Agree**. The data reveal that the respondents have a **High Awareness** regarding green infrastructure for urban flood control. This suggests that respondents are well-informed about sustainable solutions, such as permeable pavements, green roofs, and rain gardens, which are key to mitigating flood risks. Their awareness reflects an understanding of the importance of integrating nature-based solutions into urban planning to strengthen flood resilience and promote environmental sustainability. As urban areas continue to grow, the need to incorporate sustainable and climate-resilient solutions into city planning is becoming increasingly clear. This trend indicates that urban planners and decision-makers are recognizing the value of nature-based solutions in addressing urban flooding and enhancing overall sustainability (Fenner et al., 2019).

This high level of awareness is essential for driving the adoption and implementation of green infrastructure in flood management strategies. It indicates that the respondents are not only receptive to such initiatives but may also be advocates for their broader adoption within their communities. Fostering this awareness among urban populations can lead to stronger community support for policies that prioritize sustainable, eco-friendly approaches to urban flood control**.**

The indicator, **I support the use of constructed wetlands for flood management in urban areas.**, obtained the highest mean score of 3.22 (SD=0.59) which is described as **Agree**. The data reveal that the respondents have a **High Awareness** regarding the use of constructed wetlands for flood management in urban areas. This suggests they recognize the potential of nature-based solutions, like constructed wetlands, to address flood risks while promoting environmental sustainability. The strong support for such solutions indicates that respondents are not only aware of the benefits of constructed wetlands but are also open to integrating these innovative approaches into urban flood management strategies. Urban areas face significant challenges in managing flooding, which can severely impact infrastructure, property, and public safety. Traditional flood management methods, such as engineered drainage systems, have faced criticism for their lack of flexibility and limited ability to adapt to the challenges posed by climate change and rapid urbanization (Xiong et al., 2020).

On the other hand, the indicator **I am aware of green infrastructure solutions such as rain gardens and permeable pavements.**, obtained the lowest mean of 3.02 (SD=0.65) which has a description of **Agree**. The data reveal that the respondents have a **High Awareness** regarding green infrastructure solutions such as rain gardens and permeable pavements, though the mean score is slightly lower compared to other indicators. This suggests that while respondents are aware of these nature-based solutions, there may still be room for further education and engagement to fully highlight their

potential in urban flood management. Green infrastructure, like rain gardens and permeable pavements, plays a critical role in mitigating flood risks by promoting natural water absorption and reducing runoff. Despite the lower mean score, the awareness indicated here suggests that respondents are receptive to incorporating such solutions into urban planning and flood management strategies. Increasing education on these solutions could enhance their integration into flood control measures, helping cities become more resilient to the growing challenges posed by urban flooding.

Table 5
The Respondents' Assessment of Green Infrastructure for Urban Flood Control in terms of *Types of Green Infrastructure*

Items	Mean	SD	Description	Interpretation
1. I am aware of green infrastructure solutions such as rain gardens and permeable pavements.	3.02	0.65	Agree	High Awareness
2. I believe green roofs are effective in managing urban flood control.	3.20	0.55	Agree	High Awareness
3. I think bioswales can help reduce urban flooding.	3.17	0.57	Agree	High Awareness
4. I support the use of constructed wetlands for flood management in urban areas.	3.22	0.59	Agree	High Awareness
Overall Mean	**3.15**	**0.59**	**Agree**	**High Awareness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

Table 6 shows the distribution of respondents' assessment in the green infrastructure for urban control in terms of implementation scale. The overall mean is 3.28 (SD=0.63) indicates a description **Strongly Agree**. The data reveal that the respondents have a **Very High Awareness** regarding the implementation scale of green infrastructure for urban flood control. This suggests that they recognize the importance of integrating green infrastructure solutions, such as rain gardens, green roofs, and permeable pavements, on a larger scale to address urban flooding. The high level of awareness reflects an understanding of how widespread implementation of these solutions can enhance flood resilience and improve the sustainability of urban environments. This strong awareness may also indicate a recognition of the need for comprehensive, city-wide strategies that go beyond isolated green infrastructure projects. Respondents likely understand that effective flood management requires integrating these solutions into urban planning, infrastructure design, and policy-making. As urban areas continue to face growing flood risks, this awareness is crucial for advocating for the adoption of large-scale green infrastructure initiatives that can significantly reduce the impact of flooding and enhance long-term urban resilience.

The indicator, **I think green infrastructure should be implemented at a neighborhood level to manage flooding.**, obtained the highest mean score of 3.22 (SD=0.63) which is described as **Strongly Agree**. The data reveal that the respondents have a **Very High Awareness** regarding the importance of implementing green infrastructure at the neighborhood level to manage flooding. This suggests that they recognize the potential of localized solutions, such as green roofs, rain gardens, and permeable pavements, in addressing flooding risks in their communities. The strong agreement with this indicator suggests that respondents understand the value of neighborhood-level green infrastructure as a complement to broader urban flood management strategies. They likely recognize the benefits of these localized solutions in reducing flooding, improving water quality, and enhancing urban biodiversity. This high level of awareness also highlights the importance of scalable, adaptable solutions that can be tailored to the specific environmental and infrastructural needs of different areas. The findings suggest that respondents are increasingly aware of how such localized interventions can play a key role in addressing urban flood risks and supporting sustainable, resilient urban development (Sitzenfrei

et al., 2020). Moreover, by supporting the idea of implementing green infrastructure solutions at the neighborhood level, the respondents likely acknowledge the benefits of these localized interventions in reducing flooding, improving water quality, and enhancing urban biodiversity (Bousquin & Hychka, 2019). As urban areas continue to face increasing flood risks, the support for neighborhood-scale green infrastructure emphasizes the importance of community-driven, sustainable approaches to urban flood management.

On the other hand, the indicator **I support the integration of green infrastructure into urban planning policies.**, obtained the lowest mean of 3.25 (SD=0.63) which has a description of **Agree**. The data reveal that the respondents have a **High Awareness** regarding the integration of green infrastructure into urban planning policies, although the mean score is slightly lower compared to other indicators. This suggests that while there is strong support for incorporating green infrastructure into urban planning, there may be some hesitancy or perceived barriers to fully embracing this approach at a policy level. Respondents likely understand the benefits of green infrastructure for flood management, but may also recognize challenges in terms of policy implementation, cost, or coordination among stakeholders. The relatively lower score suggests a need for further advocacy and education to better highlight how green infrastructure can be integrated into existing urban policies and planning frameworks. By supporting its inclusion in urban planning, respondents recognize green infrastructure's potential role in building more sustainable, resilient cities. Increased awareness and discussions surrounding these solutions could facilitate their broader adoption in urban flood management strategies. As traditional flood control methods have their limitations, urban planners and policymakers are increasingly considering the integration of green infrastructure into flood management approaches (Fenner et al., 2019).

Table 6
The Respondents' Assessment of Green Infrastructure for Urban Flood Control in terms of *Implementation scale*

Items	Mean	SD	Description	Interpretation
1. I think green infrastructure should be implemented at a neighborhood level to manage flooding.	3.32	0.63	Strongly Agree	Very High Awareness
2. I believe city-wide green infrastructure projects are necessary for effective flood control.	3.26	0.64	Strongly Agree	Very High Awareness
3. I think green infrastructure is effective when applied to both small-scale and large-scale areas.	3.30	0.61	Strongly Agree	Very High Awareness
4. I support the integration of green infrastructure into urban planning policies.	3.25	0.63	Agree	High Awareness
Overall Mean	**3.28**	**0.63**	**Strongly Agree**	**Very High Awareness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

Table 7 shows the distribution of respondents' assessment in the green infrastructure for urban control in terms of design and maintenance practices. The overall mean is 3.34 (SD=1.01) indicates a description **Strongly Agree**. The data reveal that the respondents have a **Very High Awareness** of the importance of design and maintenance practices in green infrastructure for urban flood control. This suggests that they recognize the critical role that well-designed and properly maintained green infrastructure solutions, such as green roofs, rain gardens, and permeable pavements, play in enhancing flood resilience and environmental sustainability. The strong agreement on the importance of these practices indicates that respondents are not only aware of the potential benefits of green infrastructure but also understand that its long-term effectiveness depends on careful planning, implementation, and ongoing maintenance. This high level of awareness is crucial for promoting the successful integration

of green infrastructure into urban planning and flood management strategies. As urban communities face the growing threat of flooding, traditional methods, which rely primarily on drainage systems, have shown limitations in effectively mitigating this issue (Pamungkas & Purwitaningsih, 2019). With climate change and rapid urbanization increasing the frequency and intensity of extreme weather events, there is an urgent need to adopt more sustainable and resilient solutions, such as green infrastructure, to address the evolving challenges of urban flood management (Fenner et al., 2019).

The indicator, **I support training programs for maintenance staff on green infrastructure practices.**, obtained the highest mean score of 3.46 (SD=2.18) which is described as **Strongly Agree**. The data reveal that the respondents have a **Very High Awareness** of the importance of training maintenance staff on green infrastructure practices. This indicates that respondents recognize the critical role maintenance plays in ensuring the long-term functionality and effectiveness of green infrastructure solutions in urban flood control. Their strong support for training programs reflects an understanding that well-maintained green infrastructure is vital for managing flood risks, improving water quality, and enhancing urban sustainability. Additionally, this high level of awareness suggests that respondents see the value of investing in skilled personnel who can properly care for and sustain these systems, ensuring their continued impact on urban resilience and environmental health.

On the other hand, the indicator **I believe that proper design of green infrastructure is essential for effective flood control.**, obtained the lowest mean of 3.26 (SD=0.62) which has a description of **Strongly Agree**. The data reveal that the respondents have a **Very High Awareness** of the importance of proper design in green infrastructure for effective flood control, although the slightly lower mean score suggests there may be room for further emphasis on the critical role design plays in the success of these solutions. Respondents strongly agree on the essential role of well-designed green infrastructure in addressing flood risks, indicating a clear understanding of the need for strategic planning and thoughtful integration of nature-based solutions into urban flood management. However, the slightly lower score suggests that while respondents acknowledge its importance, they also recognize the challenges and complexities involved in ensuring proper design and implementation. This insight highlights the need for further education on the design principles that maximize the effectiveness of green infrastructure in mitigating urban flooding (Pamungkas & Purwitaningsih, 2019). This insight underscores the need for ongoing education and dialogue about the design considerations and best practices that maximize the effectiveness of green infrastructure in mitigating urban flooding.

Table 7
The Respondents' Assessment of Green Infrastructure for Urban Flood Control in terms of *Design and Maintenance Practices*

Items	Mean	SD	Description	Interpretation
1. I believe that proper design of green infrastructure is essential for effective flood control.	3.26	0.62	Strongly Agree	Very High Awareness
2. I think green infrastructure requires regular maintenance to stay effective.	3.33	0.62	Strongly Agree	Very High Awareness
3. I believe that local governments should allocate funds for the maintenance of green infrastructure.	3.31	0.63	Strongly Agree	Very High Awareness
4. I support training programs for maintenance staff on green infrastructure practices.	3.46	2.18	Strongly Agree	Very High Awareness
Overall Mean	**3.34**	**1.01**	**Strongly Agree**	**Very High Awareness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

Table 8 shows the distribution of respondents' assessment in the green infrastructure for urban control in terms of community engagement and awareness. The overall mean is 3.33 (SD=0.59) indicates a description **Strongly Agree**. The data reveal that the respondents have a **Very High Awareness** regarding community engagement and its role in urban flood control through green infrastructure. This suggests that respondents recognize the importance of involving the community in flood management efforts and the role that awareness plays in the successful implementation of such strategies. A strong emphasis on community engagement is crucial for fostering collective responsibility and encouraging active participation in sustainability initiatives. By recognizing the importance of green infrastructure in urban flood control, the respondents likely understand that involving local communities can significantly enhance the effectiveness of these measures, contributing to a more resilient urban environment over time. This highlights the need for further exploration of how community engagement can improve the success of sustainability initiatives, particularly in flood management (Pamungkas & Purwitaningsih, 2019).

The indicator, **I participate in community initiatives that promote flood control through green infrastructure**, obtained the highest mean score of 3.36 (SD=0.58) which is described as **Strongly Agree**. The data reveal that the respondents have a **Very High Awareness** and active engagement in community initiatives that promote flood control through green infrastructure. The strong agreement with this indicator suggests that many respondents not only recognize the importance of green infrastructure in managing urban flooding but are also willing to engage in local efforts to support these initiatives. As urban flooding becomes an increasingly pressing issue, driven by factors such as climate change, rapid urbanization, and the loss of natural flood-mitigating habitats, there is a growing need for effective solutions (Bousquin & Hychka, 2019). In response, approaches that blend traditional grey infrastructure with nature-based solutions—often referred to as "green infrastructure"—are gaining widespread attention for their potential to address both immediate flood risks and long-term urban resilience (Fenner et al., 2019). This high level of participation reflects a sense of community responsibility and a recognition that collective action is crucial for effectively addressing flood risks. The engagement of individuals in these efforts can significantly enhance the success of green infrastructure projects, as it encourages greater collaboration and resource sharing within communities.

Table 8
The Respondents' Assessment of Green Infrastructure for Urban Flood Control in terms of *Community Engagement and Awareness*

Items	Mean	SD	Description	Interpretation
1. I believe community awareness is crucial for the success of green infrastructure projects.	3.34	0.57	Strongly Agree	Very High Awareness
2. I participate in community initiatives that promote flood control through green infrastructure.	3.36	0.58	Strongly Agree	Very High Awareness
3. I think educational programs about green infrastructure should be provided to urban residents.	3.29	0.60	Strongly Agree	Very High Awareness
4. I feel that community support is essential for implementing green infrastructure projects.	3.32	0.62	Strongly Agree	Very High Awareness
Overall Mean	**3.33**	**0.59**	**Strongly Agree**	**Very High Awareness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

On the other hand, the indicator **I think educational programs about green infrastructure should be provided to urban residents.**, obtained the lowest mean of 3.29 (SD=0.60) which has a description of **Strongly Agree**. The data reveal that the respondents have a **Very High Awareness** regarding the importance of educational programs about green infrastructure for urban residents. This suggests that

there is a strong recognition among respondents of the value of educating the public on sustainable flood control practices. Such programs not only raise awareness about green infrastructure solutions but also encourage community engagement and participation in local flood management efforts. This level of awareness reflects an understanding of the broader role green infrastructure can play in enhancing urban resilience to flooding, and the need for informed residents who can actively contribute to the implementation and maintenance of these solutions. However, the relatively lower mean score for the indicator on educational programs could highlight the need for more comprehensive or accessible outreach efforts. It might also suggest that, despite the high awareness, there are barriers in terms of accessibility or familiarity with how these programs are implemented in the community. Providing more targeted, localized educational resources could further enhance residents' ability to engage with and support urban flood management strategies.

Table 9 shows the summary on the green infrastructure for urban flood control. The overall mean is 3.28 (SD=0.71) indicates a description **Strongly Agree**. The data reveal that respondents have a **Very High Awareness** of green infrastructure for urban flood control, reflecting their deep understanding of sustainable and eco-friendly approaches to managing flood risks. This high level of awareness likely translates into proactive engagement with strategies such as permeable surfaces, rain gardens, green roofs, and other nature-based solutions (Ye et al., 2021). This understanding supports the effective implementation of green infrastructure while encouraging its integration into broader urban planning efforts. By prioritizing sustainable practices, employees help reduce the environmental impact of flood control measures and enhance the resilience and adaptability of urban systems to future flood risks. As urban areas face increasing threats from flooding, the need for comprehensive and sustainable flood management strategies becomes critical. Employees in urban planning and flood management are at the forefront of this effort, driving the development and application of innovative solutions to protect communities and strengthen their resilience.

Table 9
Summary of the Respondents' Assessment of Green Infrastructure for Urban Flood Control

Items	Mean	SD	Description	Interpretation
Types of Green Infrastructure	3.15	0.59	Agree	High Awareness
Implementation Scale	3.28	0.63	Strongly Agree	Very High Awareness
Design and Maintenance Practices	3.34	1.01	Strongly Agree	Very High Awareness
Community Engagement and Awareness	3.33	0.59	Strongly Agree	Very High Awareness
Overall Mean	**3.28**	**0.71**	**Strongly Agree**	**Very High Awareness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

The Effectiveness of Urban Flood Control

Table 10 shows the distribution of respondents' assessment of the effectiveness in urban flood control in terms of flood reduction efficiency. The overall mean is 3.33 (SD=0.57) indicates a description **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in terms of flood reduction efficiency. This strong agreement suggests that the respondents believe the flood control measures in place are significantly reducing the impact of flooding in urban areas. It indicates a high level of confidence in the effectiveness of current flood management strategies, which likely reflects their awareness of the importance of well-executed flood

control systems in mitigating flood risks and protecting communities from water-related damages. The recognition of urban flood control effectiveness points to the crucial role of efficient infrastructure and effective planning in safeguarding urban areas against the growing threat of flooding.

The indicator, **The flood control measures provide adequate drainage during peak rainfall periods.**, obtained the highest mean score of 3.34 (SD=0.57) which is described as **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in terms of the flood control measures providing adequate drainage during peak rainfall periods. The strong agreement with this indicator suggests that respondents are confident in the ability of these flood control measures to manage excessive rainfall, preventing flooding and water accumulation in urban areas. This high level of agreement underscores the perceived reliability of urban drainage systems, emphasizing their critical role in ensuring safety and functionality during heavy rainfall. Effective drainage during peak rainfall is essential for mitigating flooding impacts, protecting infrastructure, and safeguarding public safety. The strong support for the reliability of these systems highlights their importance in maintaining the resilience of urban areas during extreme weather events. Such systems are vital for reducing potential damage to property and infrastructure, thereby enhancing overall flood management efforts (Zhou et al., 2019).

On the other hand, the indicator **The flood control system effectively reduces water levels during heavy rainfall**, obtained the lowest mean of 3.31 (SD=0.56) which has a description of **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** indicating strong confidence in the system's overall ability to manage flood risks. This suggests that while the system is generally viewed as effective, there may be areas where respondents perceive the need for improvement. This could reflect concerns about specific zones that may still experience localized flooding or areas where the system's drainage capacity might be stretched during extreme rainfall events. Nevertheless, the overall assessment underscores the respondents' strong belief in the effectiveness of urban flood control measures in reducing flood risks and maintaining water flow during peak rainfall periods. Flooding remains a significant challenge for cities, where dense populations and critical infrastructure are vulnerable to water inundation. As cities work to mitigate this growing threat, the implementation of various flood control measures has been seen as largely effective, though practitioners acknowledge areas that could benefit from further enhancement (Rainey et al., 2021).

Table 10
The Respondents' Assessment of the Effectiveness in Urban Flood Control in terms of *Flood Reduction Efficiency*

Items	Mean	SD	Description	Interpretation
1. The flood control system effectively reduces water levels during heavy rainfall.	3.31	0.56	Strongly Agree	Very High Effectiveness
2. Flooding incidents have decreased in frequency since implementation of flood controls.	3.34	0.56	Strongly Agree	Very High Effectiveness
3. The flood control measures provide adequate drainage during peak rainfall periods.	3.34	0.57	Strongly Agree	Very High Effectiveness
4. Water recedes quickly after flooding due to the current flood control systems.	3.32	0.57	Strongly Agree	Very High Effectiveness
Overall Mean	**3.33**	**0.57**	**Strongly Agree**	**Very High Effectiveness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

Table 11 shows the distribution of respondents' assessment of the effectiveness in urban flood control in terms of environmental benefits. The overall mean is 3.42 (SD=0.58) indicates a description

Strongly Agree. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness** in terms of their environmental benefits. The strong agreement indicates that respondents recognize the positive impact of these measures on the environment, highlighting the importance of sustainable flood control practices. This suggests that flood control systems not only mitigate immediate flood risks but also enhance environmental health by improving water quality, reducing erosion, and supporting biodiversity. Effective environmental management within these systems is essential for long-term resilience, especially as urbanization and climate change continue to present complex challenges. As cities confront the combined effects of rapid urban growth and changing climate patterns, the role of sustainable flood management solutions becomes even more critical (Fenner et al., 2019).

The indicator, **The system enhances water quality in local bodies**, obtained the highest mean score of 3.45 (SD=0.57) which is described as **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness** in enhancing water quality in local bodies. The strong agreement with this indicator reflects a recognition of the broader environmental benefits of flood control systems, beyond their primary role in flood mitigation. By improving water quality, these systems help create healthier ecosystems, reduce pollution, and contribute to more sustainable urban environments. While the primary function of flood control systems is well-established in protecting communities from flood risks, their additional environmental advantages are often overlooked. These systems not only safeguard urban areas from the immediate dangers of flooding but also play a significant role in enhancing ecological health and promoting long-term sustainability (Bousquin & Hychka, 2019). This finding highlights the importance of incorporating environmental considerations into flood management strategies, as they not only address immediate flood risks but also promote long-term ecological health in urban areas.

Table 11
The Respondents' Assessment of the Effectiveness in Urban Flood Control in terms of *Environmental Benefits*

Items	Mean	SD	Description	Interpretation
1. The flood control system minimizes environmental damage during floods.	3.39	0.62	Strongly Agree	Very High Effectiveness
2. Wildlife and natural habitats are protected through flood control measures.	3.38	0.57	Strongly Agree	Very High Effectiveness
3. Flood control solutions are environmentally friendly.	3.45	0.56	Strongly Agree	Very High Effectiveness
4. The system enhances water quality in local bodies.	3.45	0.57	Strongly Agree	Very High Effectiveness
Overall Mean	**3.42**	**0.58**	**Strongly Agree**	**Very High Effectiveness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

On the other hand, the indicator **Wildlife and natural habitats are protected through flood control measures**, obtained the lowest mean of 3.38 (SD=0.57) which has a description of **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in managing water flow and enhancing water quality. This suggests that the existing flood control measures are largely seen as successful in mitigating the immediate impacts of flooding, such as property damage and public safety risks, by maintaining the functionality of drainage systems during peak rainfall periods. Respondents likely recognize the critical role these systems play in protecting urban infrastructure and reducing the adverse effects of floodwaters on the built environment. However, the slightly lower score on the indicator related to wildlife and natural habitat protection

may indicate a gap in the current flood control strategies. While flood management efforts are effective in urban areas, there may be less emphasis on environmental considerations, such as preserving ecosystems and biodiversity. This insight suggests that future flood control measures could benefit from a more holistic, nature-based approach that balances the need for flood risk reduction with the protection of local wildlife and habitats. Such integration would not only improve environmental sustainability but could also foster resilience against future flood events, aligning urban development with ecological preservation.

Table 12 shows the distribution of respondents' assessment of the effectiveness in urban flood control in terms of economic sustainability. The overall mean is 3.39 (SD=0.55) indicates a description **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in terms of its social and community impact. This suggests that respondents view flood control measures not only as effective in reducing flood risks but also as enhancing community resilience. These findings align with research by Rezende et al. (2020), which highlights the role of flood control measures in strengthening communities. Moreover, this view resonates with studies emphasizing the need for an integrated strategy in urban flood risk management. Effective management requires a combination of measures to reduce flood-related impacts, while distributing responsibility and costs among a broad range of stakeholders (Driver et al., 2020). Effective flood management systems can reduce the social and economic disruptions caused by flooding, protect vulnerable populations, and maintain critical infrastructure, contributing to the overall well-being of urban communities. The strong assessment of urban flood control's social impact underscores the growing recognition of the importance of integrated solutions that safeguard both the environment and the social fabric of urban areas.

The indicator, **Flood management reduces losses for local businesses,** obtained the highest mean score of 3.40 (SD=0.57) which is described as **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in its ability to reduce losses for local businesses. This suggests that respondents recognize the crucial role of flood management in minimizing the economic disruptions caused by flooding. By preventing flood damage to commercial properties, infrastructure, and supply chains, effective flood control helps protect businesses and ensures the continuity of economic activities, which is vital for maintaining the financial stability of urban areas. The strong agreement with this indicator highlights the importance of flood control systems in supporting the resilience of local economies and businesses during extreme weather events.

On the other hand, the indicator **Flood control efforts reduce costs associated with flood damage repair**., obtained the lowest mean of 3.36 (SD=0.54) which has a description of **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in reducing the immediate impacts of flooding on local businesses and public infrastructure. This suggests that the flood control measures are viewed as highly successful in safeguarding essential services and economic activities during peak rainfall events. While respondents acknowledge the effectiveness of flood control in mitigating immediate flood risks, further improvements may be necessary to address the long-term recovery costs and broader socio-economic impacts. These findings align with those of Wishart et al. (2021), who also noted the role of urban flood control in protecting key infrastructure. Similarly, Driver et al. (2020) highlighted the importance of these systems in ensuring the resilience of urban economies against flooding. However, the slightly lower score regarding the reduction of costs associated with flood damage repair could indicate that while flood prevention is effective, the long-term financial impacts of repairing flood damage still present challenges. This finding emphasizes the importance of not only preventing flooding but also ensuring that flood control systems are resilient enough to minimize the costs of recovery and repair.

Table 12
The Respondents' Assessment of the Effectiveness in Urban Flood Control in terms of *Economic Sustainability*

Items	Mean	SD	Description	Interpretation
1. Flood control efforts reduce costs associated with flood damage repair.	3.36	0.54	Strongly Agree	Very High Effectiveness
2. The flood control system requires minimal maintenance costs.	3.40	0.56	Strongly Agree	Very High Effectiveness
3. Flood management reduces losses for local businesses.	3.40	0.56	Strongly Agree	Very High Effectiveness
4. The system minimizes expenses related to emergency response during floods.	3.42	0.55	Strongly Agree	Very High Effectiveness
Overall Mean	**3.39**	**0.55**	**Strongly Agree**	**Very High Effectiveness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

Table 13 shows the distribution of respondents' assessment of the effectiveness in urban flood control in terms of social and community impact. The overall mean is 3.38 (SD=0.58) indicates a description **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in terms of its social and community impact. The high level of agreement with this assessment suggests that respondents recognize the importance of flood control measures not only in reducing flood risks but also in fostering community resilience. These measures are viewed as crucial for ensuring the safety and well-being of residents, particularly in the face of increased urbanization and climate change challenges. This indicates that respondents appreciate the broader benefits of flood control, which go beyond mitigating physical damage to infrastructure and property, and extend to supporting the social fabric of urban communities.

The indicator, **Residents feel more secure due to the flood control infrastructure,** obtained the highest mean score of 3.40 (SD=0.59) which is described as **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in enhancing residents' sense of security. The strong agreement with this indicator suggests that respondents feel flood control infrastructure has played a significant role in increasing community safety. This aligns with the research of Driver et al. (2020), which highlights the positive impact of flood control measures on residents' perceived security and protection. These findings emphasize the importance of such infrastructure in fostering a safer and more secure urban environment. This reflects the psychological and social benefits of flood management, as well as its tangible effects in reducing flood risks. By providing reliable flood control measures, urban areas can foster greater confidence in their ability to handle extreme weather events, ultimately supporting community well-being and resilience.

On the other hand, the indicator **Flood control systems improve overall community safety.**, obtained the lowest mean of 3.35 (SD=0.56) which has a description of **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness,** particularly in improving community safety. While these measures are generally seen as essential for reducing flood risks, there may still be areas where respondents feel further improvements are necessary to optimize safety for the entire community. The findings align with research by Wishart et al. (2021), which highlights the effectiveness of urban flood control systems in enhancing safety. However, as Driver et al. (2020) suggest, there may be additional opportunities to refine these strategies to better address community needs and ensure comprehensive flood risk management. Nevertheless, the general consensus points to the positive role that flood control systems play in safeguarding residents and infrastructure from

flood-related harm. Particularly in improving community safety. While the mean score for the indicator on overall community safety was slightly lower compared to others, it still reflects a strong agreement with the effectiveness of flood control systems in enhancing safety. This suggests that while flood control measures are seen as crucial for reducing flood risks, there may be areas where respondents feel further improvements are needed to optimize overall community safety. Nevertheless, the general consensus points to the positive role that flood control systems play in safeguarding residents and infrastructure from flood-related harm.

Table 13
The Respondents' Assessment of the Effectiveness in Urban Flood Control in terms of *Social and Community Impact*

Items	Mean	SD	Description	Interpretation
1. Flood control systems improve overall community safety.	3.35	0.56	Strongly Agree	Very High Effectiveness
2. Residents feel more secure due to the flood control infrastructure.	3.40	0.59	Strongly Agree	Very High Effectiveness
3. Flood control enhances accessibility during rainy seasons.	3.39	0.57	Strongly Agree	Very High Effectiveness
4. Community awareness about flood control has improved.	3.37	0.59	Strongly Agree	Very High Effectiveness
Overall Mean	**3.38**	**0.58**	**Strongly Agree**	**Very High Effectiveness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

Table 14 shows the summary on the effectiveness in urban flood control. The overall mean is 3.38 (SD=0.57) indicates a description **Strongly Agree**. The data reveal that respondents assessed the urban flood control as **Very High Effectiveness**, underscoring their strong administrative performance and its pivotal role in ensuring the success of flood management initiatives. This effectiveness highlights respondents' ability to plan, coordinate, and implement flood control measures with precision and efficiency. Their strong administrative skills not only enhance the immediate success of flood management efforts but also contribute to long-term resilience and preparedness for future challenges. Effective flood control requires a careful balance of strategic planning, efficient coordination, and practical implementation to address both current risks and future uncertainties (Choi et al., 2021). A key factor in this process is the administrative strength of the agencies responsible for these efforts, which must demonstrate robust organizational skills in assessing flood risks, designing and constructing solutions, and maintaining essential infrastructure (Gijsman et al., 2021).

Table 14
Summary of the Respondents' Assessment of the Effectiveness in Urban Flood Control

Items	Mean	SD	Description	Interpretation
Flood Reduction Efficiency	3.33	0.57	Strongly Agree	Very High Effectiveness
Environmental Benefits	3.42	0.58	Strongly Agree	Very High Effectiveness
Economic Sustainability	3.39	0.55	Strongly Agree	Very High Effectiveness
Social and Community Impact	3.38	0.58	Strongly Agree	Very High Effectiveness
Overall Mean	**3.38**	**0.57**	**Strongly Agree**	**Very High Effectiveness**

Legend: 1.00 – 1.75 (Strongly Disagree), 1.76 – 2.50 (Disagree), 2.51 – 3.25 (Agree), 3.26 – 4.00 (Strongly Agree)

CONCLUSION

The findings of the study highlight the important but modest role of green infrastructure (GI) in urban flood control within Cebu City, particularly through its emphasis on community engagement and awareness. While GI's direct impact on the effectiveness of urban flood control is limited, as evidenced by the adjusted R^2 value of 2.1%, the statistical significance of the relationship underscores its relevance. This suggests that GI, when implemented with active community participation and awareness, contributes meaningfully to sustainable flood management practices. The findings align with the principles of Ecological Modernization Theory, which emphasizes the integration of environmental considerations into societal development through innovative and participatory approaches. GI, as a nature-based solution, reflects this integration by combining flood mitigation with environmental benefits such as ecosystem restoration and community involvement.

Similarly, the results support Green Infrastructure Theory, which advocates for the use of ecological systems as foundational elements in urban planning and environmental protection. GI projects in Cebu City demonstrate this theory by addressing flood risks while enhancing environmental sustainability, even if their measurable impact in this context is modest. The study's findings reinforce the idea that GI should be viewed as part of a broader strategy for urban resilience, emphasizing the need for continued community engagement, policy support, and multi-sectoral collaboration to maximize its effectiveness. This aligns well with both theoretical frameworks and provides a foundation for advocating sustainable urban planning in Cebu City and similar urban contexts.

Recommendations

Based on the findings and conclusion, the following recommendations may be provided for various entities in Cebu City, Philippines:

Local Government Officials of Cebu City. Local government officials may prioritize the integration of green infrastructure into urban flood management policies and allocate resources to support community engagement programs. They might also establish partnerships with private sectors, NGOs, and academic institutions to ensure the sustainable implementation of GI initiatives.

Urban Planners and Environmental Engineers. Urban planners and environmental engineers may incorporate GI principles into city zoning plans and infrastructure designs, emphasizing eco-friendly, flood-resilient solutions. They might also advocate for multi-functional designs that integrate flood control with urban aesthetics and biodiversity conservation.

Environmental Protection Agencies. Environmental protection agencies may focus on public awareness campaigns and education programs to promote understanding and support for GI among the population. They might also conduct regular assessments of GI projects to evaluate their environmental impact and effectiveness in flood control.

Residents of Cebu City. Residents may actively participate in community engagement programs and support local GI projects through volunteerism and advocacy. They might also adopt practices that complement GI initiatives, such as proper waste management and tree planting within their neighborhoods.

Academics and Researchers in Environmental Science. Academics and researchers may explore the long-term impacts of GI on urban flood control and environmental protection through empirical studies. They might also work on developing innovative GI solutions tailored to Cebu City's unique urban and environmental challenges.

Non-Governmental Organizations (NGOs) Focused on Climate Resilience. NGOs might focus on mobilizing resources and expertise to implement pilot GI projects in flood-prone areas. They may also serve as mediators between communities and local governments to ensure inclusive and participatory project planning.

Construction and Real Estate Developers. Developers may integrate GI components into residential and commercial projects to contribute to sustainable urban development. They might also collaborate with urban planners and local governments to align their developments with city-wide flood control strategies.

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