

Urban Ecopuncture: Adaptation Of Wetland Parks Criteria For A Hybrid Flood Mitigation In Cabanatuan City

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ABSTRACT

The pressing challenges posed by climate change in Cabanatuan City, including extreme flooding events, necessitate a multifaceted approach to mitigation. While traditional flood control infrastructures were implemented, they may carelessly lead to unintended consequences, emphasizing the need for a balanced and sustainable strategy. Drawn inspiration from the solutions of sponge city as the umbrella concept using Ecopuncture and Japan's evolving flood control methods, the integration of green spaces, particularly the integration of wetlands emerged as a promising solution. From these inspirations, the researcher carefully formulated considerations for extreme flood events and adopted relevant criteria in determining the most suitable locations for flood retention and green spaces in the City of Cabanatuan, this paper exhausted solutions and approaches from works of literature addressing issues aligned with climate crisis specifically flood mitigation. With practices and criteria applicable to the locale of the study adopted, the researcher was able to analyze available maps and the most significant flooding over time in the city which delineated the flow of the flood, susceptible areas to flooding considering elevation were determined, and finally the researcher was able to recommend locations for wetland parks that are suitable to demonstrate the intent of flood mitigation thru the integration of green spaces, reconnection between people and the river, and introduction of added parks with a hybrid approach.

Keywords: Cabanatuan City, Sponge City, Green Spaces, Flood mitigation, Nature-based solutions, Reconnection.

Introduction

Climate change and its effects are undeniably felt throughout the country, and one of the cities that suffers from it, is the city of Cabanatuan, it ranges from high heat index to typhoons and the like. One of the results of these changes in the climate is extreme flooding events, which is a calamity experienced by approximately 700 residents from several barangays in the city (Casilao, 2020). Aside from the natural occurrence of flooding from the Pampanga River that encompasses Cabanatuan city, this is also aggravated by a variety of factors such as sea level rise, clogging of drainage, especially the factor of having insufficient green space in the city to absorb the flood (CPDO, Cabanatuan City) which all boils down to the effects of rapid urbanization.

This is not experienced by the city of Cabanatuan city alone, according to a 2018 survey, climate change and the destruction of nature have been placed number one thrice in a row, as the most serious issue affecting the world (Loudenback, T., & Jackson, A., 2018). Flooding, being one of the most significant impacts of Climate Change, obviously is experienced by many, given the differences in climate prevailing from one country to another. In response to this, various solutions have been proposed and implemented. One such solution is the

construction of flood barriers and drainage systems (Smith, J., & Brown, A., 2015). These infrastructures are designed to control the flow of water during heavy rains, thereby reducing the risk of flooding (Johnson, K., 2017). Another solution is the restoration and preservation of natural habitats, such as wetlands and forests (Green, L., & White, R., 2018). These ecosystems play a crucial role in absorbing rainwater and slowing down its flow, thus mitigating flood risks (Miller, S., 2020). Adding to these solutions and responses is the concept of Ecopuncture. This involved a systematic hydrological analysis of the entire metropolitan region, which informed the careful planning of the park as an integral part of the green infrastructure of a water-resilient city (Turrenscape, 2021). One that benefits from ecopuncture is the concept of sponge city, which is a city that is designed to passively absorb, clean, and use rainfall in an ecologically friendly way that reduces dangerous and polluted runoff (ArchDaily Team, 2022). Sponge cities involve elements that allow greater permeability in the soil for rainwater absorption, such as parks, drainage pavements, rain gardens, green roofs and walls, and ponds and lakes (ArchDaily Team, 2022).

Similarly, Cabanatuan City has responded to this type of problem by implementing flood mitigation efforts to protect its residents and infrastructure from the damaging effects of flooding (Philippine News Agency, 2018; 2021; 2022). The flood mitigation structures were built along the Pampanga River, in 2021, DPWH-Region 3 Director Roseller Tolentino reported that they had completed projects including a 720-linear meter Pampanga river flood control, and earth dike and concrete slope protection in two villages of Cabanatuan City (Philippine News Agency, 2021). More recently, in 2022, the DPWH completed a P9.6-million drainage project in Barangay Magsaysay Sur, Cabanatuan City (Manila Bulletin, 2022; Philippine News Agency, 2022). This project is expected to reduce the threat of flooding in the area (Manila Bulletin, 2022). While these infrastructures aim to protect communities from the effects of extreme flooding, they can have unintended consequences. For instance, altering the natural flow of water can lead to flooding in areas that were not previously prone to floods (DPWH and JICA, 2004). This is because when a river's course is changed or its flow is restricted in one area, water may accumulate and cause flooding in another area (DPWH and JICA, 2004).

Meanwhile, Japan has been using concrete structures, such as dams and embankments, for flood control due to its unique weather and geographical conditions (Koike, 2021). These structures have been effective in managing floods over the years. However, with changing climate conditions and societal needs, Japan has started to rethink its approach to flood control. In recent years, Japan has been shifting towards using green infrastructure (GI) for flood control. GI is a concept that uses the functions of ecosystems for strategic planning (Ishiyama et al., 2022). It includes measures like creating flood-control basins, which are facilities that temporarily store river water to mitigate flood peaks (Taura et al., 2021). The shift towards GI is not just about controlling floods. It also contributes to biodiversity conservation and sustainable management. For instance, under the Maruyama River project near Toyooka City in Japan, large-scale wetlands were restored. This not only helped with flood control but also improved the natural habitat, attracting more visitors and boosting the local economy (Toyooka City Official Site, n.d.).

The pressing challenges posed by climate change in Cabanatuan City, including extreme flooding events, necessitate a multifaceted approach to mitigation. While traditional flood control infrastructures have been implemented, they may carelessly lead to unintended consequences, emphasizing the need for a balanced and sustainable strategy. Drawing inspiration from the solutions of sponge city as the umbrella concept using Ecopuncture and Japan's evolving flood control methods, the integration of green spaces, particularly the integration of wetlands emerged as a promising solution. To determine the most suitable locations for wetland parks in the city and careful formulation of considerations for extreme flood events and relevant criteria, this paper intends to answer the following research questions:

1. What criteria can be established for determining the suitable locations for wetland parks in Cabanatuan City through a literature review?
2. How can the significant extreme flooding events in Cabanatuan City be analyzed?
3. Where are the suitable locations for wetland parks in Cabanatuan City?

Objectives of the Study

The questions outlined above, align with the intent of Ecopuncture which assists planners in making informed decisions when addressing this type of issue, thus, establishing these main objectives:

1. To establish criteria for determining the suitable locations for wetland parks in Cabanatuan City through a literature review.
2. To analyze the significant extreme flooding events in Cabanatuan City through Map review to satisfy the exhausted criteria.
3. To recommend suitable locations for wetland parks in Cabanatuan City.

Scope and Limitations of the Study

Scope of the Study:

The study will focus on the historical extreme flooding events in Cabanatuan City, Philippines. It will set criteria for finding sites in the city for wetland parks. The study will come up with design guidelines that will help Cabanatuan City select appropriate sites for wetland parks to address the flooding problems in the city.

Limitations of the Study:

This study will only focus on Cabanatuan City and might not work in other places with different terrain and weather. Historical information about flooding depends on the available records, not all major flooding events may be included. The criteria used to choose sites for green spaces and flood protection are based on data that is currently available, and these may not take into account all possible factors. The recommended design guidelines are suggestions based on current best practices and may need to be adjusted based on practical implementation and feedback. The study doesn't look at what the suggested design guidelines would mean for the economy.

Methodology and Framework

The research methodology to satisfy the objectives of this study involves a thorough literature review to identify existing criteria related to flood retention and green space planning in urban areas. Furthermore, historical data on extreme flooding events in Cabanatuan City will be analyzed to understand their characteristics and impacts. Using this data and the synthesized criteria, potential locations for wetland parks will be identified.

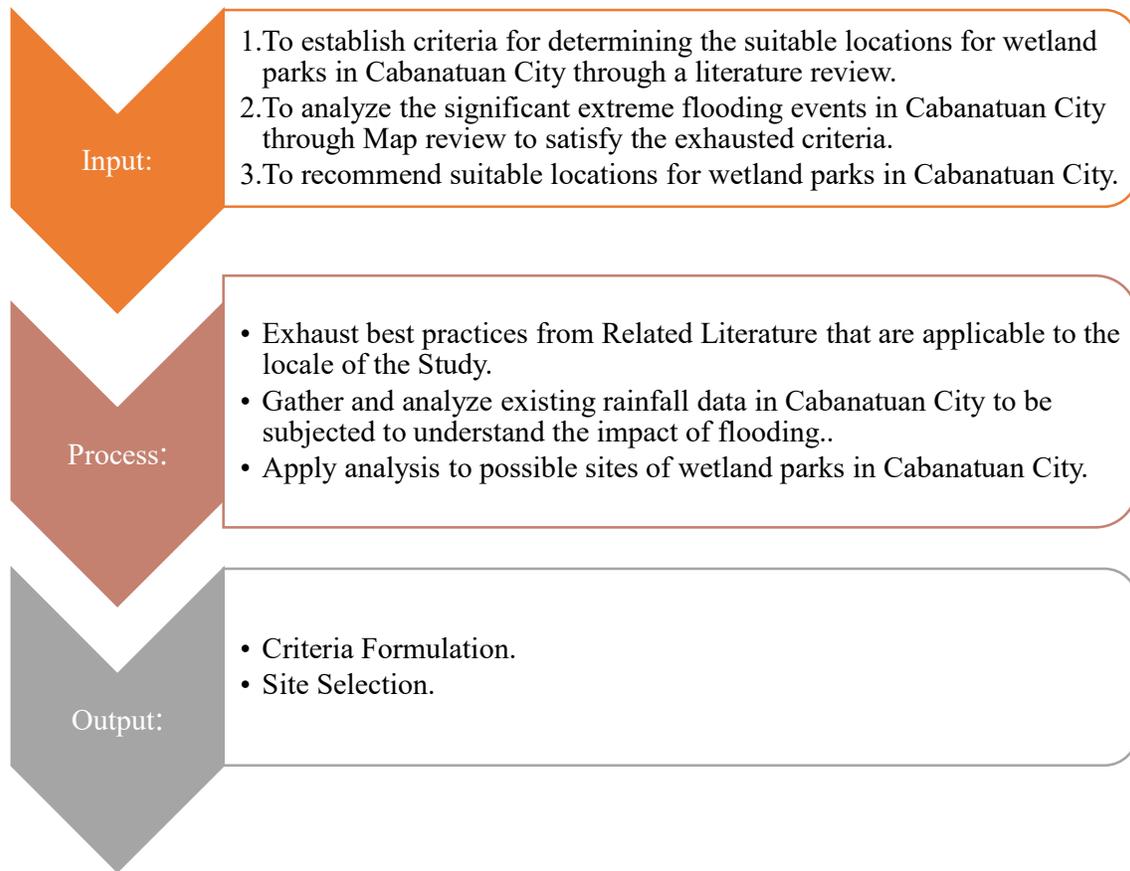


Figure 1 Conceptual Framework

Review of Related Literature

Modern Flood Control and Nature-Based Solutions

The current flood protection strategies, which primarily rely on gray infrastructure such as dams and artificial levees, are increasingly being challenged by the threat of mega floods, events that exceed a 100-year return interval, particularly in the context of climate change (Nakamura, 2022). These strategies, while effective up to a certain limit, are unable to provide additional flood mitigation once that limit is exceeded, leading to potentially catastrophic outcomes such as flooding in residential areas (Nakamura, 2022). In response to this challenge, the design flood discharge has been increased through conventional measures such as the construction of dams then followed by maintaining of current design flood discharge level but supplementing it with green infrastructure (GI), including hillside forests and floodplain wetlands that can store rainwater and retain spilled floodwater (Nakamura, 2022). The role of forests in flood protection is complex and multifaceted. On one hand, the root systems of trees and bamboo can hold soils on levees and reduce flood velocity, thereby protecting riverbanks and levees from scouring. Given these complexities, further research is needed to better understand the physical functions of green infrastructure. In recent years, Japan has introduced new flood control management policies that use a hybrid approach combining green and gray infrastructure. However, these policies still heavily focus on Grey Infrastructure for flood control measures while the concept of hybrid infrastructure in this paper emphasizes GI with multi-functionalities including biodiversity conservation at a watershed scale (Nakamura, 2022).

Additionally, it's important to note that disaster prevention and mitigation is considered the most valuable function of Green Infrastructure (GI) in Japan, according to municipality workers (M'Ikiugu, Wang, & Kinoshita, 2012). This aligns with the long-held belief that "those who control the water, control the country," underscoring the critical role of flood control in national administration (Taki, 2022).

However, the traditional measures for flood control, including basin and in-channel measures such as rainwater storage and infiltration facilities, river improvement, and flood control facilities, are proving inadequate in the face of emerging challenges. These challenges include a decline in investment capacity due to population decline, changes in social structure and lifestyles, a decline in literacy regarding water-related disaster mechanisms, and an increase in extreme events associated with climate change (Taki, 2022). The Science Council of Japan (2014) highlights the benefits of artificial structures as achieving a single function with a high degree of precision while emphasizing the benefits of GI as maintaining and creating diverse spaces that provide a variety of ecosystem services and contribute to biodiversity conservation. GI should be seen as complementing rather than replacing the function of artificial structures (Taki, 2022). An example of this can be seen along the Azumi River in Shiga Prefecture where flood prevention forests still exist. Many are bamboo groves that not only mitigate flooding but also support rich riverine biota, provide food, and have been used as materials for traditional Japanese crafts. This illustrates how GI is closely related to lifestyle and culture and forms the character of the region and its original landscape - a role that could not easily be played by functionally oriented concrete embankments (Taki, 2022).

Urban Approaches to Flood in Asia

Irvine et al. (2023) explore a multi-faceted approach to flood management, encapsulated in the “Retreat, Adapt, and Defend” strategy. The “Retreat” concept involves creating spaces that can accommodate flood waters, such as agricultural lands and naturalized pond storage areas. This strategy acknowledges that certain areas are prone to flooding and designs them to cope with this reality rather than attempting to prevent it.

The “Adapt” strategy involves structural changes to buildings to make them more resilient to floods. This could include measures such as raising buildings on stilts or designing them to withstand water damage. The “Defend” strategy involves both green and hard engineering solutions to protect areas from flooding. This could include constructing flood barriers or enhancing natural features like wetlands that can absorb excess water.

These highlight the importance of innovative, nature-based solutions in managing urban flooding. By working with nature rather than against it, these strategies aim to enhance urban resilience and sustainability. Hussain (2021) adds another dimension to the discussion by focusing on the issue of water logging in urban areas, particularly in India. The rapid pace of urbanization has led to a decrease in open spaces and spill areas that can accommodate excess water during these months. This, coupled with an increase in surface runoff due to the expansion of surfaced areas, has heightened the susceptibility of urban centers to water logging. Hussain (2021) suggests a solution which is the application of the Sponge City Concept of China by the conversion of certain areas into ponds, which can serve as either retention or detention ponds. These ponds can hold excess water during periods of heavy rainfall, reducing the risk of flooding. Incorporating these strategies into urban planning can help mitigate the effects of flooding and water logging. These solutions align with the nature-based approaches discussed by Irvine et al. (2023), further emphasizing the importance of working with nature to enhance urban resilience.

A Sponge City is designed to function like a sponge, with the ability to absorb, store, and purify rainwater during periods of rainfall, and then release it when needed. This is achieved through a combination of green infrastructures like parks, green roofs, wetlands, and permeable pavements, as well as blue infrastructures like water bodies and treatment facilities. The Sponge City initiative seeks to restore surface water storage capacity by improving surface water infiltration. By enhancing the natural ability of urban landscapes to absorb and store water, this strategy aims to mitigate flood risks, enhance urban resilience, and promote sustainable urban development (Griffiths et al., 2020).

Case Studies

Extreme Rainfall Events in the City of Cabanatuan

The Philippines is projected to experience an increase in heavy daily rainfall and extreme rainfall in Luzon and Visayas, while the number of dry days is expected to rise nationwide by 2020 and 2050. This could lead to intense flooding during wet periods, posing risks to human settlements, infrastructure, and potentially causing landslides in geologically weak areas. Such events could severely impact public infrastructure like roads, bridges, classrooms, evacuation centers, and hospitals.

To enhance adaptive capacity, impact, and vulnerability assessments should be used for strategic and long-term planning. These assessments can help anticipate areas of critical water shortages that could affect

domestic consumption, irrigation services, and energy generation in dams. Proactive planning is crucial to respond to these impacts and avoid maladaptations effectively. Adaptation strategies could include rational water management, policy planning to balance water supply and demand, upgrading dams where cost-effective, altering cropping patterns in agricultural areas, establishing rainwater collection facilities where possible, and implementing early warning systems. PAGASA-DOST. (2021). Philippine Climate Extremes Report 2020: Observed and Projected Climate Extremes in the Philippines to Support Informed Decisions on Climate Change Adaptation and Risk Management. Department Of Science and Technology.

Cabanatuan City in Nueva Ecija, Philippines, has experienced significant flooding events due to various factors. The city's location along the path of the upstream Pampanga River and its proximity to the mountainous area of Gabaldon make it susceptible to flooding (Macas, 2015). Rain from the mountains of Aurora and Sierra Madre drains into streams and rivers, causing flooding in various parts of Nueva Ecija and Bulacan (Macas, 2015).

In 2015, Typhoon Lando's slow movement resulted in prolonged rain, causing flooding in many parts of Luzon, including areas in Cabanatuan City that are usually not flood-prone (Macas, 2015). President Benigno Aquino III warned that the effects of the typhoon would be felt for about three more days as rainwater starts to come down from higher ground (Macas, 2015).

In 2020, over 700 residents from several barangays in Cabanatuan City were evacuated due to flooding from Tropical Storm Pepito (Casilao, 2020). The City Disaster Risk Reduction and Management Office (CDRRMO) reported that 13 barangays in Cabanatuan experienced flooding (Casilao, 2020). The Provincial Disaster Risk Reduction and Management Office monitored the Pampanga River, which had slightly increased water levels but was still within normal limits (Casilao, 2020).

Flood Mitigation in Cabanatuan City

Cabanatuan City, particularly barangays Aduas Centro, Aduas Norte, Aduas Sur, Bagong Sikat, Bakero, Bakod Bayan, Bantug Bulalo, Barlis, Barrera and Balite, is vulnerable to flooding (Jocson, Florencondia, & Subia, 2019). The leading causes of flooding in the city include heavy and prolonged rainfall, clogged rivers, canals, creeks and streams, lack of preventive infrastructure and facilities, and poor implementation of the waste management system (Jocson et al., 2019).

The city government has implemented flood prevention and mitigation initiatives to control the river and land. However, these measures are moderately implemented while other mitigation measures are properly implemented (Jocson et al., 2019). The vulnerable barangays should be closely monitored by the city engineering office and CCDRRMO to determine the needed assistance and facilities to prevent them from experiencing the worst floods (Jocson et al., 2019).

During Typhoon Lando in 2015, SM City Cabanatuan demonstrated its resilience by serving as a safe refuge for over 400 stranded customers and providing food, water, charging stations, and basic medical assistance. The mall was designed with a conscious and decisive approach to disaster resilience. The lower ground structure serves as a temporary flood catchment during extreme floods.(ARISE Case Studies in Disaster Risk Management).

Flood Mitigation Around the World

Cities around the world are developing innovative solutions to increase their resilience to flooding. In Copenhagen, a plan was developed that combines blue and green spaces projects to manage water while improving amenities for the community (McManus, 2021). One such project is Enghaveparken, a park originally built in the 1920s that was recently redesigned to retain its original character while significantly enhancing flooding resilience. Features like lowered hockey courts and paths now serve as reservoirs during rainstorms (McManus, 2021).

In the United States, Origin Park, a 600-acre urban park project along the Ohio River in Indiana, is being designed as the first climate-resilient park in the Midwest (Edwards, 2023). The park plans to turn floods into an attraction by building infrastructure for public viewing during floods. The park will have 35 miles of park lawns, 22 miles of trails, and a 2.8 mile elevated trail called the Infinity Loop that allows visitors to walk over the river (Edwards, 2023).

Bangkok, on the other hand, is grappling with the consequences of rapid urbanization and climate change, which have led to frequent and devastating floods (Voraakhom, 2017). The city is sinking due to these factors, prompting innovative solutions to mitigate the impact. One such solution is the Chulalongkorn University

Centennial Park, a green oasis in the heart of Bangkok. Designed by landscape architect Kotchakorn Voraakhom, the park serves multiple purposes - it reconnects residents with nature, collects and cleans water, and can hold nearly one million gallons of water during severe floods (Voraakhom, 2017). The park's design is inspired by raintrees and includes features such as wetlands and a retention pond. It also utilizes gravity to move rain and floodwater from the highest point (the green roof) to the retention pond. While one park alone cannot solve the city's flooding problem, it does spark ideas for other porous solutions like canal restoration and green roofs (Voraakhom, 2017).

Another example of a nature-based solution to Bangkok's flooding problem is the Benjakitti Forest Park. The park uses cut-and-fill techniques to create wetlands dotted with islets. These parks serve as examples of how urban design can be used to address environmental challenges while also providing recreational spaces for residents.

In the case of Suzhou Zhenshan Park, two main strategies were employed. The first was the creation of a "Sponge Park", which is designed to absorb, clean, and use rainfall in an ecologically effective manner. This strategy helps to manage stormwater runoff, improve water quality, and enhance the beauty of the park (Turenscape, 2019). The second strategy was the construction of a productive, low-maintenance landscape. This involves using plant species that are well-adapted to the local climate and soil conditions, reducing the need for irrigation, fertilizers, and pesticides (Turenscape, 2019).

For the Dong'an Wetland Park, the plan called for more space for water and for removing the concrete flood walls that had channelized and reduced the resiliency of rivers. These hard infrastructures were replaced with eco-friendly embankments. The park integrates wetlands, ponds, rice paddies, greenways, parks, and coastal habitats into a holistic sponge system designed to retain and cleanse water and recharge the aquifer (Turenscape, 2021).

Results and Discussion

I. Criteria for determining the suitable locations for Wetland parks in Cabanatuan City, based on the literature review:

1. **Flood Retention and Filtration Capability:** These areas should be elevated to hold and retain water and become green spaces that serve as flood retention areas during heavy rainfall (Voraakhom, 2017). These areas can recharge groundwater and maintain the city's water table (Mohamad et al., 2012; Irvine, 2023; Hussain, 2021). Being prone to flooding does not mean it should be the lowest possible location, which will impede stormwater runoff retention. Instead, it should be medium to high floodable area to delay and retain flood flow, as shown in the figures

2.

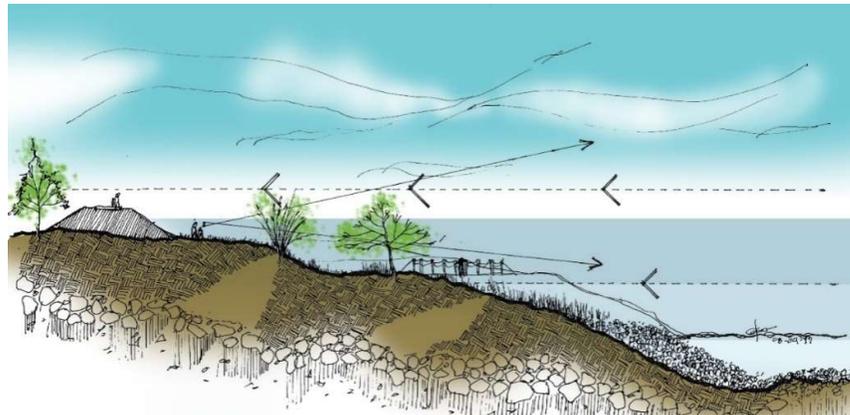


Figure 2 This analysis displays that the flood will only flow normally and gradually in low elevations and there will be little to no retention and filtration will be permitted. Flood Study Sketch by the Researcher.

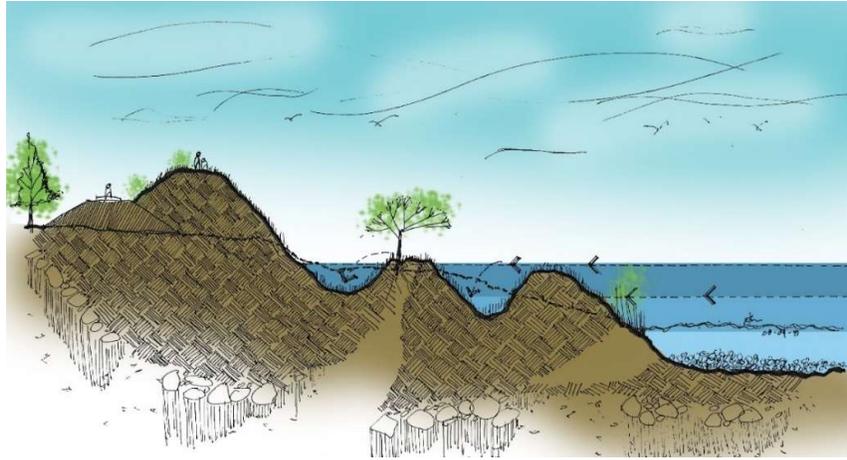


Figure 3 This sketch shows possible run-off flow if flood retention spaces are placed on higher elevations, which may allow flood and/or flood recharge zones to be filtered, as interpreted in the next Figure. Flood Study Sketch by Researcher.

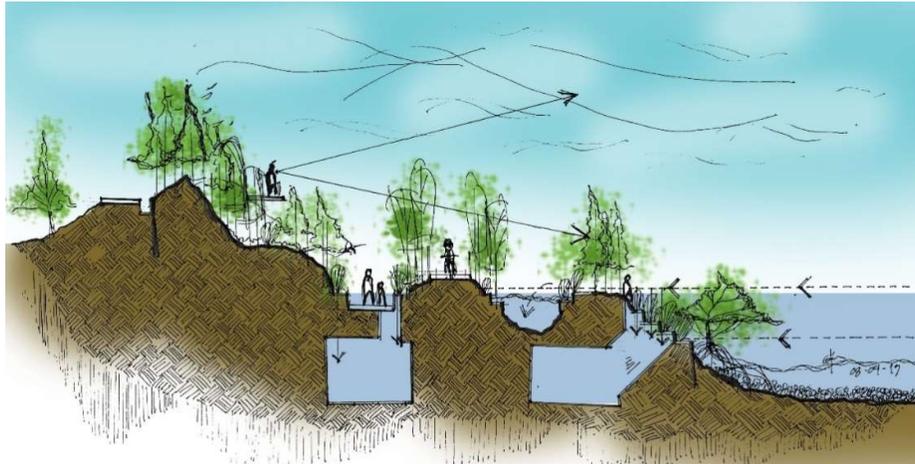


Figure 4 Flood Retention may be increased thus will lessen the flood runoff in the areas situated in lower elevations (Turrenscape, 2023) And will also provide opportunity of recreational spaces. Flood Study Sketch by the Researcher.

3. **Appropriate Configuration for Green Spaces:** Designs should accommodate wetlands, ponds, and parks. These spaces help manage stormwater runoff, improve water quality, and provide wildlife habitat (Nakamura, 2022; Taki, 2022; Griffiths et al., 2020; Voraakhom, 2017; Turrenscape, 2019; 2021). The physical characteristics of these locations will also demonstrate the function of blue and green spaces, such as filtering floodwater and retaining stormwater runoff. According to the authors' designs, most

floodable parks are curvilinear, allowing flood water to flow naturally while being filtered by bioswales, riparian forests, and green embankments.



Figure 5 Curvilinear landscape configuration, Sketch study by the researcher.

4. **Public Accessibility and Reconnection Opportunities:** The site should be easily accessible to the public and offer reconnection among the users and bodies of water. This not only enhances the quality of life for residents but also promotes environmental awareness and stewardship (McManus, 2021; Edwards, 2023). The location of the site should offer immediate access to the public's sight for an attraction that will eventually generate reconnection opportunities.
5. **Compatibility with Existing Landscape:** The site blends seamlessly with the city's landscape to enhance its aesthetic appeal and identity (Taki, 2022; Turrenscape, 2019; 2021). This would involve using local plants that can filter floodwater. These elements are crucial to the city's identity and sustainability, so they should be preserved and improved (Nakamura, 2022; Taki, 2022). These spaces can blend into Cabanatuan City's landscape by using bamboo forests, native bushes that filter water, and a landscape configuration that doesn't overpower the flat and plain terrain.

II. Analysis of Extreme Flooding Events in Cabanatuan City and Site Selection for WetlandParks

1. Natural slope of bodies of water and their flow.

To determine the behavior of flood in the city, it is imperative to establish the physical characteristics of the river regarding its slope, with this, the stream of the river will be established which can lead to the determination of surface runoff during flooding. In the following images, the river elevations are displayed proceeded by the determination of the natural stream of the bodies of water in the city. This shows that all the bodies of water flow towards the Pampanga River as this has the lowest elevation among the bodies of water in the city.

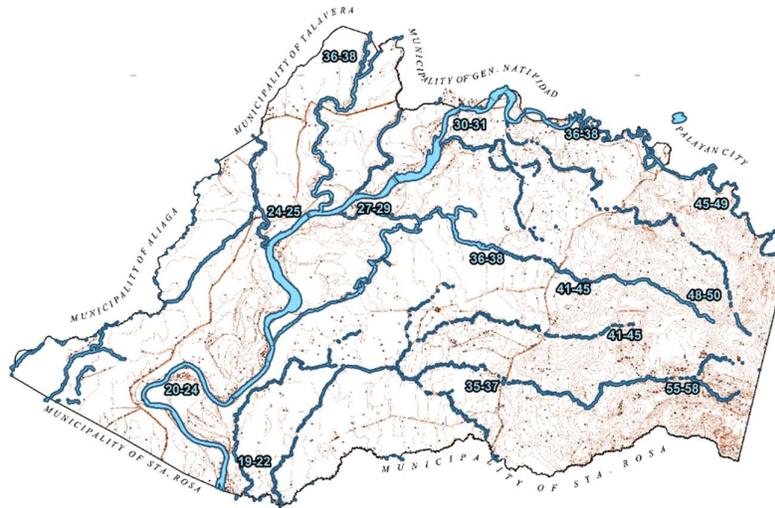


Figure 6 Topography of Cabanatuan City's bodies of water. Topography Map retrieved from CPDO, Cabanatuan.

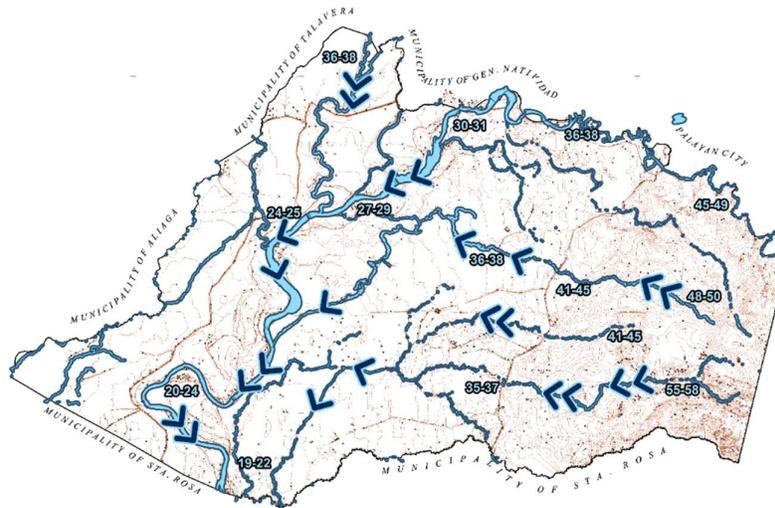


Figure 7 Natural flow of the river based on the topography level of bodies of water. Topography Map retrieved from CPDO, Cabanatuan.

2. Flood Flow

Based on Criteria 1 and 2, floodable spaces are identified through mapping of flood hazard zones, but they are not limited to just being within these areas. Elevations are also observed to satisfy Criterion 1, that the site of a wetland park should have the capacity to retain flood water and improve its quality, so yellow-marked sites in Figure 7 are selected.

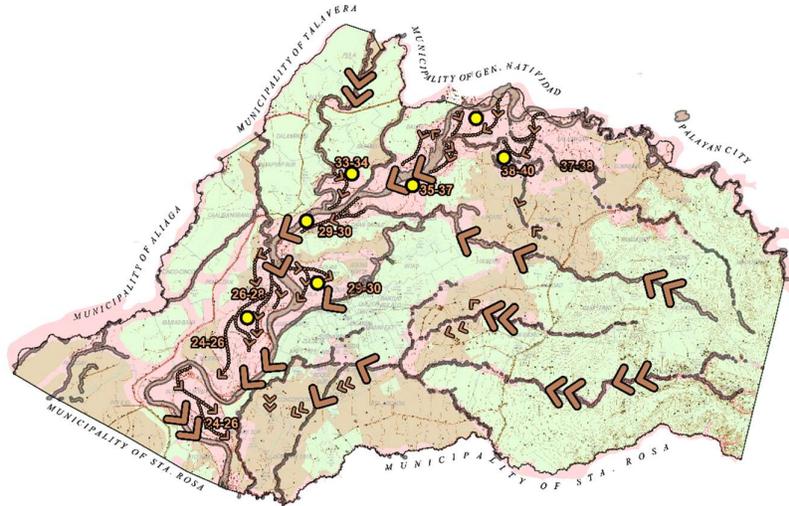


Figure 8 Hazard Map of Cabanatuan City showing the flood base from extreme flooding events recorded. Flood Hazard Map retrieved from CPDO, Cabanatuan.

For criterion 2, a wetland park should be configured to allow flood flow normally. The figure shows flood flow based on elevations and slopes from the same analysis. The site selected marked in orange shows that the flood will flow through the land and back to the discharge zone, unlike the other sites where it will flow through the land and then to its neighboring barangay.

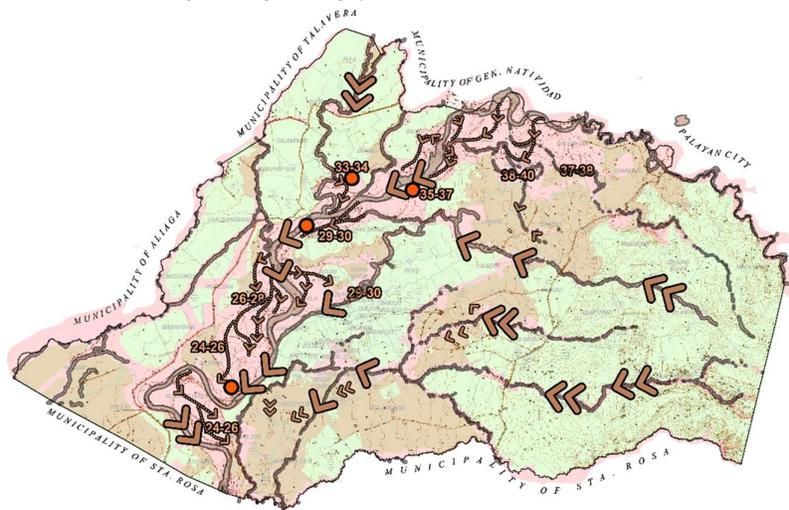


Figure 9 Site selected from the analysis of flood flow. Cabanatuan Map Retrieved from Cabanatuan CPDO

For Criterion number 3, the following figure shows the accessibility of the selected sites from the previous criterion and the sites marked in blue are the most accessible to the public thus offering an opportunity for reconnection to bodies of water in the city.

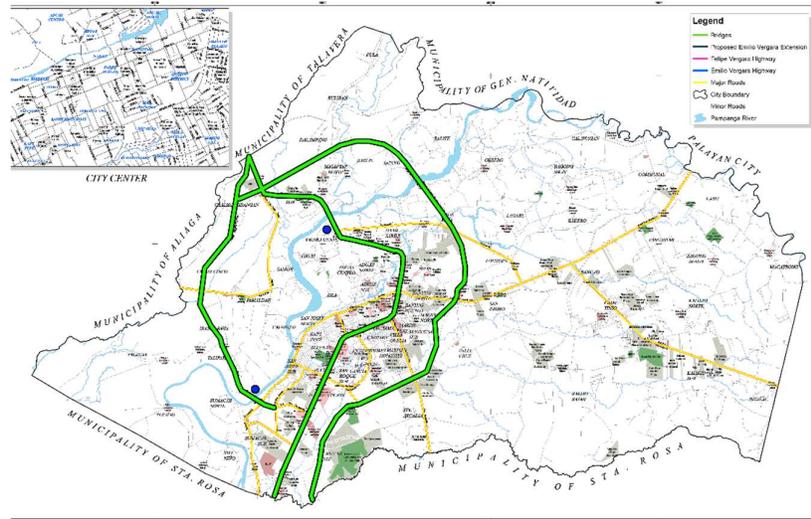


Figure 10 Sites Selected base from criterion number 3. Cabanatuan Map Retrieved from Cabanatuan CPDO

For the fourth criterion, both sites selected from the previous criteria possess landscape and vegetation native to the site as shown and identified in Figure 10 and 11.



Figure 11 One of the selected site located beside General Luna Bridge at Barangay Valdefuente, Cabanatuan City.



Figure 12 One of the chosen site located at Brgy. Sumacab Este, Cabanatuan City. Photo Retrieved from Google Streetview.

Conclusions and Recommendations

This study provided comprehensive criteria for determining Cabanatuan City's wetland park locations, offering a multi-faceted approach to flooding and environmental and social improvements. After a thorough literature review, flood retention and filtration capability, green space configuration, public accessibility, and landscape compatibility were determined. The focus on flood retention capacity shows a forward-thinking plan that uses natural features to effectively handle stormwater runoff. The city can use the natural landscape to retain and delay floodwaters during extreme weather by strategically placing wetland parks in medium to high floodable elevations. This method reduces flooding damage to urban infrastructure and replenishes groundwater reserves, ensuring long-term water security.

Wetland parks are dynamic ecosystems that provide environmental services, and their green spaces demonstrate this. Curvilinear wetlands, ponds, and parks increase biodiversity and filter pollutants, improving river and stream water quality. Cabanatuan City can improve its flood resilience and create vibrant green spaces for humans and wildlife by incorporating these features into urban planning.

The emphasis on public accessibility and reconnection emphasizes community engagement and stewardship. The city can promote environmental conservation by making wetland parks accessible to residents and visitors. These parks offer experiential learning and a deeper appreciation for nature.

The focus on compatibility with Cabanatuan City's landscape emphasizes the need to preserve and improve its unique identity. Wetland parks can blend into the urban fabric and improve the city's aesthetics by using native vegetation and design elements. The findings show that wetland parks can reduce flood risks, improve water quality, and improve community well-being as resilient green infrastructure.

For future studies in Cabanatuan City, thorough assessments of wetland parks' long-term effectiveness are crucial. Evaluations should explore their role in mitigating flooding and enhancing water quality, and biodiversity. Emphasizing participatory planning fosters community engagement and sustainability. Involving local stakeholders ensures greater buy-in and stewardship, promoting social cohesion. Understanding the hybrid nature of wetland parks, and blending natural processes with grey infrastructure can optimize their functionality and resilience. Prioritizing in-depth evaluations of wetland parks' contributions to urban resilience is essential for informed decision-making and effective management in Cabanatuan City.

References :

- Uchiyama, S., Bhattacharya, Y., & Nakamura, H. (2023) Implementing Green Infrastructure for Urban Stormwater Management: A systematic review to identify future challenges for Japan. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4358478
- McManus, K. (2021, July 14). Floodable parks as a tool for local flood resilience. Retrieved from <https://lgiu.org/floodable-parks-as-a-tool-for-local-flood-resilience/>
- Edwards, B. (2023). Origin Park: The First Climate-Resilient Park in the Midwest. The Indiana Environmental Reporter. Retrieved from <https://limestonepostmagazine.com/amphibious-park-clarksville-anticipates-climate-change-impact/>
- ARISE Case Studies in Disaster Risk Management. (n.d.). UNISDR Private Sector Alliance for Disaster Resilient Societies. Retrieved from <http://www.unisdr.org/partners/private-sector>
- Macas, T. (2015, October 19). Why Lando caused massive flooding — and why threat isn't over yet. GMA

- Network. Retrieved from [<https://www.gmanetwork.com/news/scitech/weather/541244/why-lando-caused-massive-flooding-and-why-threat-isn-t-over-yet/story/>]
- Amngosing, F. (2015, October 20). Cabanatuan City starts cleaning up mud after worst flood in years. Retrieved from <https://newsinfo.inquirer.net/733114/cabanatuan-city-starts-cleaning-up-mud-after-worst-flood-in-years>
- Casilao, J. L. (2023, October 15). Over 700 residents evacuated in Cabanatuan City due to flooding from tropical storm Pepito. GMA News. Retrieve from <https://www.gmanetwork.com/news/topstories/regions/760879/over-700-residents-rescued-13-barangays-flooded-in-cabanatuan/story/>
- Uchiyama, S., Bhattacharya, Y., & Nakamura, H. (2023) Implementing Green Infrastructure for Urban Stormwater Management: A systematic review to identify future challenges for Japan¹². Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4358478
- Mohamad, I. M., Nekooie, M. A., & Ismail, Z. B. (2012). Amphibious House, a Novel Practice as a Flood Mitigation Strategy in South-East Asia¹². *Innovative Systems Design and Engineering*, 3(3), 66-76.
- M'Ikiugu, M. M., Wang, Q., & Kinoshita, I. (2012). Socio-Green Infrastructure Gauge: A tool for evaluating green infrastructure inclusion in existing and future urban areas. *Procedia - Social and Behavioral Sciences*, 68, 815–825doi:10.1016/j.sbspro.2012.12.26923
- Jocson, J. C., Florencondia, N. T., & Subia, G. S. (2019). Flood Prevention and Mitigation Initiatives towards a Flood-Free City¹*American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, 58(1), 215-22423.
- Taki, K. (2022). Flood Management Policy in Shiga Prefecture, Japan: Implementation Approach of a Risk-Based Flood Management System at Catchment Scale. Retrieved <https://doi.org/10.1007/978-981-16-6791-6>
- Nakamura, F. (2022). Concept and application of green and hybrid infrastructure. Retrieved from [<https://doi.org/10.1007/978-981-16-6791-6>]
- (Trakuldit and Faysse 2019; Irvine et al. 2022c).Irvine, K. N., Suwanarit, A., Likitswat, F., Srilertchaipanij, H., Sahavacharin, A., Wongwatcharapaiboon, J., Boonkam, P., Ingegno, M., & Janpathompong, S. (2023). Nature-based solutions to enhance urban flood resiliency: case study of a Thailand Smart District. Retrieved January 13, 2023, from [<https://link.springer.com/article/10.1007/s40899-023-00821-6>]
- Urkude, T., Kumar, A., Upadhye, A., & Padwal, M. (2019). Review on Amphibious House¹. *International Research Journal of Engineering and Technology (IRJET)*, 6(1), 1558-1562.
- Edwards, B. (2023). Origin Park: The First Climate-Resilient Park in the Midwest. *The Indiana Environmental Reporter*.
- Voraakhom, K. (2017). CU Park: A Flood-Proof Park in Bangkok. TED Fellows. Retrieved from <https://ideas.ted.com/when-bangkok-floods-and-it-floods-a-lot-this-park-does-something-amazing/>
- Turenscape. (2023, April 07). Benjakitti Forest Park. Retrieved from <https://www.turenscape.com/en/project/detail/4751.html>
- Turenscape. (2019). Suzhou Zhenshan Park. Retrieved from [[turenscape.com](https://www.turenscape.com)]
- Turenscape. (2021, April 30). Sanya Dong'an Wetland Park. Retrieved from [[turenscape.com](https://www.turenscape.com)]