STORMWATER MANAGEMENT AND THE ASSESSMENT OF GREEN INFRASTRUCTURE IMPLEMENTATION IN NEW ORLEANS

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ABSTRACT: Located on a flood-prone delta, the city of New Orleans is faced with several challenges and hazards caused by stormwater runoff that affects the built environment. The inundation of stormwater impacts the normal use of facilities, floods the environment, carries unwanted pollutants to nearby watersheds, and affects the purity of its water system. In New Orleans, stormwater runoff impacts are felt every time there is heavy rain. There is a vital need to implement a more sustainable drainage system for effective stormwater management. Green infrastructure (GI) mimics the dynamics of the natural ecosystem by managing stormwater runoff through a regenerative process. This article assesses the environmental, social, and economic impacts of the implementation of green infrastructure in New Orleans, looking at the strategies employed, and challenges faced by the city government, non-governmental organizations, and neighbourhoods. The paper engages local stakeholders on the implementation of GI. Local practitioners' points of view are then juxtaposed with the scientific literature on stormwater management to provide a nuanced understanding between practice and literature, and suggest how to improve the implementation of GI in the city.

KEYWORDS: Green infrastructure, urban sustainability, stormwater management, New Orleans

Introduction

Recent changes in global climatic conditions have been linked to the impact of human activities on the environment, from greenhouse gas emissions to deforestation of natural forests to the architectural designs of the built environment (Anderson et al, 2014). Developments in urban areas have disrupted the natural environment and its ecosystems; real estate developments, asphalt road infrastructures, concrete pavements, and artificially constructed drainage systems have changed the dynamics of the interaction of nature (Young, 2011). Heavy rainfalls, for instance, have caused monumental damage to communities, destroying households and amenities, causing loss of life and property. This is a result of stormwater that would naturally seep in through the ground or flow naturally to other water bodies or streams. Urban regions, compared to rural areas, are the highest contributors to climate change because of the built environment, emissions from motorists, and industrial pollution (Barthel, 2013). Therefore, there is the need for the integration of green infrastructure planning into a widespread city plan in urban centres like New Orleans to help adapt to climate change (Kithia and Lyth, 2011).

Scientists have associated human activities with rising sea levels due to climate change that are threatening coastal cities. These sets of events are threatening coastal cities. Pertinently, Bettencourt et al (2008) established that over half of the global population now lives in urban regions. Similarly, a United Nations report reveals that 56.2% of the world's population lives in urban areas (Buchholz, 2020). This high population stresses already overburdened urban ecosystems and leads to a shortage of natural resources because of overexploitation. Liu et al (2014) argue that in cities with stormwater treatment facilities, stormwater runoff overburdens the city wastewater treatment facilities and carries unwanted materials and pollutants into the urban streams, thereby contaminating water bodies. Stormwater has also caused excessive flooding in coastal cities, resulting in enormous economic and social losses to residents. Many cities around the globe have adopted different forms of successful green infrastructure to reduce stormwater damages to the built environment.

New Orleans: a city on water

New Orleans is built on marshland along the Mississippi River. Historically, the Mississippi has carried billions of tons of sediment from its headwaters towards the Gulf of Mexico, depositing it in the river delta, which created the land upon which the city was built (Anderson et al, 2014). About half of New Orleans is below mean sea level, therefore, with or without storm surge, the city uses pumping machines to remove water from the city. Because of the city's physical location, levees and floodwalls are built around it to protect it from the river water that is a part of its geography. These factors have made the city of New Orleans prone to excessive flooding because of stormwater runoff and sudden surges in water bodies that surround the city. One of the most crucial examples was Hurricane Katrina, which hit the city in 2005. Many of the floodwalls and levees were overtopped while several were breached, allowing billions of cubic metres of water to flow from the Gulf of Mexico, Lake Borgne, and Lake Ponchartrain into the into New Orleans, flooding a major portion of the city. Fischetti (2015) argues that the major causal factor of that disaster was the depleted state of thousands of square kilometres of wetland marshes and swamps that once provided a buffer between the city's coastline and the ocean. He contended that the built levees had starved the wetlands of needed nutrients, weakening the plants. This whole process is exacerbated by the human-made canals that have further torn the vegetation apart, channelling water from large water bodies, thereby allowing Katrina's storm surge to be much more fatal.

Another major incident occurred in 2017, leaving hundreds of homes and businesses flooded. The city has struggled with century-old pumps that are constantly failing, a situation worsened by faulty drainage facilities that are often clogged. As previously identified, with about half of the city below sea level, the topography does not allow for gravity to channel water to nearby lakes, so water must be pumped out mechanically but the current condition of the pumps makes it impossible to drain stormwater effectively. Former New Orleans Mayor Mitch Landrieu emphasised that the city needed over $9 billion to restore its outdated pumping system. This is a cost the city is unable to fund. Similarly, Hurricane Ida made landfall in New Orleans on the 16th anniversary of Hurricane Katrina, on August 29th, 2021, bringing 430 millimetres of rain that flooded areas around the city, causing loss of lives and huge economic losses (Livingston, 2021).

These incidences and factors make the integration of other economically viable alternatives to stormwater management strategies in the city.

Green infrastructure (GI) implementation is a cost-effective, environmentally friendly, and effective method for stormwater management, which can significantly reduce the impacts of flooding. GI applies the basic principles of the natural environment by using on-site facilities to manage stormwater runoff, which is the chief source of urban flooding (Liu et al, 2014). Mell (2009) describes GI as an economically and environmentally viable approach for developing sustainable and resilient communities. Because GI facilities mimic the natural process involved in stormwater drainage systems by allowing stormwater to sink into the ground, evaporate, runoff, or be stored in a water capture facility, they help restore the natural features of a water-absorbent environment (Ferguson, 2016). Depending on the nature of the area, its geography, rain volumes, or size, various forms of GI or an integrated GI system can be implemented for efficiency in stormwater management or protecting the environment (Mentens et al, 2006).

This article complements Balan and Bordelon's (2021) study of the role of water and tourism management in Venice and New Orleans in *Shima* (v15 n1) by looking at an aspect of water management and inundation that they do not address. The present article evaluates the social, environmental, and economic impact of GI implementation in New Orleans, examines the actions and strategies of the city government, non-governmental organisations, and community residents in promoting the use of green infrastructure, and identifies some common challenges faced in green infrastructure implementation in the city. The article garnered the perspectives of local stakeholders on GI implementation, juxtaposing their ideas with scientific literature. The practitioners were asked questions on how GI is implemented by the city administration, non-governmental organisations, communities, and households; how green infrastructure implementation impacts communities in New Orleans; challenges of GI implementation, and recommendations to resolve these issues.

The article is organised as follows. Section one is an introduction to the subject matter; section two presents the strategies used in the implementation of an integrated GI system in the city and projects implemented; section three discusses the impacts of GI in New Orleans; section four enumerates the challenges and recommendations to overcome them, and section five is a summary and conclusion of the study.

I. Strategies for the Implementation of GI in New Orleans

Multi-actor partnerships and the delivery of multi-functional benefits are crucial components of GI implementation; therefore, a holistic approach is needed to secure the full benefits of green infrastructure in the city (Cheshmehzangi and Griffith, 2014). While the city government creates policies directed at weaving GI into the master plan, a multilateral system of implementation is required to ensure an efficient stormwater management system for the city (City of New Orleans Master Plan, 2010). Other stakeholders include non-governmental organisations, community neighbourhoods, and households (see Figure 1). Lovell and Taylor (2013) contend that it is essential to engage the public during the early initiation of GI planning, to demonstrate its impacts through the lens of climate change, limited resources, and food insecurity. This may encourage participation and individual adoption of GI strategies in communities.

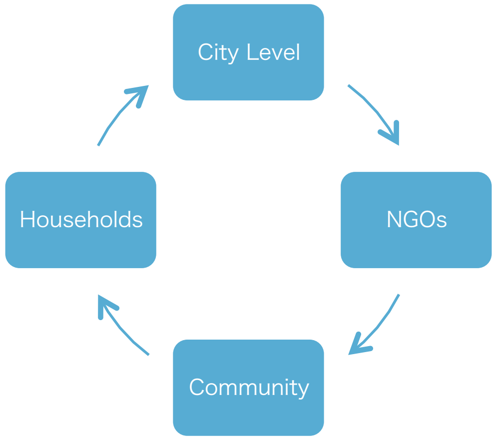

Figure 1. Multi-actor partnership

City Level

In a bid to improve sustainability, the city of New Orleans officially replaced Article 23 of the Comprehensive Zoning Ordinance policy with a unified Stormwater Code located within Chapter 1, Section 121 of the Building Code (City of New Orleans, 2018a). The new code is broader as it captures requirements to protect the City's drainage system during construction, as well as post-construction stormwater management requirements for some projects. This policy enforces erosion and sediment control on sites, as well as the provision of catch basins for the adjacent facilities. The new code states that:

> *the new requirements apply to any new development or redevelopment, aside from single-, two-family, or residential properties with less than six (6) dwelling units, that is five thousand (5,000) square feet or more of impervious surface or a total site area of one (1) acre or more. It requires that the plan retain or detain and filter the first one and one-quarter inch (1.25") of stormwater runoff during each rain event and limit the post-development runoff rate.*

Results of a study commissioned by the US Geological Survey indicate a reduction in pollutant load - such as phosphorus, E. Coli, and Enterococci - by using permeable pavements in communities (Selbig and Buer, 2018). It also concluded that there is a reduction in the volume of runoff depending on how much pollutants are retained on the surface of the permeable pavements. A representative of a previous component manufacturing and installation company operating in New Orleans interviewed by the author also stressed similar findings from the study, arguing that New Orleans GI policy has helped alleviate the impact of nature on built facilities around the city. The company argue that New Orleans has a unique blend of planning enforcements that makes it stand out in comparison to other similar cities around the US as indicated in the new city building code.

In another effort to improve stormwater management, New Orleans has created six resilience districts based on geographic areas of shared risks and opportunities (The City of New Orleans, 2015). The city proposes to tailor unique interventions for each district according to its features and needs. New Orleans is presently investing $141.3 million from the US Housing and Urban Development (HUD) National Disaster Relief funds in 2016 to develop a robust GI system in the Gentilly Resilient District (GRD), which will serve as a prototype for the five other districts (see Figure 2). Lessons learned from the pilot district's project will aid officials in formulating a resilience-building design for further implementation in the other five districts that will survive and thrive. The GRD has a mix of GI facilities serving different purposes (see Table 1).

New Orleans also enjoys stormwater management grants from the Federal Emergency Management Agency (FEMA). FEMA allocates stormwater management funds, through its Hazard Mitigation Grant Program (HMGP), to cities after disasters to help prevent damage from future disasters (Kincaid, 2021). The projects financed must show a 1:1 benefit-cost ratio, meaning the cost to design and build must be less than the predicted cost of future damage if the project was not built.

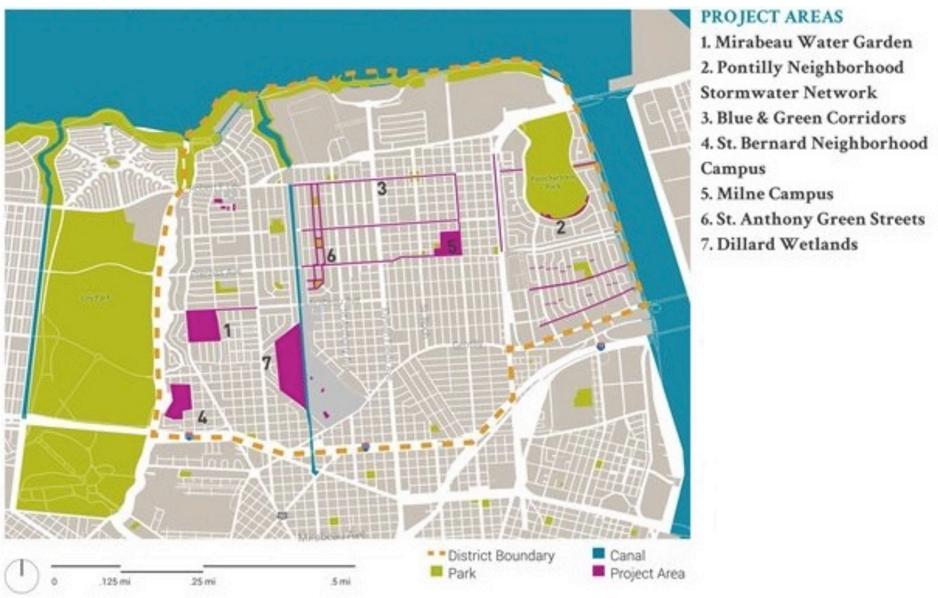

Figure 2. Gentilly Resilience District (GRD) (City of New Orleans, 2018b).

Non-Governmental Organisations (NGOs), Communities and Households

Another important strategy for the effective implementation of GI in New Orleans is the active participation of several NGOs who engage with the government, the communities, and households. GI literature like Bergstrom et al, 2014; Department of Communities and Local Government (DCLG), 2006; United States Environmental Protection Agency (EPA, 2013) and Wells et al, 2021, contends that sustainable communities can be achieved through adequate knowledge of the needs of the communities, inclusive engagement, and by reinforcing the roles that social and environmental justice play in developing a better and more liveable environment. Therefore, a deliberate push for inclusive, safe, well-designed, and environmentally sound landscapes is necessary (DCLG, 2006). Well-designed community engagement strategies are championing the implementation of GI in New Orleans.

Many non-governmental organisations are actively engaged in propagating the importance of GI through volunteering, providing training for communities, and offering incentives to residents for GI implementation. They also conduct community engagement workshops, community and city-wide campaigns, community visioning, and planning charrettes to ensure extensive engagement. A local stakeholder engaged in GI implementation in the city contacted during research for this article also argues that through participatory engagements, planners can minimise displacement and gentrification in communities. For example, in the Tremé neighbourhood of New Orleans, Water Wise NOLA collaborates with the Greater Tremé Consortium to identify, install, and manage GI facilities in their community. However, Einstein et al (2020) argue that community participatory planning could come with issues of race and class that can skew decisions reachable by the communities, thereby affecting results. But such issues can be minimised in communities like Tremé, because of its relatively homogenous demography.

Similarly, the Front Yard Initiative (FYI), a New Orleans-based advocacy group, provides residents with hands-on experiences in GI development, ultimately creating workforce opportunities in the green investment sector as it grows. The Front Yard Initiative also pays eligible residents to replace paving with greenery; participants are paid $2.50 per square metre of paving removed, up to 152.4 square metres. Again, the Greater New Orleans Foundation (GNOF) launched the Urban Water Series program to help promote GI implementation in New Orleans. The Urban Water Series program has been implemented in phases;

Phase one: (2013) GNOF hosted a series of five workshops in which national GI and stormwater management experts from five vanguard cities shared their knowledge and strategies with over 400 New Orleans practitioners.

Phase two: (2014) GNOF brought a diverse group of 26 city government staff, NGOs, and community leaders to study firsthand the implementation of GI in Austin, Philadelphia and Milwaukee.

Phase three: (2015) GNOF worked to build a movement called 'living with water' in partnership with other NGOs and the public sector through educating the public on the importance of GI, supporting community-based organisations that represent vulnerable neighbourhoods, and "helping build the capacity of the Sewerage & Water Board of New Orleans and the city of New Orleans to effectively implement GI infrastructure and stormwater strategies" (GNOF).

GNOF has also facilitated a staggered technical masterclass in various spheres of GI implementation in December 2016-May 2018. Topics like how to live with water, integrating GI with complete streets, integrating GI in site design, urban living, and climate change, etc. have been taught to the public by professionals at no cost.

Several other entities are engaging with the city to bolster sustainability and effective stormwater management; Soul NOLA, Propeller, Green Light NOLA, etc. In May 2021, the Mayor of New Orleans signed a memorandum of understanding with Soul NOLA in support of developing a comprehensive reforestation plan for the city. It will provide an actionable plan for the city to achieve its goal of increasing the city canopy by 50% (Soul NOLA 2021). This is a big deal concerning the improvement of the urban environment, reducing heat especially in the summers, and improving the overall liveability of the city. The following table details a range of GI projects currently underway.

Mirabeau Water Garden	• Public works project that will transform a 101,171 square metre open site into a recreational and educational amenity that reduces flood risk. • It will divert and store up to 37 trillion litres of water, infiltrate water into soil, clean impurities, provide educational and recreational opportunities. • Estimated Construction Budget: $15M HMGP, NDR • Construction: May 2022 to October 2024
Milneburg Neighborhood Stormwater Resilience	• Add value to existing and future programs at the site, including NORDC, NOLA FOR LIFE, and aid water-focus education and economic opportunity, engaging the youth. • Estimated Construction Budget $6.04M • Construction: February 2023 to March 2024
Pontilly Project	• Dwyer Canal acts as a barrier between two historically segregated neighbourhoods developed in the 1950s. • Drainage improvements store stormwater and beautify the Ponchartrain Park and Gentilly woods neighbourhoods. • Budget: $15.5M HMGP • Completed April 2021
Dwyer Canal Improvements	• Public space and placemaking amenities along and near the Dwyer Canal that connect the Gentilly Woods and Ponchartrain Neighbourhoods and enhance the 100% FEMA-funded GI and drainage improvements. • Beautifies, improves walkability, provides recreational activities and educational opportunities. • Estimated Budget: $2.1M NDR • Construction: December 2022 to November 2023
Blue-Green Corridors	• Transform major boulevards in Gentilly into a series of blue and green corridors that reduce flooding and subsidence. • Increases stormwater storage, available green space, high-quality multimodal facilities, civic spaces, and gorge distinct identity for Gentilly • Budget (USD): $28M NDR • Anticipated completion: August 2022

St. Anthony Green Streets	• Seek to establish a new standard for neighbourhood streets and parks that incorporate stormwater as a key component. • Improve stormwater management and reduce flood risk and subsidence; empowers residence to participate in adapting their block and neighbourhood to manage stormwater. • Budget: $13.06M NDR, USD$11.67M HMGP • Anticipated completion: Spring 2023
St. Bernard Neighborhood Campus	• Enhances existing academic site with GI, improves connectivity between social service facilities with GI and stormwater management features. • Reduce flood risks, provides recreational space, and promote health education • Estimated Construction Budget: $15 NDR • Current Status: 90% Design • Construction: May 2022 to August 2023
Dillard Wetlands	• Enhances 109,265-metre square urban forest by removing invasive species and routing stormwater through wetland to enhance quality. • Detains and filters stormwater from the surrounding neighbourhood, creates an outdoor classroom and recreational asset, protects the urban forest, and reduces invasive species. • Budget: $6 M NDR • Design phase • Construction: August 2022 to August 2023
Community Adaptation Program	• Adds stormwater management features to households through grants managed by New Orleans Redevelopment Agency (NORA). • Residents choose features such as rain gardens, permeable surfacing, and rain barrels, while the contractors install them. • Diverts stormwater runoff 0 over 200 properties with an average grant award between $10,000 and $25,000, beautifying homes. • Budget: $5.9M NDR • In construction

Table 1: New Orleans GI Projects: GRD and other community projects (source: Kincaid, 2021).

Impacts of GI Implementation in New Orleans

The successful incorporation of green infrastructure in New Orleans will have social, economic and environmental impacts on communities within the city.

Social Impacts

If implemented appropriately, GI can promote environmental justice and social inclusion, which requires equal access to resilient community assets based on walking distance to parks and other amenities. The multi-actor partnerships and the multi-functional benefits in GI design support the provision of economic, recreational, and social amenities for diverse demographic groups. New Orleans faces social stresses from high levels of poverty, unemployment and violence. Although the city experienced a post-Katrina economic boom, only some of the population benefited. The median income of $25,102 for African American households is less than half of that of Caucasian households in New Orleans. According to the five-year estimates of the American Community Survey 2015-2019, 23.7% of New Orleans residents are living in poverty (U.S. Census Bureau 2021). This is a figure that exceeds 39% for children and 58% for single mothers (Catalanello, 2019). These challenges are exacerbated by environmental hazards that disproportionately affect low-income households and people of colour (a typical case of environmental injustice). Heckert and Rosan (2016) argue that it is crucial to efficiently distribute GI facilities through prioritising the needs of communities, types of infrastructure to develop, and the stakeholders involved in the process. This enhances equity and inclusion in the city, and an overall improvement of the quality of life of the people. They emphasised it is necessary to develop a GI equity index to determine GI investment allocation, arguing that it provides a more nuanced analysis of communities taking into consideration the built environment, and the socio-economic conditions. According to stakeholders in the New Orleans GI ecosystem, equity is a major factor in the implementation and improvement of sustainable facilities within the city. They argue that the GRD project is a case in point for equitable distribution of GI investment, looking at the need of the area, social and demographic factors.

GI can enhance the existing infrastructures through an integrative design, a balancing of environmental and ecological functions, and an overall enhancement of the physical and social infrastructure (DCLG, 2006). The successful incorporation of green infrastructure in New Orleans improves equity in the city, promoting communal inclusion. Weatherby (2005) contends that designing landscapes that do not provide several beneficial functions for target populations hinders patronage and leads to the development of exclusionary spaces. Landscape functionality is, therefore, an essential component of development. GI achieves this goal by providing several simultaneous functions, including health, recreation, and general wellbeing to promote social inclusion. Mell (2008) contends that there is the potential to increase awareness, use, and subsequent ownership of spaces and develop long-term sustainable use via a systematic approach to green infrastructure development. This promotes several principal features of an urban renaissance by increasing public use of green spaces, allowing people to feel part of a space's wellbeing, and making spaces safer and more attractive to others (Ryding 1998). Properly implemented GI facilities may help improve healthy living for communities (Tzoulas et al, 2007). GI facilities may ameliorate air pollution and may encourage people to stay more outside, increasing physical activities. The GRD projects provide a conducive environment that will encourage people to come out and engage in physical activities for longer times, thereby improving their wellbeing. Similarly, such sustainable environmental practices help reduce pollution by improving air quality, a core goal for the GRD project.

Further, improving equity also requires that the city ensures that it will not retrofit socially inclusive landscape spaces without appropriate public consultation to determine community wants and needs (Mell, 2008). The potentially inclusionary nature of the green infrastructure concept provides opportunities to engage people and bring together diverse knowledge, experience, and information to develop best-practice techniques for development. The city's Gentilly Resilience District project is designed with these factors in mind and focuses on some of the most vulnerable parts of the city. In general, it improves resilience, inclusiveness, wellbeing, and equity for the communities by providing social amenities near the people.

Economic Impacts

Flooding in cities has been associated with heavy economic losses. Adikani and Yoshitani (2009) argue that there has been over a 500% increase in economic losses due to water-related hazards since the early 1980s, primarily due to rapid urbanisation of exposed areas. It has also been established that flood disasters account for 30% of total economic losses caused by all-natural disasters (UNIDR, 2012). New Orleans' overburdened and often failing drainage system requires at least a $9 billion investment to restore and upgrade so they can adequately and efficiently manage stormwater in order to address citywide flood risk, a cost the city is unable to fund. A well-integrated GI system will help reduce flooding damage and invariably reduce road maintenance costs that may arise as a result of subsidence. A 50-year conservative estimate of the cost attributable to repairs to housing, amenities, not including major infrastructure, because of subsidence in New Orleans is a staggering $2.1 billion (City of New Orleans, 2015). According to the New Orleans city government, the city experiences extended power outages caused by strong floods that it estimates causes losses in tax revenue of about $3 million per day because of the inability of businesses to open and operate during these outages. This is a huge loss for a city of its size.

GI reduces domestic energy and water usage. Watersense, a GI advocacy organisation, is a proponent for water efficiency systems to save water outdoors and improve the sustainability of the water system through all seasons in New Orleans. They argue that reducing water run-off helps mitigate water shortages and improves efficiency by saving energy and lowering utility bills. They propagate the use of GI facilities like the stormwater barrels, arguing that water caught in barrels can be used for watering lawns, cutting the use of water and reducing water bills. This smart water management process is practiced in the Tremé community. In the summer of 2018, for instance, I was one of a group of volunteers who engaged in the installation of a few stormwater barrels within the community in a process managed by Watersense. Similarly, professionals from the Front Yard Initiative (FYI), another major stakeholder in the New Orleans GI orbit, contend that GI projects in communities tend to increase their housing values as well as real estate values for properties near the interventions. GI improves placemaking and general liveability of communities, thereby increasing demand for housing in these communities. With the present mix of stakeholders, projects, and education, GI is poised to create huge green investments and potentially create new job opportunities.

Environmental Issues

If properly implemented, GI can promote a healthy ecosystem that stimulates the individual health of citizens and improves their quality of life. Issues like climate change have dominated global discourse due to its devastating impacts, such as impacts of rising sea levels, and global warming. Similarly, the need for the preservation of renewable resources (like water) has become critical to sustainability and urban regeneration (Mell, 2008). It is estimated that the Louisiana coast loses more than 4047 square metres of coastal wetlands every hour and remains one of the most vulnerable areas in the United States to climate change, experiencing the world's greatest relative sea-level rise, 1.3 metres anticipated by 2100 according to NOAA sea level rise projections (City of New Orleans, 2015). The New Orleans' built environment is also compromised by chronic subsidence issues that partly result from the piping and pumping system that is used to mechanically drain stormwater out of the city and into the lakes. GI helps recharge groundwater from retention, reducing subsidence due to excessive water drainage in the city. This is demonstrated in the goals and objectives of the GRD project (see Table 1).

Another essential impact of GI is the reduction of the heat island effect, a situation where the average temperature of an area is higher than nearby rural areas. This is most often caused by materials used in the development of urban areas, like concrete and asphalt, which absorb a lot of sunlight and store it in large thermal masses. Norton et al (2015) contend that urban greening infrastructure reduces urban heat, especially if properly implemented, using the right plant species on the right soil type. The implementation of GI facilities throughout the New Orleans area would help reduce this effect, especially during its hot summers. Cameron et al (2012) argue that, "gardens can play a strong role in improving the environmental impact of the domestic curtilage, e.g. by insulating houses against temperature extremes they can reduce domestic energy use and that gardens "also improve localised air cooling; help mitigate flooding and provide a haven for wildlife" (2012, p. 2). GI installations around the city are poised to reduce heat, especially during the hot summers in New Orleans; this can also be seen in the project goals of the facilities being developed in the city.

As a major tourism destination New Orleans plays host annually to millions of visitors from around the globe who come to enjoy its many cultural sites, celebrations, and festivals. The festivals produce high amounts of waste materials that clog the drainage system and are carried by stormwater along with poisonous chemicals (e.g. pesticides, herbicides) and drained into the major water supply. GI facilities filter stormwater before it reaches the lakes and the rivers ensuring improved water quality. GI systems also encourage the recycling of plastics. A major GI stakeholder involved in the installation of pervious pavements emphasises that most of the materials used in producing the grids for pervious pavement are recycled plastics. With the huge turnover of plastic waste in the city, especially during festivals like Mardi Gras, recycling would positively impact the environment.

Challenges and Recommendations of GI Implementation in New Orleans

One of the major challenges impeding the implementation of GI in New Orleans is the lack of funding and improper allocation of funds. Although the city has been able to secure some grant funding from the HUD National Disaster Relief Fund, it is not enough for city-wide implementation. There is a need to seek alternative funding streams that are sustainable. A renowned landscape architect in New Orleans contacted during research for this article contends that it is essential to follow up city planning with the necessary public funding appropriations for an effective GI implementation citywide. The city also enjoins HMGP grants from FEMA, but this can be expanded through potential funding from US

President Biden's Build Back Better infrastructural policy, which is geared towards building sustainable infrastructure in the US. There are also HUD and FEMA funds available for communal GI projects. Additionally, public-private partnerships can bring additional funding and expertise from the private sector to match politically approved funding. The Sewage and Waterboard (S&WB) Administration Building Stormwater Green Roof Project is an example of a viable public-private partnership that could be enduring. S&WB partnered Hanging Gardens LLC, Evans & Lighter Landscape Architecture LLC, Morphy Makofsky Incorporated, Independent Roofing Systems Incorporated, Greensite LLC, and AD Greenroof LLC, to establish a blue and green roofing system at the S&WB Downtown Administration Building at 625 St. Joseph Street in the Central Business District. Hanging Gardens will perform analysis of the green roofing systems performance, maintenance of the installation, establish a supplemental educational curriculum program, and provide tours for community organisations and the public (S&WB, 2021).

A change in the leadership of New Orleans in 2018 also created another challenge in the implementation of GI policy. While the policy was initiated by the previous mayor, Mitchell Landrieu, the new mayor, La Toya Cantrell, fully supports GI implementation and has continued work on the Gentilly Resilient District Project, albeit with some delay while assuming office. There is a need for an integrative policy-making mechanism to ensure coverage, consistency, and continuity of the city master plan that incorporates GI implementation. Also, there is a need for making policies in sync with spatial planning, with clear goals to what is to be achieved and how to achieve it. Doing so will enable city officials, in collaboration with relevant agencies (research institutions, NGOs, etc.) and the host communities, to determine complementary varieties of GI strategies that can be embedded in city planning policy (Mathews et al, 2015). GI plans and policies should also be coordinated with other departments, such as housing, health, transportation, etc., to develop consistent GI city codes and regulations. By doing so, New Orleans leadership, businesses, industries, and its citizens would have a legal obligation to integrate green infrastructure principles within urban renewal projects.

A final barrier to GI implementation is the definitional ambiguity that contributes to inaction on the application of efficient flood mitigation strategies such as green infrastructure. This lack of uniformity could muddy existing programs and initiatives that deal with green space (Mell, 2008). This is exacerbated by the lack of adequate community awareness programs to improve GI knowledge and the potential impact of a holistic integrated GI system in the city. Although there are many NGOs involved in GI advocacy, they are not enough to ensure success. GI is a new frontier for environmental management and, therefore, needs adequate community engagement and orientation on the system and its impacts to encourage the needed participation of the residents. Dhakal and Chevalier (2017) emphasise the lack of adequate knowledge about GI despite over two decades of expert advocacy. They argue that cities around the world still prefer heavier investments in grey infrastructure despite the known adverse effects on the environment, and lesser consideration of GI despite its enormous sustainability benefits. As a matter of improving community sustainability and resilience, the city and other stakeholders can encourage the conversion of vacant lots in communities into gardens, residential yards, or sports fields. Kremer et al (2013) contend that by assessing the ecological features of vacant lots, and the social characteristics of a neighbourhood, planners may be able to support such community sustainability. It is interesting that the New Orleans Redevelopment Authority has converted five of its vacant lands and nearby planting strips along Perlita Street into a stormwater management facility for the reduction of floods. If this idea is translated into policy, it will help improve GI implementation in the city.

Summary and Conclusion

This article has explored the consequences of inundation and stormwater, and the efficient strategies adopted by the city to mitigate these impacts through green infrastructure implementation. As Mell (2009) argues, GI is an economically viable approach for developing sustainable and resilient communities and adapting to climate change. Although it is a new frontier in environmental management and the improvement of urban ecosystems, it is receiving much attention around the globe. Cities in the United States have implemented GI projects to improve the liveability of their communities. Communities in New Orleans are beginning to promote and integrate GI in their communal plan, and the mayor continues to support the implantation of GI in the city according to major stakeholders in New Orleans. The city also prioritises the issue of equity in the implementation of green infrastructure; this may enhance community participation overall. Interestingly, communities are continuously learning the importance of GI as a tool for improving the urban ecosystem and are embracing the subject matter. This is one of the impacts of the synergy between stakeholders in the city. Although there are some barriers to implementing and sustaining GI projects, such as funding, technical know-how, awareness, and infrastructure ownership and management, these could be alleviated with a city-wide GI comprehensive plan in place. The good news for GI is that it is receiving national attention and there is hope that more will be done to support GI development nationally especially through the recent sustainable infrastructural policy thrust of President Biden's national administration.

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