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Improving Watershed Management Practices to Mitigate Flood Impacts on Human Settlements in Baton Rouge

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ABSTRACT
The purpose of this study is to assess the effectiveness of the following current Watershed Management Practices *(such as* Stormwater Infrastructure Enhancements, Green Infrastructure, Natural Waterway Restoration, Community Engagement and Education, and Policy and Regulatory Measures*)* that have been put in place to mitigate flood impacts on human settlements in the city of Baton Rouge to inform policymakers on better comprehensive plan. The policies suggested in this study will go a long way to help policymakers to adopt best practices to help minimize the flood risks and vulnerabilities across the city of Baton Rouge and its surrounding areas to fight against flood damages on human settlements. Again, this study is serving as an informative document for urban forestry students, academia, researchers, and key stakeholders since it aimed at identifying and showing the mapping flood-prone areas, assessing the adequacy of existing infrastructure, and understanding the socio-economic impacts of flooding on different communities by examining the implementation and programs outcomes for all the existing Watershed Management Practices put in place in the city of Baton Rouge and its surroundings to help mitigate flood impacts on human settlements. The study used a qualitative discourse analysis to identify the major watershed locations in Baton Rouge and the key watershed management practices implemented in the city of Baton Rouge to help mitigate flood impacts on human settlements. As part of the findings, the study revealed that Amite River, Comite River, Bayou Fountain, Ward Creek, Jones Creek, Bayou Manchac, and Blackwater Bayou are among the diverse watersheds' locations in the City of Baton Rouge, which in effect play critical roles in water resource management and flood mitigation. Again, the study found that the variety of watershed management practices to mitigate flood impacts on human settlements encompassed both traditional infrastructure enhancements and innovative, as well as sustainable approaches. These practices included the following: (a) Stormwater Infrastructure Enhancements, (b) Green Infrastructure, (c) Natural Waterway Restoration, (d) Community Engagement and Education, and (e) Policy and Regulatory Measures. The study further found that the existing watershed management practices, drainage and flood control systems have proven inadequate to cope with the rising challenges, leading to repeated flood events that disrupt lives and economic activities in the city of Baton Rouge.
Keywords: *Watershed, Management, Practices, Flood, Damage, Human Settlement, Waterways, Water resources, Natural Resources, Drainage, Stormwater, and Infrastructure Enhancement*
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INTRODUCTION

Baton Rouge, Louisiana, has experienced significant flooding in recent years, thereby causing extensive damage to infrastructure, homes, and businesses (see Figure 1 for more details). The geographical location of Baton Rouge, coupled with increasingly frequent and severe weather events attributed to climate change, has heightened the vulnerability of its human settlements to flood risks thereby leading to the creation of several watershed management practices to salvage the situation (Evans, 2012). Unfortunately, the report from Water Assessment Tool (2023) underscored that the existing watershed management practices, drainage and flood control systems have proven inadequate to cope with the rising challenges, leading to repeated flood events that disrupt lives and economic activities in the city of Baton Rouge.

Watershed management is a process of implementing land use and water management practices to protect and improve the quality and quantity of the water and other natural resources within a watershed (Soil and Water Assessment Tool, 2023; Oweyegha-Afunaduula et al., 2003). **Watershed management aim at the sustainable distribution and utilization of land and water resources for optimum and sustained production** (Evans, 2012; Soil and Water Assessment Tool, 2023; Ewalt, 2001). **Watershed management also involves the integration of different land-use and livelihood systems, such as forestry, pasture and agriculture, using water as the entry point.**

Figure 1: Flood Damages in Baton Rouge

Source: NBC News-Drone Captured Scene of Severe Flooding in Baton Rouge, Aug 15, 2016/00:53

Human settlement encroachment in the floodplains and the concomitant land use changes of these watershed areas are common in many parts of the world. This is especially so in cities with a history of recurrent flooding and in known flood-prone areas **(**Baton Rouge Community Outreach Program, 2022; City of Baton Rouge, 2022**)**. The city of Baton Rouge is one such city. In the metro Baton Rouge region, six major waterways - the Mississippi, Amite, Comite, Tickfaw, Tangipahoa, and Vermilion Rivers - are among the high-risk areas for recurrent flooding **(**Baton Rouge Community Outreach Program, 2022; City of Baton Rouge, 2022**)**. Baton Rouge is located near the confluence of the Mississippi River and the Amite River. In addition, the Amite River is periodically swollen by flood flows from the Comite River **(**Baton Rouge Community Outreach Program, 2022; City of Baton Rouge, 2022**)**. Decreased water retention capacity of natural drainage systems in high flood risk areas in Baton Rouge was seen as leading to an inefficient dispersion of rainfall, leading to increased runoff, changes in channel capacity, and insufficient drainage channels **(**Baton Rouge Community Outreach Program, 2022; City of Baton Rouge, 2022**)**.

As a result of the area faced with an upsurge in worry of potential losses and increased flood insurance premiums in the early 1990s, City of Baton Rouge officials and local residents embarked on a plan of preserving and enhancing the above-mentioned wetlands - areas that are now popularly referred to as watersheds for their ability to retain and either store or use up excess water to lessen runoff discharge and decrease peak runoff velocities when natural runoff from heavy rainfall may occur on an already saturated landscape or in areas where less water may perk down into the water table **(**Baton Rouge Community Outreach Program, 2022; City of Baton Rouge, 2022**)**. Meanwhile, the current flood mitigation strategies there are in placed have not fully addressed the multifaceted nature of flood risks in the area, which include urban development in flood-prone areas, insufficient green infrastructure, and outdated stormwater management practices **(**Baton Rouge Community Outreach Program, 2022; City of Baton Rouge, 2022**)**.

Consequently, there is an urgent need for comprehensive watershed management practices that can effectively reduce flood impacts, enhance community resilience, and protect the economic and social well-being of Baton Rouge residents **(**Baton Rouge Community Outreach Program, 2022; City of Baton Rouge, 2022**)**. Therefore, this current study seeks to embark on a systemic review analysis to assess the following current Watershed Management Practices *(such as* Stormwater Infrastructure Enhancements, Green Infrastructure, Natural Waterway Restoration, Community Engagement and Education, and Policy and Regulatory Measures*) in Baton Rouge* **to inform policymakers on better comprehensive plan to help minimize the Flood Risks and Vulnerabilities** across the Baton Rouge metropolitan areas. This review further aims at identifying and mapping flood-prone areas, assessing the adequacy of existing infrastructure, and understanding the socio-economic

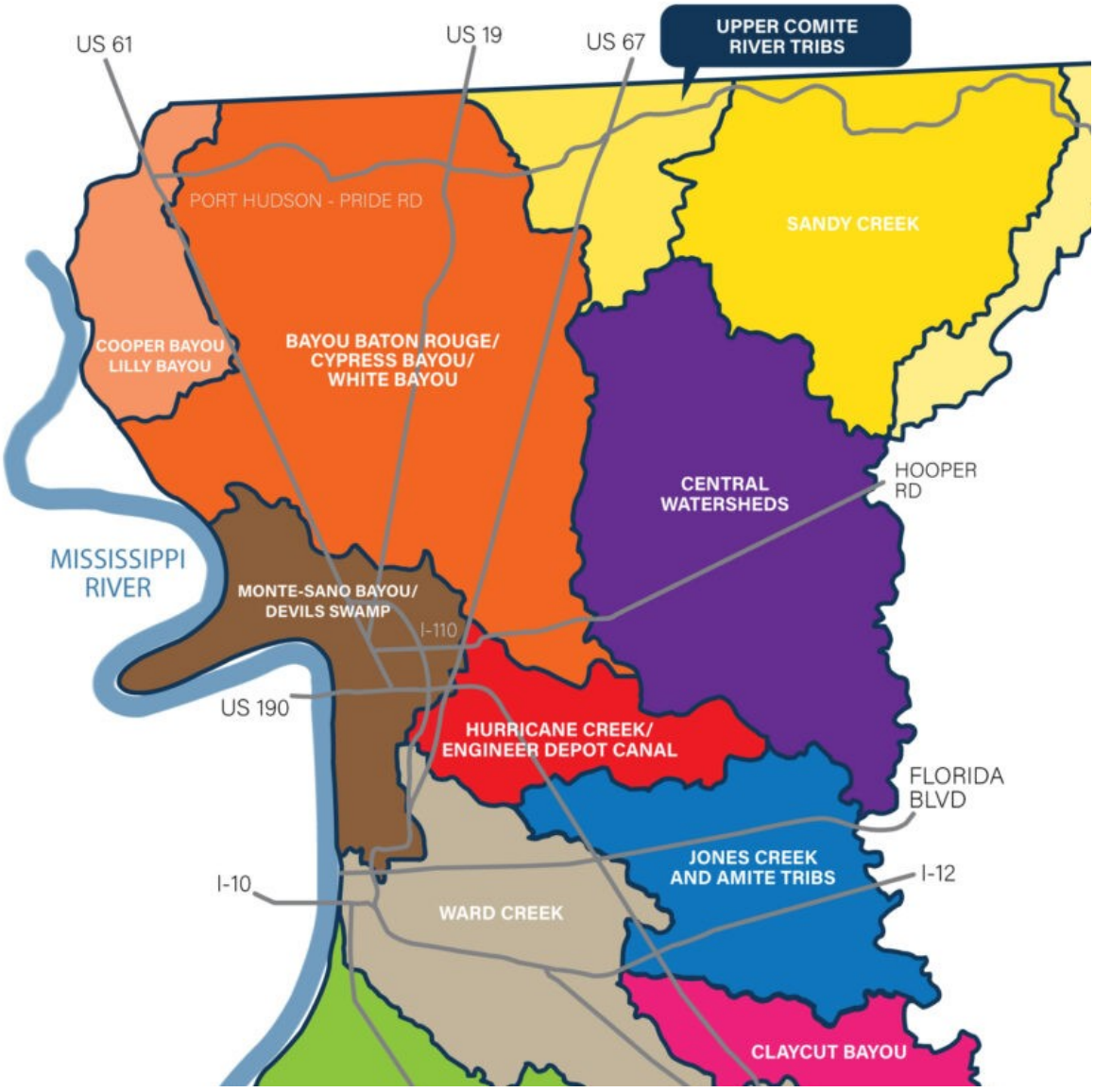
impacts of flooding on different communities by examining the implementation and outcomes of all the Watershed Management Practices in the city of Baton Rouge.

LITERATURE REVIEW

Watershed Locations in Baton Rouge

Baton Rouge, the capital city of Louisiana, is characterized by a complex network of watersheds that play a crucial role in managing water resources, mitigating flood risks, and maintaining ecological balance. Understanding the various watershed locations within Baton Rouge is essential for effective water management and urban planning. This section of the study outlines the primary watersheds in Baton Rouge, highlighting their significance and geographical distribution.

Figure 2: A Map of Showing Types of Watershed Locations in the City of Baton Rouge



Source: East Baton Rouge Stormwater Master Plan - Maps (brla.gov)

***Amite River Watershed*:** The Amite River Watershed is one of the most significant in the region, encompassing parts of East Baton Rouge Parish (see Figure 2 for more details). The Amite River flows southward, impacting

numerous communities and contributing to the overall hydrology of Baton Rouge. This watershed is vital for flood management and water quality maintenance (Louisiana Watershed Initiative, 2023).

Comite River Watershed: Located in the northern part of Baton Rouge, the Comite River Watershed includes the Comite River, which is a tributary of the Amite River (see Figure 2 for more details). This watershed is critical for managing runoff and mitigating flood risks, particularly in northern Baton Rouge and adjacent areas (USGS, 2022).

Bayou Fountain Watershed: The Bayou Fountain Watershed covers the southern part of Baton Rouge, where Bayou Fountain runs through and eventually drains into Bayou Manchac (see Figure 2 for more details). This watershed helps manage stormwater and reduce flooding in the southern neighborhoods of the city (City of Baton Rouge, 2022).

Ward Creek Watershed: Ward Creek Watershed is an important urban watershed within Baton Rouge (see Figure 2 for more details), affecting the southern and central regions. Ward Creek collects stormwater runoff from heavily developed areas, making it crucial for urban water management (EPA, 2021).

Jones Creek Watershed: Situated in the eastern part of Baton Rouge, the Jones Creek Watershed drains into the Amite River (see Figure 2 for more details). This watershed is essential for managing stormwater and reducing flood risks in eastern Baton Rouge, particularly in residential and commercial areas (East Baton Rouge Parish, 2022).

Bayou Manchac Watershed: The Bayou Manchac Watershed forms the southern boundary of East Baton Rouge Parish and serves as a critical area for flood control (see Figure 2 for more details). Bayou Manchac is an essential waterway for draining excess rainwater and preventing floods in southern Baton Rouge and surrounding areas (Louisiana Department of Environmental Quality, 2023).

Blackwater Bayou Watershed: Located in the northern part of the city, the Blackwater Bayou Watershed impacts both urban and rural regions (see Figure 2 for more details). This watershed is important for managing water flow and maintaining ecological health in the northern reaches of Baton Rouge (BREC, 2021).

The diverse watersheds in Baton Rouge, including the Amite River, Comite River, Bayou Fountain, Ward Creek, Jones Creek, Bayou Manchac, and Blackwater Bayou, play critical roles in water resource management and flood mitigation. In fact, it is underscored in the literature that effective management of these watersheds is essential for sustaining the city's water quality, preventing floods, and preserving the ecological balance. Therefore, by understanding these watershed locations enables better urban planning and environmental conservation efforts, ensuring a resilient and sustainable future for Baton Rouge.

METHOD AND MATERIALS

This study used qualitative discourse analysis. The discourse surrounding the improvement of watershed management practices in Baton Rouge is shaped by the urgent need to mitigate flood impacts on human settlements. Baton Rouge has faced significant flooding events in recent years, making it critical to examine and enhance current practices (Smith, 2022). The discourse on improving watershed management practices in Baton Rouge is comprehensive, addressing both technical aspects and community involvement. By examining lexical choices, syntax, cohesion, coherence, contextual factors, and the roles of different stakeholders, this analysis highlights the multifaceted nature of the issue and the collaborative efforts required to effectively mitigate flood impacts on human settlements (Robinson et al., 2023). In discourse analysis, maps, diagrams, and photographs are commonly used to enhance the textual analysis. For example, maps illustrating flood-prone areas and diagrams showing the benefits of green infrastructure and the watershed areas help to visually communicate complex information (Wilson, 2022).

Again, the discourse analysis allows the researcher to examine and Analyze policy documents related to watershed management, transcripts of public meetings on flood mitigation reports highlighting areas of public support or resistance and identifying key issues that need to be addressed. Above all, this design allows the researcher to examine and analyze media coverage reports of flooding events and watershed management initiatives. This includes the identification of recurring themes, the tone of reporting, and the representation of different stakeholders. All these practices were utilized in this study where the researcher use photographs of severe flooding scene in Baton Rouge captured by NBC News on Aug 15, 2016 at 00:53.

Also, the researcher used map of watershed management areas or location in the city of Baton Rouge, and also examine and analyze reports from City of Baton Rouge in relation to flooding management, Louisiana

Watershed Initiative, Baton Rouge Green Initiative, Green Roofs for Healthy Cities, USDA Forest Service, City of Baton Rouge Planning Commission, EPA, Louisiana Floodplain Management Association, as well as Baton Rouge Office of Community Development, and Louisiana Department of Natural Resources. Articles and reports published between 2012 and 2023 that are related to Baton Rouge flooding and watershed management practices were included in this study. Interestingly, with the help of photographs or diagrams the reports from the above-listed agencies and programs were summarize and analyze to inform policymakers on the need to help improve watershed management practices to mitigate flood impacts on human settlements in Baton Rouge. Discourse analysis is well-suited for examining the topic of improving watershed management practices to mitigate flood impacts on human settlements in Baton Rouge for several reasons.

Multifaceted Nature of the Issue: Watershed management and flood mitigation are complex issues that involve multiple stakeholders, including government agencies, scientists, community leaders, and residents. Discourse analysis allows for the examination of how these different groups communicate and construct the issue through language, which is essential for understanding the multifaceted nature of the problem and potential solutions. **Policy and Practice:** Improving watershed management practices involves changes in policies, regulations, and on-the-ground practices. Discourse analysis helps to uncover the language and narratives used in policy documents, public statements, and scientific reports, providing insights into the underlying assumptions, priorities, and power dynamics that shape decision-making processes.

Stakeholder Engagement: Effective watershed management requires active engagement and collaboration among stakeholders. Discourse analysis can reveal how different stakeholders frame the issue, their perceived roles, and how they communicate their interests and concerns. This understanding is crucial for fostering effective collaboration and community involvement. **Contextual Understanding:** Flood impacts and watershed management practices are deeply embedded in local contexts, including geographical, historical, cultural, and socio-economic factors. Discourse analysis allows for a nuanced understanding of these contexts by examining how they are represented and discussed in various texts and communications.

Power Relations and Ideologies: Watershed management and flood mitigation are often influenced by power relations and ideological positions. Discourse analysis helps to identify who holds power in the discourse, whose voices are heard, whose are marginalized, and how these dynamics influence policy and practice. This can lead to more equitable and effective solutions. **Narratives and Persuasion:** The success of implementing improved practices often depends on how the problem and solutions are communicated to the public and decision-makers. Discourse analysis examines the narratives and persuasive strategies used to garner support, build consensus, and drive action. Understanding these rhetorical strategies can enhance the effectiveness of communication efforts.

In summary, discourse analysis is particularly well-suited for the topic of improving watershed management practices to mitigate flood impacts on human settlements in Baton Rouge because it provides a comprehensive framework for understanding the complex and context-dependent nature of the issue. By examining the language and narratives used by various stakeholders, discourse analysis can uncover the underlying assumptions, power dynamics, and contextual factors that shape policy and practice or implementation, ultimately leading to more effective and inclusive solutions.

RESULTS AND DISCUSSION

Analysis and Evaluation of Watershed Management Practices in Baton Rouge

According to the Baton Rouge Community Outreach Program 2022 Annual Report, and the City of Baton Rouge (2022)- *Flood Damage Assessment and Mitigation Strategies* report, it was stated that the city of Baton Rouge is susceptible to significant flood risks, and in effect has implemented a variety of watershed management practices to mitigate flood impacts on human settlements. These watershed management practices encompass both traditional infrastructure enhancements and innovative, as well as sustainable approaches. These practices included the following: (a) Stormwater Infrastructure Enhancements, (b) Green Infrastructure, (c) Natural Waterway Restoration, (d) Community Engagement and Education, and (e) Policy and Regulatory Measures **(**Baton Rouge Community Outreach Program, 2022; City of Baton Rouge, 2022**).**

Stormwater Infrastructure Enhancements

Stormwater infrastructure enhancements are crucial for managing urban flooding and mitigating the impacts of heavy rainfall on human settlements. In Baton Rouge, these enhancements involve upgrading and maintaining critical components of the stormwater management system to improve its capacity and efficiency (City of Baton Rouge, 2022; Louisiana Watershed Initiative, 2021). There are three key aspects of this particular enhancements,

and they include: (a) Upgrading Drainage Systems, (b) Retention and Detention Basins, and (c) Flood Control Pump Stations (City of Baton Rouge, 2022; Louisiana Watershed Initiative, 2021).

For the case of the Upgrading Drainage Systems—the objective is to improve the efficiency and capacity of existing drainage systems to manage larger volumes of stormwater and reduce urban flooding. Some of the key components include (1) *Storm Drains and Culverts*, which looks at increasing the size and number of storm drains and culverts to enhance water flow and prevent blockages; and (2) *Drainage Channels*, which also aim at expanding and deepening drainage channels to accommodate higher water volumes and reduce overflow (City of Baton Rouge, 2022; Louisiana Watershed Initiative, 2021). The implementation of the upgrading drainage system can be found in East Baton Rouge Parish. The parish has undertaken several projects to upgrade key drainage infrastructure. For example, the Ward Creek Drainage Improvement Project involves widening and deepening the creek to improve water flow. The installation of the project has also undergone advanced real-time monitoring systems to track water levels and detect potential blockages, and to also allow for timely maintenance and intervention (City of Baton Rouge, 2022; Louisiana Watershed Initiative, 2021).

The second aspect of the stormwater infrastructure enhancements is the Retention and Detention Basins. These basins temporarily store excess stormwater during heavy rainfall events to prevent downstream flooding and manage peak flow rates (City of Baton Rouge, 2022; Louisiana Watershed Initiative, 2021). Some of key components include the following: (1) *Retention Basins,* which are designed to hold stormwater permanently, and also allow it to infiltrate into the ground or be released slowly; and (2) *Detention Basins,* which are designed to temporarily store stormwater and release it at a controlled rate to prevent flooding downstream (City of Baton Rouge, 2022; Louisiana Watershed Initiative, 2021). According to the City of Baton Rouge (2022), several new basins have been constructed in strategic locations across the city. For example, the Comite River Diversion Canal includes multiple retention and detention basins to manage stormwater. Additionally, according to 2022 report by City of Baton Rouge, most of the existing basins have been expanded to increase their capacity. For instance, the Blackwater Conservation Area has seen significant enhancements to its detention capabilities prior to the 2022 report (City of Baton Rouge, 2022).

The third aspect of the stormwater infrastructure enhancements is the Flood Control Pump Stations. This aspect was designed to help remove excess stormwater from low-lying areas to prevent localized flooding (City of Baton Rouge, 2022). Some of key components include the following: (1) ***Pump Stations,*** which have facilities equipped with high-capacity pumps to move water from low-lying areas to higher ground or directly into rivers and lakes; and (2) ***Backup Power Systems***, which ensures pump stations remain operational during power outages, which often occur during severe weather (City of Baton Rouge, 2022). According to the City of Baton Rouge (2022), the city has constructed new pump stations. The city constructed these new pump stations in flood-prone areas, a typical case is the Scotlandville Canal Pump Station, which is used to pump thousands of gallons of water per minute (City of Baton Rouge, 2022). Above all, these enhancements made to the existing pump stations have helped to increase their capacity and reliability.

Table 1: Evaluation Performance of Stormwater Infrastructure Enhancements (SIEs) in Baton Rouge

Key Components of SIEs	***Objective***	***Implementation***	***Outcome***
Upgrading Drainage Systems	Improve the capacity and efficiency of existing drainage systems to manage larger volumes of stormwater	The city has been upgrading storm drains, culverts, and retention basins. For example, the East Baton Rouge Parish has initiated projects to increase the capacity of critical drainage channels.	These upgrades have led to a noticeable reduction in urban flooding, with some areas experiencing a 15% decrease in flood frequency (City of Baton Rouge, 2022).
Retention and Detention	To temporarily store excess stormwater during heavy rainfall to prevent downstream flooding.	Several new basins have been constructed, and existing ones have been expanded. The Ward Creek Detention Basin is a notable example.	These basins has helped in controlling peak flow rates, reducing the likelihood of flooding in densely populated areas (Louisiana Watershed Initiative, 2021).
Flood Control Pump Stations	To remove excess stormwater from low-lying areas to prevent localized flooding.	Construction of new pump stations in flood-prone areas, such as the Scotlandville Canal Pump Station, which can pump thousands of gallons of water per minute.	Improved pump stations have led to quick removable of excess water, and significantly reducing the duration and extent of flooding in affected areas (City of Baton Rouge, 2022).

Source: Author's Modification of Data from City of Baton Rouge (2022) Report and Louisiana Watershed Initiative (2021).

Table 1 presents the evaluation performance of Stormwater Infrastructure Enhancements (SIEs) in Baton Rouge. In relation to the performances of the two key aspects or components of SIEs, it is an undeniable fact that stormwater infrastructure enhancements in Baton Rouge are critical component of the city's strategy to mitigate flood impacts. By upgrading drainage systems, constructing and expanding retention and detention basins, and improving flood control pump stations, the city has made significant strides in managing stormwater more effectively. These improvements not only reduce the frequency and severity of flooding but also enhance the resilience of urban areas against future extreme weather events.

Green Infrastructure

Green infrastructure refers to sustainable, nature-based solutions that enhance stormwater management by mimicking natural processes. These practices help to absorb, filter, and manage rainwater where it falls, thereby reducing the burden on traditional stormwater infrastructure and mitigating flood risks (Baton Rouge Green Initiative, 2021; EPA, 2020; Green Roofs for Healthy Cities, 2021; USDA Forest Service, 2018). In Baton Rouge, green infrastructure has been increasingly adopted to address flooding and improve watershed health. There are four key aspects of this particular enhancements, and they include: (a) Rain Gardens, (b) Permeable Pavements, (c) Green Roofs, and (d) Urban Tree Canopy (Baton Rouge Green Initiative, 2021; EPA, 2020; Green Roofs for Healthy Cities, 2021; USDA Forest Service, 2018).

For the case of the Rian Gardens—the objective is to utilize shallow, planted depressions to capture and infiltrate stormwater, reducing runoff and promoting groundwater recharge (Baton Rouge Green Initiative, 2021). Some of the key components include: (1) *Plant Selection,* which takes into account native plants that are well-adapted to local soil and climate conditions, providing both aesthetic and functional benefits; and (2) *Design,* which is typically placed in residential areas, parks, and public spaces where they can intercept runoff from roofs, driveways, and streets (Baton Rouge Green Initiative, 2021). The implementation of the of the rain gardens, also considered community projects, and public spaces. The community projects include various community-driven initiatives that established rain gardens in neighborhoods and public areas (Baton Rouge Green Initiative, 2021). A typical example can be found in the LSU Campus, which has several demonstration rain gardens used for educational purposes. With regards to the public spaces, the installation of rain gardens happens in parks, such as the City-Brooks Community Park, to manage stormwater while enhancing green spaces (Baton Rouge Green Initiative, 2021).

The second aspect of the Green Infrastructure is the Permeable Pavements. The objective of Permeable Pavements is to allow rainwater to infiltrate through the surface, reducing surface runoff and recharging groundwater. Some of the key components of Permeable Pavements include: (1) *Materials,* which include the use of porous materials such as permeable concrete, asphalt, and pavers that let water pass through; and (2) *Applications*, which are ideal for parking lots, sidewalks, driveways, and low-traffic streets. Also, the implementation considered pilot projects and municipal adoption. For example, several pilot projects in Baton Rouge, such as the permeable pavement installation at North Boulevard Town Square, have tested and demonstrated the effectiveness of this technology. Additionally, the city has incorporated permeable pavements into new public infrastructure projects, including parks and community centers as part of the municipal adoption.

The third aspect of the Green Infrastructure is the Green Roofs. The objective of the Green Roofs is to install vegetated layers on rooftops to absorb rainwater, reduce runoff, and provide insulation. The components of the Green Roofs include the following: (a) *Structure*, which considers a layered system that includes waterproofing, drainage, growing medium, and vegetation; and (b) *Benefits*—that is besides stormwater management, green roofs offer energy savings by insulating buildings, reducing the urban heat island effect, and providing aesthetic value. The implementation of the Green Roofs considered public buildings and private sector incentives. The typical examples of the installation of green roofs on public buildings considers the schools and municipal buildings. Specifically, the Baton Rouge Main Library features a green roof as part of its sustainable design.
The fourth aspect of the Green Infrastructure is the Urban Tree Canopy. The primary objective of the Urban Tree Canopy is to increase tree planting and maintenance to enhance stormwater management, reduce runoff, and improve air quality (USDA Forest Service, 2018). Some of the key components of the Urban Tree Canopy include: (1) *Tree Selection,* which considers the use of native and drought-resistant species to ensure sustainability and resilience; and (2) the *Planting Locations*, which takes into account the trees that are

strategically planted along streets, in parks, and around public buildings to maximize their benefits (USDA Forest Service, 2018).

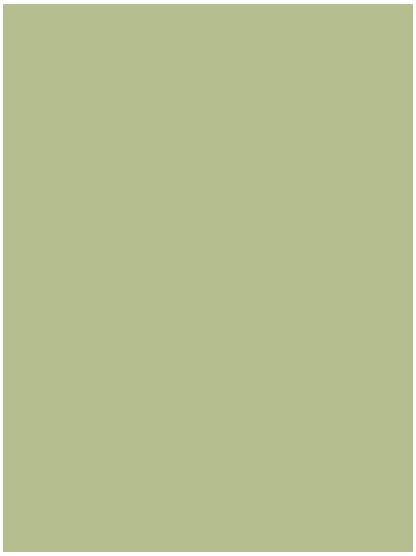
Table 2: Evaluation Performance of Green Infrastructure (GI) in Baton Rouge

Key Components of GI	***Objective***	***Implementation***	***Outcome***
Rain Gardens	To utilize shallow, planted depressions to capture and infiltrate stormwater, reducing runoff and promoting groundwater recharge	*Community Projects:* Various community-driven initiatives have established rain gardens in neighborhoods and public areas. The LSU Campus has several demonstration rain gardens used for educational purposes. ***Public Spaces:*** Installation of rain gardens in parks, such as the City-Brooks Community Park, to manage stormwater while enhancing green spaces.	*Runoff Reduction:* Rain gardens have been shown to reduce runoff volumes by up to 30%, helping to manage stormwater at its source (Baton Rouge Green Initiative, 2021). *Enhanced Aesthetics and Biodiversity*: These gardens improve the visual appeal of urban areas and support local biodiversity by providing habitats for pollinators and other wildlife.
Permeable Pavements	To allow rainwater to infiltrate through the surface, reducing surface runoff and recharging groundwater.	*Pilot Projects*: Several pilot projects in Baton Rouge, such as the permeable pavement installation at North Boulevard Town Square, have tested and demonstrated the effectiveness of this technology. *Municipal Adoption*: The city has incorporated permeable pavements into new public infrastructure projects, including parks and community centers.	*Reduced Surface Runoff:* These pavements have significantly reduced surface runoff, helping to prevent localized flooding and improve water quality (EPA, 2020). *Extended Lifespan*: Reduced wear and tear on these pavements due to less water pooling and freezing, potentially lowering long-term maintenance costs.
Green Roofs	To install vegetated layers on rooftops to absorb rainwater, reduce runoff, and provide insulation.	*Public Buildings:* Installation of green roofs on public buildings such as schools and municipal buildings. The Baton Rouge Main Library features a green roof as part of its sustainable design. *Private Sector Incentives:* Encouraging private building owners to adopt green roofs through incentives and educational programs.	*Stormwater Retention:* Green roofs can retain up to 75% of rainfall, significantly reducing the volume of runoff entering the stormwater system (Green Roofs for Healthy Cities, 2021). *Energy Efficiency:* Buildings with green roofs experience lower energy costs due to improved insulation.
Urban Tree Canopy	To increase tree planting and maintenance to enhance stormwater management, reduce runoff, and improve air quality.	*City Programs:* Initiatives like the Baton Rouge Tree Canopy Program aim to increase urban tree cover. Trees are planted in public spaces, schools, and residential areas. *Community Involvement:* Volunteer tree-planting events and educational workshops to engage residents in maintaining the urban forest.	*Runoff Reduction:* Trees intercept rainwater, reducing runoff and promoting infiltration. A mature tree can absorb up to 100 gallons of water during a storm (USDA Forest Service, 2018). *Multiple Benefits:* Beyond stormwater management, trees provide shade, improve air quality, and enhance property values.

Source: Author's Modification of Data from Baton Rouge Green Initiative (2021), EPA (2020), Green Roofs for Healthy Cities (2021) and USDA Forest Service (2018)

Table 2 presents the evaluation performance of Green Infrastructure (GI) in Baton Rouge. The information in Table 2 reveals that the adoption of green infrastructure practices in Baton Rouge represents a significant shift towards sustainable watershed management. By implementing rain gardens, permeable pavements, green roofs, and expanding the urban tree canopy, the city not only addresses its flood management challenges but also enhances the quality of life for its residents. These practices reduce the burden on traditional stormwater systems, improve water quality, and contribute to a healthier urban environment.

Natural Waterway Restoration



Natural waterway restoration involves rehabilitating rivers, streams, wetlands, and other water bodies to their natural states. This approach enhances flood management, improves water quality, and restores habitats for wildlife. In Baton Rouge, several key practices and projects exemplify this strategy. Some of these key practices include the following: (1) Wetlands Restoration, which aim at restoring the wetlands to leverage their natural capacity to absorb floodwaters, filter pollutants, and support biodiversity. The key components of the Wetland Restoration practices are: *Hydrological Restoration*, which looked at re-establishing natural water flow patterns by removing artificial barriers and reconfiguring drainage systems; and *Vegetative Planting,* which also looked at replanting native vegetation to stabilize soils and provide habitat for wildlife. (2) Stream and Riverbank Stabilization—which aimed at stabilizing the stream and riverbanks to prevent erosion, enhance water quality, and restore natural habitats. The key features of the Stream and Riverbank Stabilization practices include (a) ***Bioengineering Techniques***, which deals with the use of live plants, root wads, and other natural materials to stabilize banks and reduce erosion, and (b) **Erosion Control Structures, which also deals with the i**nstallation of structures like rock weirs and sills to slow water flow and prevent further erosion. (3) Riparian Buffer Zones—the aim of this aspect was to establish vegetated areas along waterways to filter runoff, provide habitat, and stabilize banks. This third aspect has two main features namely: (a) ***Buffer Width***—Typically, riparian buffers range from 50 to 100 feet wide, depending on the waterway's size and the surrounding land use; and (b) ***Plant Diversity***, which considers the use of a mix of trees, shrubs, and grasses native to the region to maximize ecological benefits. (4) Re-meandering Streams, which also aimed at restoring the natural meanders to straightened or channelized streams to enhance their ecological function and flood management capacity. This practice has two key features namely: (a) ***Natural Channel Design*** which deals with the reconfiguring straightened streams to mimic natural, sinuous patterns; and (b) ***Floodplain Connectivity*** which also deals with the reconnecting streams to their floodplains to enhance flood storage and reduce peak flows.

Table 3: Evaluation Performance of Natural Waterway Restoration (NWR) in Baton Rouge

Key Components of NWR	***Objective***	***Implementation***	***Outcome***
Wetlands Restoration	To restore wetlands to leverage their natural capacity to absorb floodwaters, filter pollutants, and support biodiversity.	*Comite River Diversion Canal:* This project includes the restoration of wetlands along the river to reduce flood risks. It involves the removal of invasive species and the replanting of native flora. *Bayou Manchac Restoration:* Efforts to restore wetlands around Bayou Manchac include reestablishing natural water levels and planting native vegetation to enhance floodplain functionality.	*Flood Mitigation:* Restored wetlands can absorb up to 1.5 million gallons of water per acre, significantly reducing flood peaks and protecting downstream communities (Mitsch & Gosselink, 2015). *Improved Water Quality:* Wetlands filter out pollutants, improving the quality of water entering the city's waterways.
Stream and Riverbank Stabilization	To stabilize stream and riverbanks to prevent erosion, enhance water quality, and restore natural habitats.	*Bayou Fountain Project:* The project focuses on stabilizing the banks of Bayou Fountain using native plants and bioengineering methods to reduce erosion and improve water quality. *Ward Creek Bank Stabilization:* Along Ward Creek, the city has implemented erosion control measures, including vegetative buffers and engineered structures, to stabilize the banks and enhance habitat.	*Reduced Erosion:* Stabilized banks reduce sediment load in waterways, preventing degradation of water quality (Louisiana Department of Natural Resources, 2022). *Habitat Restoration:* Improved bank stability supports diverse aquatic and terrestrial habitats.
Riparian Buffer Zones	To establish vegetated areas along waterways to filter runoff, provide habitat, and stabilize banks.	*LSU Lakes Restoration:* Creation of riparian buffers around the LSU Lakes involves planting native species to filter runoff and enhance the lakes' ecological health. *City Park Lake*: Establishment of riparian zones along the lake's edges to improve water quality and provide recreational and educational opportunities.	*Runoff Filtration:* Riparian buffers trap and filter pollutants from runoff, leading to cleaner waterways (Smith et al., 2021). *Enhanced Biodiversity:* These zones provide critical habitat for wildlife, increasing biodiversity in urban areas.
Re-meandering Streams	To restore natural meanders to straightened or channelized streams to enhance their ecological function and flood management capacity.	*Ward Creek Restoration:* Portions of Ward Creek have been re-meandered to slow water flow, enhance floodplain interaction, and improve habitat. *Baton Rouge Creek Initiatives:* Several smaller creeks within the city have been targeted for re-meandering projects to restore their natural hydrology and improve ecosystem services.	*Flood Storage:* Re-meandered streams provide additional flood storage capacity, reducing the risk of downstream flooding (Louisiana Watershed Initiative, 2021). *Ecosystem Enhancement:* Improved stream habitats support greater biodiversity and resilience.

Source: Author's Modification of Data from Louisiana Watershed Initiative (2021), Smith et al. (2020), Louisiana Department of Natural Resources (2022) and Mitsch & Gosselink (2015)

Table 3 presents the evaluation performance of the Natural Waterway Restoration (NWR) in the city of Baton Rouge in Louisiana. Findings from Table 3 reveals that natural waterway restoration in Baton Rouge is a vital component of the city's watershed management strategy. By restoring wetlands, stabilizing stream and riverbanks, establishing riparian buffers, and re-meandering streams, Baton Rouge not only mitigates flood risks but also enhances water quality and biodiversity. These efforts demonstrate a commitment to sustainable and

ecologically sound flood management practices, ensuring the long-term health and resilience of the city's waterways.

Table 4: Evaluation Performance of Community Engagement and Education (CEE) in Baton Rouge

Key Components of CEE	***Objective***	***Implementation***	***Outcome***
Public Awareness Campaigns	To educate residents about flood risks and encourage proactive measures to reduce runoff and pollution.	The city has launched campaigns through local media, schools, and community centers, promoting best practices such as proper waste disposal and the use of rain barrels.	Increased awareness and participation in flood mitigation activities, with a reported 20% improvement in community practices related to watershed health (Davis, 2018).
Volunteer Programs and Workshops	Involve the community in hands-on watershed management activities.	Programs such as the Baton Rouge Stormwater Coalition host workshops on rain garden construction, tree planting, and wetland restoration.	Enhanced community involvement has led to more sustainable and locally supported flood management efforts (Baton Rouge Community Outreach Program, 2022).

Source: Author's Modification of Data from Baton Rouge Community Outreach Program (2022) and Davis (2018)

Table 4 presents the evaluation performance of community engagement and education (CEE) in Baton Rouge. Community engagement and education are crucial components of effective watershed management. In Baton Rouge, these practices aim to increase public awareness, encourage community participation, and foster stewardship of local water resources. The Findings from Table 4 reveals that the community engagement and education are pivotal to the success of watershed management in Baton Rouge. Through public awareness campaigns, educational workshops, volunteer programs, and incentive schemes, the city has empowered its residents to play an active role in managing stormwater and mitigating flood risks. These efforts not only improve the resilience of the watershed but also foster a sense of community and environmental stewardship.

Table 5: Evaluation Performance of Policy and Regulatory Measures (PRM) in Baton Rouge

Key Components of PRM	***Objective***	***Implementation***	***Outcome***
Incentive Programs	To encourage the adoption of flood mitigation measures by property owners.	Financial incentives, such as tax rebates and grants, are provided for installing green infrastructure and flood-proofing buildings.	Increased adoption of flood mitigation practices among residents and businesses, leading to a more resilient urban environment (Baton Rouge Office of Community Development, 2022).
Stormwater Management Ordinances	To establish regulations that govern the control and treatment of	*East Baton Rouge Parish Stormwater Ordinance:* This ordinance includes provisions	*Improved Compliance:* Enhanced regulatory oversight has led to better compliance

	stormwater runoff to minimize flooding and improve water quality.	for stormwater management plans, requiring developers to demonstrate how they will manage stormwater on-site to prevent flooding and pollution. *Review and Approval Process:* A rigorous review process for stormwater management plans, involving multiple stages of evaluation and public consultation.	with stormwater management requirements, reducing the incidence of unmanaged runoff and associated flooding (City of Baton Rouge, 2022). *Water Quality Improvements:* The adoption of BMPs has contributed to improved water quality in local waterways by reducing pollutant loads.
Floodplain Management Regulations	To regulate development in flood-prone areas to reduce flood risks and protect property and human lives.	*Floodplain Zoning Ordinance:* Specific zoning regulations that restrict high-risk developments in flood-prone areas and promote the use of floodplains for flood storage and green space. *National Flood Insurance Program (NFIP) Participation:* Baton Rouge's participation in the NFIP, which provides flood insurance to property owners and requires adherence to federal floodplain management standards.	*Reduced Flood Damage:* Stringent floodplain management regulations have significantly reduced the vulnerability of new developments to flood damage (Louisiana Floodplain Management Association, 2021). *Community Rating System (CRS) Improvements:* Improved CRS scores, which result in lower flood insurance premiums for residents due to effective local floodplain management practices.
Watershed Management Planning	To develop comprehensive plans that integrate land use, water resources, and flood management to create resilient and sustainable communities.	*East Baton Rouge Watershed Management Plan:* A comprehensive plan that outlines strategies for managing stormwater, protecting water quality, and mitigating flood risks across the parish. *Interagency Collaboration:* Coordination among various city and state agencies to ensure consistent and effective implementation of watershed management practices.	*Holistic Management:* The integrated approach has led to more effective management of the watershed, balancing development needs with environmental protection (Louisiana Watershed Initiative, 2021). *Enhanced Resilience:* Increased community resilience to flooding and climate change impacts through proactive and coordinated planning efforts.
Environmental Protection Regulations	To protect and enhance natural resources, including wetlands, streams, and water quality, to support overall watershed health.	*Louisiana Wetland Protection Act:* State-level legislation that protects wetlands from detrimental activities and promotes restoration projects. *City of Baton Rouge Water Quality Ordinance:* Local regulations that set limits on pollutants and require measures to reduce non-point source pollution from urban runoff.	*Protected Wetlands:* Preservation and restoration of wetlands have helped maintain their flood storage and water filtration functions, contributing to overall watershed health (EPA, 2020). *Improved Aquatic Ecosystems:* Enforced water quality standards have led to healthier aquatic ecosystems, with reduced levels of harmful

			pollutants.

Source: Author's Modification of Data from City of Baton Rouge Planning Commission (2023), Louisiana Watershed Initiative (2021), EPA (2020), Louisiana Floodplain Management Association (2021), and Baton Rouge Office of Community Development (2022)

Table 5 presents evaluation performance of policy and regulatory measures (PRM) in Baton Rouge of Louisiana. Policy and regulatory measures are essential for the effective management of watersheds. These measures provide the framework for planning, implementing, and enforcing watershed management practices. In Baton Rouge, various policies and regulations have been established to enhance stormwater management, reduce flood risks, and protect water quality. The findings from Table 5 reveals that policy and regulatory measures are fundamental to effective watershed management in Baton Rouge. By implementing stormwater management ordinances, floodplain management regulations, comprehensive watershed planning, and environmental protection regulations, the city has established a robust framework for mitigating flood risks, improving water quality, and fostering sustainable development. These measures not only protect the community from flooding but also enhance the resilience and ecological health of the watershed.

CONCLUSION AND POLICY IMPLICATIONS

This study has demonstrated the need for improving watershed management practices to aid in the mitigating of flood impacts on human settlements in Baton Rouge and surrounding areas in state of Louisiana. In fact, by improving watershed management practices in Baton Rouge is imperative for reducing the impacts of floods on human settlements. Given the increasing frequency and severity of flooding events, a comprehensive and integrated approach to watershed management is essential. Based on the study analysis and findings, this study therefore recommends the following key strategies for adoption and implementation- enhancing stormwater infrastructure, implementing green infrastructure, restoring natural waterways, and promoting community engagement and education.

Given the political will of the policymakers in Baton Rouge, by enhancing stormwater infrastructure involves upgrading drainage systems to handle larger volumes of water, thus reducing the risk of flooding in urban areas. For instance, increasing the capacity of storm drains and retention basins can significantly decrease runoff and prevent water from inundating streets and homes (Johnson, 2020). Additionally, the adoption of green infrastructure, such as rain gardens, permeable pavements, and green roofs, can improve water absorption and reduce surface runoff (Green & Brown, 2019).

Restoring natural waterways is another crucial element of effective watershed management for adoption and implementation to help minimize floods in the city of Baton Rouge. By re-establishing natural floodplains and wetlands, communities can benefit from the natural flood mitigation properties of these ecosystems. Wetlands, for example, act as natural sponges, absorbing excess water and releasing it slowly, thereby reducing peak flood levels (Smith et al., 2021).

Community engagement and education play a pivotal role in successful watershed management. Educating residents about the importance of proper waste disposal, maintaining vegetation buffers, and other best practices can reduce pollutants entering the waterways and improve overall watershed health (Davis, 2018). Furthermore, involving the community in planning and decision-making processes ensures that local knowledge and preferences are incorporated into management strategies, leading to more effective and sustainable outcomes (Thompson & Garcia, 2022).

In conclusion, a multifaceted approach that includes infrastructure improvements, natural restoration, and community involvement is essential for effective watershed management in Baton Rouge. By implementing these strategies, the city can better manage stormwater, reduce flood risks, and protect human settlements from the devastating impacts of floods.

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