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I, Samantha McLean, hereby submit this original work as part of the requirements for the degree of Master of Community Planning in Community Planning.

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Heritage Preservation in a Changing Climate: The Potential of Green Infrastructure on the Île de Saint-Louis, Senegal

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Heritage Preservation in a Changing Climate:
The Potential of Green Infrastructure on the Île de Saint-Louis, Senegal

by

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Abstract

The imminent effects of climate change pose a great threat to the livelihood of social, ecological, and built environments. An important aspect of those environments is tangible cultural heritage. Cultural heritage is not a relic of the past. It has historic and aesthetic value for contemporary and future societies; however, it is currently threatened by the changing climate. This research explores how heritage sites can build resilience in the face of climate change threats using green infrastructure, while preserving their authenticity and integrity.

The UNESCO World Heritage Site of Île de Saint-Louis, Senegal, is examined as a case study. The Île de Saint-Louis is remarkable for its architecture, town plan, and unique landscape in a river delta. Its location in the middle of the Senegal River, proximity to the Atlantic Ocean, and dense urban fabric make it vulnerable to climate change. The very future of the heritage site is contingent upon building climate change resilience, requiring a preservation approach that extends beyond the restoration of individual buildings.

This research uses mixed methodologies to answer its research question: “In light of the climate change threats facing heritage sites, how can climate change planning in heritage sites use green infrastructure?” The case study methodology includes an in-depth study of site components and current and future climate risks faced by the site. Following this study, a vulnerability analysis is conducted for each block on the island using composite variables of sensitivity and exposure to climate. The results of the vulnerability analysis are combined with opportunity for green infrastructure variables to create a weighted suitability for green infrastructure intervention analysis. This analysis identifies blocks on the island most suitable for green infrastructure intervention. Informant interviews are used to illuminate threats to and characteristics of the heritage site. Finally, a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis is conducted for two site management plans, determining aspects of the plan that support or dissuade the use of green infrastructure tools.

The findings of these methodologies yield insights into appropriate green infrastructure tools and locations for intervention on the heritage site. While there are increased restrictions on the types of interventions allowed in heritage sites, there are still opportunities to use green infrastructure while maintaining the historic authenticity of the site. This research provides a framework for heritage site managers to use when considering if and where to incorporate green infrastructure to increase their site’s climate change resilience.

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Chapter 1: Introduction

1.1 The Challenges of Preservation in Light of Climate Change Threats

The imminent effects of climate change pose a great threat to the livelihood of social, ecological, and built environments. An important aspect of those environments is cultural heritage. Cultural heritage encompasses three categories, as defined by the United Nations Education, Scientific and Cultural Organization (UNESCO): tangible cultural heritage, including, but not limited to paintings, sculptures, monuments, archaeological sites; intangible cultural heritage, including, but not limited to oral traditions and rituals; and natural heritage sites, such as landscapes and geological formations (UNESCO 2016).

Cultural heritage is not a relic of the past; it has historic and aesthetic value for contemporary and future societies (Rodrigo-Cervantes 2006, 71). The Taj Mahal in India, the banks of the Seine in Paris, and the Acropolis in Athens are all cultural heritage sites synonymous with tourism. These sites provide an international audience the opportunity to learn and explore past histories and current experiences. However, beyond tourism and rich pasts, these heritage sites are living and breathing. Residents live, work, and recreate within or just beyond the sites' boundaries. Heritage sites are not only odes to the past, they are present-centered and as such, need to be protected from present threats, such as climate change (Harvey and Perry 2015, 4).

Elaborated upon in Chapter 2, climate change is defined by major shifts in temperatures and weather patterns. Marzeion and Levermann explore the loss of cultural world heritage due to sea-level rise, one effect of increasing temperatures due to climate change. They found that if the current global mean temperature is maintained over the course of the next two millennia, 6% of UNESCO heritage sites will be affected (40 sites) (Marzeion and Levermann 2014, 1). These sites will be lost due to sea-level rise or will require considerable action to protect them (Marzeion and Levermann 2014, 9). Marzeion and Levermann's study does not account for other climate change related threats beyond sea-level rise; therefore, the actual number of UNESCO heritage sites at risk can be assumed to be much larger than 40.

The relationship between heritage and climate change had not been examined in depth until recently (Harvey and Perry 2015, 4). Heritage professionals, scientists, government officials, and urban planners are realizing the need for action in the face of continuing climate change threats. The diversity in the geography, climate, population, and site characteristics makes it impossible to craft one single solution to heritage preservation in the face of climate change.

However, heritage sites provide a unique opportunity to promote climate resilience through careful preservation and conservation of their ecosystems (O'Brien et al. 2014, 100). This research aims to look at that opportunity by exploring the potentiality of heritage sites to use green infrastructure as a tool to build climate resilience. This relationship will be studied through an in-depth case study of the UNESCO World Heritage Site, the Île de Saint-Louis in Senegal.

1.2 Introduction to the Île de Saint-Louis, Senegal, UNESCO World Heritage Site

1.2.1 A Brief History of UNESCO and World Heritage Site Designation

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) ratified the *World Heritage Convention* in 1972, creating the World Heritage Centre and system for designating world heritage sites. The convention recognized the importance of preserving cultural and natural heritage, stating that “... the deterioration or disappearance of any item of the cultural or natural heritage constitutes a harmful impoverishment of the heritage of all the nations of the world (UNESCO World Heritage Centre 2016).” The designation system provides an additional layer of protection against social, economic, and environmental threats. Inscription onto the UNESCO World Heritage list is the highest heritage recognition that a site can receive (Dawson 2015, 250). There are two types of heritage sites: cultural and natural. Cultural sites consist of tangible, primarily man-made culture, such as monuments and buildings, whereas natural sites are naturally occurring landscapes. If a site is recognized for its significant interaction between a natural landscape and humans, then it is considered a cultural landscape rather than a heritage site.

In order to be designated as a World Heritage site by UNESCO, a site must meet at least one of the 10 designation criteria. The Île de Saint Louis in Senegal was designated as a heritage site in 2000 based on: “Criterion ii: to exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design” and “Criterion iv: to be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history (UNESCO World Heritage Centre 2005).” The historic island of Saint-Louis boasts significant “values and influences on the development of education and culture, architecture, craftsmanship, and services in the large part of West Africa

(UNESCO World Heritage Committee 2000),” satisfying criterion ii. The island’s colonial architecture, street plan, and location near the mouth of the Senegal River satisfies criterion iv.

1.2.2 The Île de Saint-Louis

The Île de Saint-Louis is a part of the city of Saint-Louis in Senegal. Senegal is located in West Africa, bordered by Mauritania to the north, Guinea and Guinea-Bissau to the south, and Mali to the east. The northwest city of Saint-Louis is located 250 kilometers north of Senegal’s capital, Dakar. Formerly the capital of Senegal, the city of Saint-Louis remains the administrative capital for the Saint-Louis region.

Map A: Location maps of the Île de Saint-Louis

Source: Google Earth 2016

The Île de Saint-Louis is 2 kilometers in length by 400 meters in width (.4 kilometers) totaling 80 hectares (197 acres) in area. The island houses approximately 9% (15,000) of the city's 176,000 residents (Climate Change and Urban Vulnerability in Africa 2012; Martinez-Quintana and Caceres-Morales 2016, 300). The island is situated in an estuary of the Senegal River, 25 kilometers north of its mouth, and separated from the Atlantic Ocean on the west by a narrow 300-meter-wide peninsula called the Langue de Barbarie (Climate Change and Urban Vulnerability in Africa 2012, 68). Its location made the island strategic as a port city; however, the same geographic components that made the island thrive in the past are limiting its growth in the 21st century. Since the island is very dense and built up, most of the growth in the city, especially residential land use, is happening on the mainland of Saint-Louis. Additionally, the deteriorating conditions of the buildings and the vulnerability to flooding has made the island undesirable for new homeowners (Martinez-Quintana and Caceres-Morales 2016, 230). Today, the island is used for administrative functions, housing, tourism-related industries, and commercial activity.

Image A: Aerial location of Île de Saint-Louis

Source: Hotel Cap Saint-Louis; Author

The island, known as N'Dar in the Wolof¹ language, was named Saint-Louis in 1659 after French traders settled on it. It became the first French-settled city in Africa. The island was uninhabited when the French arrived, but was included in the Futa Toro region. The region was ruled by the Empire of the Great Fulo that reigned from the late 15th century through the mid-17th century (Hirschi 2011; Martin 2016). During the settlement's first century (1659-1779), the island was managed by ten French trading companies, then had a brief English occupation. In 1789, the French regained control of the colony. In the following decades, the island grew into a fully functioning colonial city.

The Alignment Plan of 1820 planned the foundation for the island's orthogonal grid street network. The evolution of the island can be seen in Map B. Throughout the 19th century, straw and non-permanent structures (as indicated in yellow on the maps) were replaced by permanent structures (as indicated in orange on the maps). From 1854-1865, Governor Faidherbe, an ambitious leader and eponym of the island's primary bridge, led an impressive building and design agenda, developing some of the island's most iconic buildings, such as the Governor's Palace, docks and river ports, and public spaces. He also encouraged the paving of main streets running from north to south and widespread planting schemes. Additionally, public services, such as water supply and gas lighting, were introduced to the island. These developments led to Saint-Louis becoming the administrative capital of French West Africa in 1895. During the next decade, the north of the island developed and the last of the island's wetlands were filled in (PSMV Volume 1 2006).

¹ Wolof is the language of the Wolof ethnic group, primarily located in Senegal, the Gambia, and Mauritania.

Map B: Evolution of development on the Île de Saint-Louis

Source: Suzanne Hirschi; Author

The 19th century birthed a great colonial city; however, the 20th century did not bring further expansion for the Île de Saint-Louis. In 1902, the capital was moved from Saint-Louis to Dakar. When administrative and economic functions moved to Dakar, Saint-Louis became deprived of the economic resources it had used to develop in the 19th century. However, the north of the island became fully urbanized in the middle of the century due to high levels of rural-to-urban migration. After its national administrative and economic status as capital was lifted, the

island sought to regain its identity as a regional administrative hub and capitalized upon its rich heritage, emphasizing education and culture (PSMV Volume 1 2006).

Over the years and into the 21st century, the Île de Saint-Louis has struggled with preserving its historic buildings, while simultaneously facing environmental challenges. The city of Saint-Louis was identified as one of the African cities most threatened by rising sea levels associated with climate change (Climate Change and Urban Vulnerability in Africa 2012, 52). Due to its location in the middle of the Senegal River, separated from the Atlantic Ocean by only a two-kilometer-wide island, known as the Langue de Barbarie, the Île de Saint-Louis faces the threat of rising sea levels. However, more so than the international crisis of rising sea levels, the island is threatened by its compromised estuarine ecosystem. In 2003, a four-meter breach was made in the Langue de Barbarie, west of the island, in order to relieve river flooding and direct it into the Atlantic Ocean. Today, the breach has widened to over three kilometers. This manmade breach has disturbed the natural flows of the river and ocean, as well as the surrounding habitat. In addition to complications from the breach, anticipated increases in extreme rain events will lead to more severe flooding (Climate Change and Urban Vulnerability in Africa n.d.)

The island faces additional climate change threats, such as increases in rainfall and temperature (an increase of 1.5 degrees Celsius between 2010 and 2050). Currently, it averages 300 millimeters of rain a year, normally between the months of June to August. Situated in the Sahel region, its average yearly temperature is 27 degrees Celsius (The World Bank Group 2016). Its climate is primarily dry between the months of October and June. It is predicted that the island will face increased duration of droughts, dry periods, and heatwaves (Climate Change and Urban Vulnerability in Africa n.d.).

The Île de Saint-Louis faces diverse challenges by way of preservation and the environment. However, it is the island's beautiful and unique landscape, along with its historic architecture, that elevated it to UNESCO World Heritage designation. The challenge of a large heritage site, such as that of the Île de Saint-Louis, requires the need for a vision and overall urban policy that extends beyond that of restoring buildings (PSMV Volume 1 2006). This challenge makes it an ideal heritage site to examine in the context of climate change resilience. The study of this site is also relevant in the face of a threat to decommission the site. On December 23, 2016, UNESCO and the government of Senegal met in Dakar to discuss the urgent needs of the island in light of UNESCO threatening to put the Île de Saint-Louis on the "World Heritage in Danger"

list and perhaps revoking its World Heritage designation (AFP 2016). In 2010, after reviewing a report on the site's state of conservation, the UNESCO World Heritage Committee issued recommendations on how to better preserve the site. Since then, there has been little implementation of the recommendations and the site's state of conservation has continued to deteriorate. As a result, UNESCO issued this threat (UNESCO World Heritage Centre 2016). Losing the World Heritage designation would be a setback for the site itself and for all the Saint-Louisians and other professionals who have worked in the past to preserve the site (Hirschi 2011). The future of the heritage site is contingent upon the resilience of the island as it pertains to climate threats and preservation.

1.3 Overview of Research

This research is delivered in nine chapters, including this introduction. Before exploring the potential for green infrastructure on the Île de Saint-Louis, the main components of the research, heritage and climate change, will be examined. Chapter 2 presents a literature review of climate change. Its causes and threats, in general, to urban areas, and to heritage sites, are explained. Climate adaptation, mitigation, and resilience are presented as ways to address climate change threats and green infrastructure is presented as a tool within climate change resilience.

A literature review of heritage preservation follows in Chapter 3. The importance of heritage preservation is presented through the framework of UNESCO's World Heritage Centre and designation criteria. The intricacies of heritage management are reviewed in order to better understand the standards, restrictions, and opportunities given by World Heritage Site designation. The review includes a look at the heritage management system, the major actors in heritage management, and the requirements of heritage managers.

Chapter 4 defines the problem of heritage preservation in a changing climate in further detail and elaborates on the research question: "In light of the climate change threats facing heritage sites, how can climate change planning in heritage sites use green infrastructure?" The chapter examines three relationships: that between climate change and heritage, that between climate change and green infrastructure, and that involving climate change, heritage, and green infrastructure.

Chapter 5 outlines the methodologies used to address the research question: case study, interview, and plan analysis. The case study of Île de Saint-Louis is used to explore the research

question as applied to one particular heritage site. As such, the site's components, residential buildings, non-residential buildings, public spaces, roads, and view corridors are examined by their use and materials. Climate risk factors facing the island, both present and future, are identified. Knowing the state of the site's components and the current and future climate risks, a vulnerability analysis is created to indicate which blocks of the island are most at risk to climate threats. A suitability for green infrastructure intervention analysis is derived using composite vulnerability and green infrastructure opportunity variables. The suitability analysis aims to identify areas of the island most suitable for green infrastructure intervention. The second methodology, interviews, supplements the information collected for the vulnerability map and provides further insight on threats and opportunities present on the island. The interviews were semi-structured and conducted with five professionals working in Senegal. The third methodology, plan analysis, consists of strengths, weaknesses, opportunities, and threats (SWOT) analysis of two site management plans, the *Safeguarding and Enhancement Plan for Saint-Louis* (2006) and the *Action Plan for Saint-Louis* (2015). The plan analysis illuminates how the plans and regulations would support the use of green infrastructure or create challenges for the use of green infrastructure.

Chapter 6 through 8 present the findings from the three methodologies. Starting with the case study, Chapter 6 identifies the location and the characteristics of five site components: residential buildings, non-residential buildings, public spaces, roads, and view corridors. Residential and non-residential buildings share some similar characteristics and therefore are faced with similar preservation challenges caused by lack of maintenance and climate. This chapter elaborates on those challenges and provides descriptions on the varied types of architecture found on the island, including balcony houses, gallery houses, wooden barracks, modernist buildings, and neo-classical institutional architecture. Three types of public space are identified on the island: its docks, the formal Place Faidherbe, and the less used, Place Blaise Diagne. These public spaces yield unique preservation challenges and provide opportunity for green infrastructure implementation. It is found that roads are viewed as public space as well. They are used for multimodal transit, but also for gathering and playing. The different types of roads on the island are located and studied. Lastly, the view corridors are identified and noted as important areas to preserve on the island

The current and future climate risks facing the island, such as drought and increased intensity of rain events, are identified in Chapter 6 and from that, a block-by-block vulnerability analysis is conducted from the block's sensitivity and exposure to those climate threats. Lastly, a suitability for green infrastructure intervention analysis identifies the blocks on the island most suitable for green infrastructure based on its vulnerability and opportunities present for intervention.

Chapter 7 presents the findings from interviews with five professionals who have worked on the preservation of the Île de Saint-Louis. They provide their opinions and insights on the major threats facing the preservation of the heritage site, along with how they see green infrastructure fitting into the fabric of the island. Major themes concerning climate and non-climate related preservation threats emerge, as well as suggestions for how to build the island's resilience.

Chapter 8 analyzes the *Safeguarding and Enhancement Plan for Saint-Louis* (2006) and the *Action Plan for Saint-Louis* (2015) using a SWOT (strengths, weaknesses, opportunities, and threats) analysis. The analysis reveals the plans' involvement (or lack thereof) with climate change. Additionally, regulations and guidelines included in the plans are identified as either supporting or dissuading the use of certain types of green infrastructure on the heritage site.

In the concluding chapter, Chapter 9, recommendations are made on the appropriate types of green infrastructure and locations for intervention on the island based on the synthesis of findings from the three methodologies. Furthermore, this research is framed as a replicable process that can be used by heritage site managers in determining where green infrastructure can be implemented on their site and which types are most suitable. Lastly, limitations of the research are explained, as well as potential areas of further study.

Chapter 2: Literature Review of Climate Change

2.1 *Climate Change*

Climate change refers to major shifts in temperature and weather patterns, such as precipitation and wind patterns, that occur over the course of a few decades (Environmental Protection Agency 2016). The increased output of greenhouse gases is the primary cause of climate change. Since 1850, atmospheric carbon dioxide has increased by 35% (National Research Council (U.S.). Committee on Ecological Impacts of Climate Change 2008, 9). The increase in greenhouse gases are linked directly to anthropogenic activities, such as industrialization and changes in land use which, in turn, encourage more vehicle use and hence greenhouse gas emissions (O'Brien et al. 2014, 101). Global warming refers to the rise in average global temperatures throughout the last few decades; however, global warming is just one aspect of climate change, which includes overall changes in weather patterns, as well. In looking forward to the future, there is a sense that the planet will face climate variability that has no modern precedent (Mguni, Herslund and Jensen 2016, 241). As such, it is imperative that future development considers this climate change and variability.

2.2 *Climate Change Threats*

The change in climate not only affects the environment and natural landscapes, but many other aspects of human life, including settlement patterns, mortality rates, food security, economic opportunities, and more (O'Brien et al. 2014, 101). Due to the expansive nature of climate change threats, this literature review focuses on specific climate change threats to urban areas and heritage sites.

2.2.1 *Climate Change Threats to Urban Areas*

Climate change threats to cities are similar to climate change threats at large; however, due to the density of development and population in urban areas, climate change presents a more concentrated risk in cities (Lankao 2008, 4). Traditionally, cities were settled close to rivers or on coastlines to facilitate trade. Cities' close proximity to water makes them more vulnerable to sea level rise and flooding (Lankao 2008, 5). In the short- and medium-term, climate threats to cities associated with water are storm surges and floods, due to the increase in frequency and intensity of rain (Lankao 2008, 5; O'Brien et al. 2014, 101). Due to the increased concentration of

impermeable surfaces in cities, stormwater runoff from heavy rain events is difficult to contain and could cause flooding.

In addition to climate threats associated with water, cities face threats of prolonged droughts and heatwaves. Cities will be disproportionately affected by heatwaves due to the urban heat island effect. The urban heat island effect refers to the fact that temperatures are warmer in urban areas than in surrounding rural areas. This is due to the fact that cities have relatively less vegetated surface area that can absorb heat, as compared to rural areas. In the long term, cities will need to cope with shifts in biodiversity due to changing weather patterns (O'Brien et al. 2014, 101). Cities will need to examine how they can increase shade, strengthen flood defenses, and improve stormwater drainage systems (O'Brien et al. 2014, 101).

As seen, climate threats will impact cities' energy demands and drainage capacities, creating long-term vulnerability (Lankao 2008, 5). While urban areas are increasingly vulnerable to climate change threats, they are positioned to be a hub for climate adaptation due to the concentration of human and economic capital (Lankao 2008, 4). A further discussion on climate adaptation, mitigation, and resilience is found in Chapter 2.3.

2.2.2 Climate Change Threats to Heritage Sites

UNESCO-designated World Heritage sites include both cultural heritage sites and natural heritage sites. Both of these heritage site categories face unique threats due to climate change. Due to the nature of this research, this part of the literature review focuses primarily on the climate impacts to built cultural heritage, such as monuments and buildings.

The climate change threats to heritage sites can be classified into two broad categories: threats associated with more frequent, intense rainfall and threats associated with temperature changes. A table of climate change threats and their specific impact on heritage sites can be found in Table A.

Table A: Climate change threats and their impacts on heritage sites

Climate Change Threat	Impact on Heritage Site
<i>Threats associated with more frequent, intense rainfall</i>	
Water penetration into fabric of building	Masonry decay, staining of building materials
Blockage of gutters	Water overflows onto and into buildings
Stormwater runoff	Flooding under floors or into building
Flash flooding, fluvial flooding	Sewage build up, damage of building materials, hasty and insensitive clean up
<i>Threats associated with temperature change</i>	
Changes in humidity	Deterioration of building materials and contents, increase in insect population
Higher internal and external temperatures (human)	Thermal discomfort of residents and tourists
Higher external temperatures (environment)	Ground shrinkage leading to the movement of building foundations

Source: Author; O'Brien et al. 2015; Adaptation Scotland 2016

Many of the climate change threats to heritage sites in Table A were highlighted in Adaptation Scotland's 2016 publication, *Climate Change Adaptation for Traditional Buildings* (Adaptation Scotland 2016). Adaptation Scotland is a sustainability organization funded by the Scottish Government. As stated in its title, the guide not only presents the threats to historic buildings, but also adaptation tools for use. Some of the adaptation tools require weather proofing the building materials, while others call for reducing impermeable surfaces and improving natural landscaping to maximize drainage, minimizing water splashback onto buildings and providing natural air-conditioning (Adaptation Scotland 2016). While many of the climate change threats faced by heritage sites are similar to those faced in urban areas at large, the impacts of the threats are intensified due to the age and delicate nature of the structures.

Beyond the physical effects of climate change on the sites, climate change threatens intangible aspects of cultural heritage sites as well. Climate change can threaten certain industries, such as agriculture or fishing. With this impact on certain jobs, laborers may be forced to relocate to other areas of the country, weakening traditional cultural practices. Additionally, the tourism industry that accompanies most heritage sites may experience negative impacts due to climate change (O'Brien et al. 2014, 103). Longer seasons of unfavorable climate (such as extreme hot seasons or longer rainy periods) could shorten the peak tourist season.

2.3 *Climate Change Resilience*

This research focuses on the potential use of green infrastructure to build climate resilience. One definition of resilience is “the ability and capacity of a city to maintain functions and recover from a disaster (van der Heijden 2014, 5).” While that definition focuses on resilience as it relates to a disaster, resilience can also be defined as a city’s ability to maintain its functions in the face of threats, such as those threats posed by climate change. The ICLEI - Local Governments for Sustainability define resilience more broadly, stressing continuous growth rather than just maintenance of the status quo: “The capacity of a social or ecological system to cope with hazardous shocks and stresses in a timely and efficient manner by responding, adapting, and transforming in ways that restore, maintain, and even improve its essential functions, structures, and identity while retaining the capacity for growth and change (ICLEI 2017).”

Adaptation and mitigation are also important terms in climate change vernacular. Adaptation is an aspect of resilience. Adaptation requires a city to adjust to changes in the climate by changing its systems. Mitigation aims to slow down climate change through a reduction of greenhouse gases (Lankao 2008, 7). In the past, mitigation was preferred. However, as the reality of decades of greenhouse gas emissions become more evident on Earth, adaptation is a necessity for survival (Harvey and Perry 2015, 10). Today, the line between mitigation and adaptation is blurred with resilience laying at the intersection (Johnston et al. 2013, 218).

2.3.1 *An Overview of Green Infrastructure and Its Role in Climate Change Resilience*

As discussed in Chapter 2.2.1, urban areas face many climate change threats. Many cities lack the regulatory frameworks that allow them to plan and implement resiliency initiatives. In rapidly developing cities, the government struggles to manage the development rates causing haphazard land development and a lack of grey infrastructure (van der Heijden 2014, 1). In

established economies, the opposite is true; transformation is slow and therefore regulatory frameworks supporting resilience require a longer time to take effect (van der Heijden 2014, 2). These cities need a flexible tool that capitalizes upon their city's landscape and strengths. Green infrastructure is a resilience tool that addresses these needs.

Green infrastructure is defined in many ways, most broadly to encompass all green space and most narrowly, referring to green spaces, natural and engineered, that address stormwater management needs. One of the most widely used definitions is: "An interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations (Benedict and McMahon 2006, 12)." The aforementioned benefits are provided through four types of ecosystem services: provisioning, regulating, cultural, and supporting. Green infrastructure provides food and water. It regulates the climate and environmental events, such as floods. It provides cultural services such as aesthetic value and recreational opportunities. Lastly, it supports natural systems, such as biodiversity, soil formation, and photosynthesis (Climate change and Urban Vulnerability in Africa 2013). Green infrastructure harnesses the natural landscape in order to provide these necessary ecosystem services. These services will be increasingly in-demand as climate change challenges the environment.

One of the most well-known benefits of some green infrastructure tools is stormwater management. Green infrastructure tools that help capture stormwater runoff include rain gardens, bioswales, and green roofs. The glossary in Appendix A provides definitions for many of these green infrastructure tools. These tools reduce the quantity of runoff through capturing water where it lands, slowing the speed of the runoff, and improving the quality of stormwater as it is treated through infiltration (Mguni, Herslund and Jensen, 2016, 244). As a sustainable and resilient approach, specific green infrastructure tools often provide more than one benefit. For example, a tree canopy can aid in carbon storage and removal (a regulating ecosystem service) and provide shade for street vendors (a provisioning ecosystem service) (Ranjha 2016).

Beyond its diverse array of benefits, including stormwater management, carbon sequestration, social benefits, and biodiversity promotion, green infrastructure encourages a holistically sustainable process. The green infrastructure approach addresses the triple bottom line: economics, the environment, and equity (Mguni, Herslund, and Jensen 2016, 245). Additionally, since green infrastructure provides many different types of benefits, it requires the

involvement of stakeholders, which create a more integrated approach, rather than a top-down regulatory framework (Ranjha 2016).

The green infrastructure approach has been successfully implemented worldwide. Mguni, Herslund, and Jensen explore the strengths and challenges of using green infrastructure in sub-Saharan African cities, of which this research's case study is one. The challenges lie in the potential cost of operations and maintenance of green infrastructure, the coordination across multiple stakeholders and decision-making bodies in order to implement green infrastructure, and that it is a new, relatively untested approach on the continent. However, the strengths of green infrastructure are seen in its ability to address flood risk, support biodiversity, and manage stormwater. Additionally, it is a more affordable and adaptive option for the long-term (Mguni, Herslund, and Jensen 2016, 247). Regardless of its challenges, the green infrastructure approach provides cities with a tool to build their resilience in the face of climate change threats.

2.4 Discussion

While there are efforts to mitigate the causes of climate change through reductions in fossil fuel consumption and the use alternative energy, the threats of climate change are unavoidable in the present and near future. New climate patterns are affecting and will continue to affect cities, their structure, their residents, and their infrastructure. The same is true for heritage sites, but with an increased layer of threat due to the sensitivity of historic buildings and monuments to weather. As such, there is a crucial need to not only mitigate the causes of climate change, but also to build climate resilience. Building climate resilience involves adapting to climate threats in a sustainable manner, ensuring that current actions will benefit all aspects of the triple bottom line (the economy, the environment, and an equitable society). Climate resilience also requires a forward-thinking approach so that actions taken today will make the city stronger in the face of climate change threats in the future. Building resilience requires a variety of approaches; green infrastructure is one such approach. The ways in which green infrastructure can address climate threats is illuminated in Table B.

The table captures the threats of climate change (X-axis) that were illuminated through the literature review, as well as, green infrastructure tools (Y-axis). The body of the table illustrates which green infrastructure tools could be used to address certain climate change threats (demarcated by an "X"). This table was informed primarily by two pieces of literature: the Center

for Neighborhood Technology’s *The Value of Green Infrastructure: A Guide to Recognizing its Economic, Environmental and Social Benefits* and Di Leo, Escobedo, and Dubbeling’s article *The Role of Urban Green Infrastructure in Mitigating Land Surface Temperature in Bobo-Dioulasso*. Both of these pieces presented specific green infrastructure tools and explained their benefits, some of which address regulating climate change threats. Chapter 4.2 elaborates on how certain green infrastructure tools directly address climate change threats. A glossary of key terminology, including the green infrastructure terms in the table, can be found in Appendix A.

Table B: Climate Threat Matrix with Associated Green Infrastructure Tools

Threats Tools	Flood	Increased Stormwater Runoff	Urban Heat Island	Desertification	Drought	Sea Level Rise	Economic Insecurity
Permeable Pavement	X	X					
Rain gardens	X	X					
Bioretention & Infiltration	X	X				X	
Tree planting	X	X	X	X			
Water Harvesting	X	X			X		X
Green Facade			X				
Green Roof	X	X	X				
Constructed wetlands/Wetlands	X	X				X	
Urban garden		X					X
White roofs			X				
Xeriscape		X		X	X		

Source: Author; Di Leo, Escobedo, and Dubbeling 2015, 375-375; Center for Neighborhood Technology 2010

Chapter 3: Literature Review of Heritage Preservation and Management

3.1 *The Importance of Heritage Preservation*

Heritage sites “link past, present, and future (O’Brien et al. 2014, 103).” Heritage sites provide focus for citizens, through the provision of political and cultural spaces, as well as an emotional attraction (O’Brien et al. 2014, 103). Recognizing the importance of these sites, the *World Heritage Convention* was ratified in 1972 at the General Conference of UNESCO. The *Convention* contains three primary aspects: it defines what sites can be considered for inscription on the World Heritage site list, the roles of State Parties, and how the World Heritage fund can be used.

“State Parties”, national governments that sign onto the *Convention*, receive many benefits. First and foremost, there is prestige that comes with their outward commitment to preserve world heritage. Increasing honor is bestowed when sites are inscribed on the World Heritage List. Inscription on the list brings increased awareness and, often, increased tourism to the site. Inscribed sites also benefit from a management plan that is required by the *Convention*. Additionally, local management teams often receive technical capacity training. The management plans and system are further elaborated upon in Chapter 3.2. Finally, inscribed sites have the opportunity to access the World Heritage Fund for preservation activities (UNESCO World Heritage Centre 2015). The central idea of the *Convention* is that inscribed sites must have “Outstanding Universal Value” to the world by meeting one of the inscription criteria. It is the site’s Outstanding Universal Value that must be preserved and maintained through the heritage management system.

3.2 *Heritage Management*

The literature on World Heritage sites is vast; this literature review focuses specifically on the primary players in heritage management, the heritage system, and requirements of State Parties in heritage management.

3.2.1 *Major Actors in Heritage Management*

There are seven major actors in heritage management: the UNESCO World Heritage Committee, the UNESCO World Heritage Centre, the three advisory bodies: ICCROM (the International Centre for the Study of the Preservation and Restoration of Cultural Property),

ICOMOS (the International Council on Monuments and Sites), and IUCN (the International Union for Conservation of Nature), State Parties, and other stakeholders.

The UNESCO World Heritage Committee consists of 21 members and meets on an annual basis. They are tasked with reviewing the inscription nominations for cultural and natural sites and the Reactive Monitoring and Periodic Reporting (see Chapter 3.2.3) of existing World Heritage sites. Upon review, the Committee decides whether existing sites should remain on the World Heritage List, be transferred to the List of World Heritage in Danger, or removed from all lists. Additionally, the Committee grants distribution of the World Heritage Fund. The World Heritage Fund is funded through voluntary donations, the sale of World Heritage publications, and mandatory contributions from State Parties to the Convention. Funds are distributed on an as needed basis and used for a variety of site support projects, such as training for site staff, provision of lacking equipment or material, expert evaluations and reports, and low-interest loans. The Committee is required to submit a biennial report to the UNESCO General Assembly and revise the *Operational Guidelines* (UNESCO World Heritage Centre 2016).

The UNESCO World Heritage Centre acts as the Secretariat. The Centre is responsible for organizing all General Assembly and Committee meetings. Additionally, the Centre is tasked with ensuring proper communication and coordination between all key actors, such as State Parties, advisory bodies, and the Committee. They do so in coordinating and organizing received reports and transmitting the necessary information. They sometimes participate in Advisory Missions to UNESCO World Heritage sites.

There are three advisory bodies to the UNESCO World Heritage Committee: ICCROM (the International Centre for the Study of the Preservation and Restoration of Cultural Property), ICOMOS (the International Council on Monuments and Sites), and IUCN (the International Union for Conservation of Nature). ICCROM aids in training for site managers, helping with monitoring reports, and reviewing World Heritage Fund requests for cultural heritage sites. IUCN provides the same assistance for natural heritage sites. ICOMOS assists the Committee in reviewing inscription nominations, monitoring the condition of sites, and supporting capacity building activities (UNESCO World Heritage Centre 2016).

The State Parties, or countries, are responsible for organizing the management of the heritage sites in their country. UNESCO encourages State Parties to involve a variety of stakeholders in the management process, including site managers, local and regional

governments, community organizations, and non-governmental organizations (UNESCO World Heritage Centre 2015, 2). State Parties work with these stakeholders and delegate responsibility to them. They work to protect, conserve, and present heritage sites, using appropriate measures, such as legal, scientific, technical, and administrative measures. This includes, but is not limited to: writing site management plans, planning educational programming, securing financial resources, and passing protection laws. Additionally, the State Parties must conduct studies and write reports in order to provide the World Heritage Committee information on the state of the heritage sites. Of all the actors in heritage management, the State Parties are the most engaged with the daily operations of individual heritage sites.

3.2.2 *The Heritage Management System*

The aforementioned *World Heritage Convention* is supported by the *Operational Guidelines for the Implementation of the World Heritage Convention*. It is updated continuously by the World Heritage Committee, the main body responsible for the implementation of the *Convention*. The *Operational Guidelines* provides detailed information on criteria for inscription, provision of the World Heritage Funds, and management requirements. These guidelines are used primarily by State Parties, the World Heritage Committee, the UNESCO World Heritage Centre, advisory bodies, site managers, stakeholders, and partners (UNESCO World Heritage Centre, 2015).

The *Operational Guidelines* explain that an effective management system depends on the needs and characteristics of the heritage site within its particular cultural and environmental context. There is no set prescription for a heritage management system. Some may include formal urban planning tools, while others may rely upon pre-existing traditional practices or informal engagement. With that being said, there are common aspects to successful management systems. These aspects include: transparency, engagement of diverse stakeholders, shared understanding of the site, capacity building of stakeholders, consistent monitoring and reporting on changes occurring at the site, and “a cycle of planning, implementation, monitoring, evaluation and feedback (UNESCO World Heritage Centre 2015. 23).”

UNESCO’S *Managing Cultural World Heritage Resource Manual* presents a common management system framework. It consists of three aspects: elements, processes, and results. The elements allow the processes to occur and the results are products of those processes. The three elements are the legal framework, institutional framework, and resources, such as human,

financial, and intellectual resources that aid in creating operational capacity. The three processes that occur in a management system are planning, implementation, and monitoring. These processes lead to the results: outcomes and improvements to the system (ICCROM 2013). This common framework is illustrated in Figure A.

Figure A: Common framework for a heritage management system

Source: Author

Regardless of the management system chosen for any given UNESCO site, it is imperative that it uses an integrated planning approach that is flexible and includes short-, medium-, and long-term actions to preserve the site. This will ensure that the Outstanding Universal Value of the site is being properly maintained.

3.2.3 Requirements of Heritage Management

For the most part, UNESCO allows State Parties to determine how they will structure the management of heritage sites in their country. State Parties are left to decide what approach to use and how to implement preservation activities and educational programming. However, UNESCO requires three mandatory documents from State Parties for each of their heritage sites: a management plan, State of Conservation monitoring reports, and periodic reports.

The *Operational Guidelines* state that each property must have a management plan or equivalent document that explains how the site will be preserved (UNESCO World Heritage Centre 2015, 108). Beyond stating that, “the purpose of a management system is to ensure the effective protection of the nominated property for present and future generations (UNESCO

World Heritage Centre 2015, 109),” the *Operational Guidelines* do not elaborate on necessary or required aspects of the management plan.

On an annual basis, the State Parties must submit State of Conservation reactive monitoring reports for each of their sites to the World Heritage Committee. These reactive monitoring reports inform the committee on any developments that have had an impact on the Outstanding Universal Value of the site. These reports can contain impact studies to illustrate issues at hand. Often times, the World Heritage Committee will issue a response to the reactive monitoring reports with suggestions on how to mitigate any conservation issue mentioned in the report (ICCROM 2013, 37).

In addition to the annual State of Conservation reactive monitoring report, State Parties must submit a Periodic Report every six years. These reports are reviewed by the World Heritage Committee and serve to assess whether the site’s Outstanding Universal Value stated at the time of application continues to be present and preserved. The Periodic Report should contain any information that has affected or will affect the site, such as changing administrative, financial, and environmental circumstances (ICCROM 2013, 45).

In the case of the Île de Saint-Louis, the management system includes all three elements: legal, resources, and institutional. There are three main Senegalese legal texts that support the site: the 1971 law and decree protecting historic sites and monuments, the 1975 order requiring the publication of the list of historic sites and monuments, and the 2008 decree supporting the *Safeguarding and Enhancement Plan of Saint-Louis*, the site management plan. The State Party delegates responsibility to local organizations for the daily management and operations of the site including, the Association for the Restoration and Conservation of Saint-Louis Architecture, the Office of Tourism for Saint-Louis, the local ICOMOS chapter, and various community associations. These institutional actors are responsible for alerting the State Party of any changes in the conservation of the site and are charged with implementing activities to protect and preserve the site. Resources, both technical and financial, are provided by the France-UNESCO Cooperation Agreement and the French Development Agency. The State Party submitted a Periodic Report to the World Heritage Committee in 2006 and 2014. State of Conservation reactive monitoring reports were submitted every year between 2006 and 2017 except for 2007 and 2012. These reports are published on the UNESCO World Heritage Centre website (UNESCO World Heritage Centre 2017b). Upon reviewing these reports, the World Heritage

Committee provides suggestions to the State Party on how to improve site activities. As elaborated upon in Chapter 8.2, the 2014 State of Conservation reactive monitoring report alerted the World Heritage Committee to site issues, leading to the advice that an action plan to address the preservation issues should be written.

Chapter 4: The Intersection of Climate Change, Heritage Planning, and Green Infrastructure

The literature notes that heritage sites contribute to the cultural well-being of local society, but also to mankind as a whole. However, climate change is undoubtedly one of the largest threats these sites will face in the coming decades. Much needed climate change resiliency can be assembled through a variety of methods, one of which is the use of green infrastructure. Realizing all of these factors, this research aims to answer, “In light of the climate change threats facing heritage sites, how can climate change planning in heritage sites use green infrastructure?” To explore this research question, two relationships are examined: the relationship between climate change and heritage and the relationship between green infrastructure and climate change. Finally, the composite relationship between green infrastructure, climate change, and heritage sites is synthesized.

4.1 *Climate Change and Heritage*

In discussing the relationship between climate change and heritage, it should be noted that the term heritage is being used as it is related to UNESCO World Heritage sites. While non-UNESCO designated heritage sites are affected by climate change, it is important to understand climate change in the context of the UNESCO heritage structure for this research. Most of the developments around climate change and heritage have emerged since 2005 when a group of concerned individuals and organizations confronted the World Heritage Committee. The World Heritage Committee then requested that the World Heritage Centre and the advisory bodies form a working group to study and produce a report on the impacts of climate change on heritage.

The working group produced *World Heritage Report No. 22: Predicting and Managing the Effects of climate change on World Heritage and a Strategy to Assist States Parties to the Convention to Implement Appropriate Management Responses* in 2006 (UNESCO World Heritage Centre 2006). This report presented an overview of climate change impacts on heritage and presented some strategies for management, adaptation, and risk management for heritage sites in light of climate change. It suggested that sites incorporate climate adaptation planning into their management plan and continuously monitor the vulnerability of the site to climate change. The report focused on the importance of collaboration at the local level and encouraged involving the local community in identifying adaptation interventions. It also called for the World

Heritage Centre to strengthen its relationship with the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) (UNESCO World Heritage Centre 2006). Perhaps most importantly, the report suggested that when the *Operational Guidelines* are updated, “climate change-related aspects” be considered for addition (UNESCO World Heritage Centre 2006, 42). It should be noted that the *Operational Guidelines* were last updated in 2016. As of the last update, climate change is mentioned once. The guidelines now require that nominated sites list climate change threats to the site in their nomination form (UNESCO World Heritage Centre 2016).

Shortly after these reports, a formal *Policy Document on the Impacts of Climate Change on World Heritage Properties* was released and approved by the World Heritage Committee. This document identified the aspects of the *World Heritage Convention* that were related to a State Party’s responsibility to protect their site against the threats of climate change. One such aspect of the *Convention* is Article 4, which states, “Each State Party to this Convention recognizes that the duty of ensuring the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage...belongs primarily to that State. It will do all it can to this end, to the utmost of its own resources and, where appropriate, with any international assistance and co-operation, in particular, financial, artistic, scientific and technical, which it may be able to obtain (UNESCO World Heritage Centre 2016, 6).” The report draws attention to the fact that climate change threatens the very existence of heritage and that the State Party is tasked with doing all it can to preserve the site against threats. The document suggests policies in the following areas: understanding materials vulnerability, monitoring change, modelling and projecting climate behavior, managing cultural heritage, and preventing damage (UNESCO World Heritage Centre 2016, 11).

In addition to these reports, the World Heritage Centre has encouraged the sharing of best practices and, to that end, published *Case Studies on Climate Change and World Heritage* in 2007 (UNESCO World Heritage Centre 2017). These reports are significant because they officially illuminate the threat of climate change on heritage sites and make recommendations on how to address the impacts. Most recently, the World Heritage Committee suggested that State Parties participate in the 21st Conference of the Parties (COP21) to the UNFCCC in December of 2015. While these reports and suggestions are important, they do not have any direct impact on the sites themselves. The decisions that determine how resources are allocated for climate change and

which actions are taken are made at the State Party level, not the international level (Harvey and Perry 2015, 4). That is why ICOMOS, an advisory body to the World Heritage Committee, encouraged their national committees to take action against climate change threats within their national borders (Barthel-Bouchier 2015, 158).

Within countries, much of the progress made on climate change and heritage sites has been implemented in the form of special projects or voluntary goodwill from stakeholder organizations (Yung and Chan 2015, 237). Many successful initiatives involving climate change and heritage have been found in European countries. However, in developing countries, heritage organizations are not as well-funded or staffed; therefore they have had to choose between prioritizing climate change programming or encouraging tourism (Barthel-Bouchier 2015, 160). While addressing climate change threats will have a positive outcome regarding tourism, the reality is that these heritage organizations are overburdened by work, so short-term gains win compared to long-term investments.

Despite the fact that there has been a significant amount of published work in the area of climate change and heritage, there is no agreed upon approach to cultural heritage conservation in the face of climate change (O'Brien et al. 2015, 100). However, heritage professionals see opportunity in using climate change as a platform to access more funding, support, and recognition for heritage sites (Barthel-Bouchier 2015, 154).

4.2 *Green Infrastructure and Climate Change*

Green infrastructure is introduced in Chapter 2.3.1 as an approach for building climate change resilience. This section will further elaborate on how green infrastructure can be used to address the effects of climate change, such as flood risk, droughts, coastal erosion, sea level rise, and the urban heat island effect.

As the climate continues to change, there will be more high intensity storm events. The frequency and intensity of these events will increase, leading to a similarly increased risk of flooding. Green infrastructure can be integrated into an area to minimize flood risk by absorbing the rainfall and associated runoff. By having green infrastructure capture some of the rainfall, sewer systems are less likely to be overwhelmed and water is less likely to pool in areas, reducing the risk of flooding.

While there will be an increase in frequency and intensity of rainfall events, there will also be more prolonged periods of no rain in certain areas of the world, leading to drought. Green infrastructure cannot reduce the chance of drought, but can be used to build resiliency to the drought. Green infrastructure can capture rain during the intense rain events, allowing it to be treated and stored for use when there is a drought.

Sea level rise is one of the most well-known effects of climate change. As ice melts in the polar regions, the sea level rises, affecting coastlines. Green infrastructure can help combat coastal erosion through the creation of a system of coastal wetlands. By engineering wetlands on coasts, the wetlands absorb the ocean current rather than having the current erode the shoreline.

Climate change also brings increased temperatures. In cities, temperatures can be even hotter due to the abundance of pavement and other hard surfaces which absorb and retain heat. This is known as the urban heat island effect (UHI). Green infrastructure, in the form of trees and other vegetative surfaces, addresses the UHI. Trees and vegetation deflect heat and turn it into moisture. Additionally, trees provide shade which cools surfaces (Environmental Protection Agency 2016c).

As seen, green infrastructure tools directly address climate change impacts and have been adopted and promoted by national and international organizations, such as the United States Environmental Protection Agency and the United Nations Environmental Program. While traditional grey infrastructure can help relieve some climate change stress, such as levees to protect against flooding, it must be supported by green infrastructure in the case that the grey infrastructure fails. Additionally, green infrastructure builds not only environmental resilience to climate change, but also provides economic and social benefits needed for a sustainable community.

4.3 The relationship between climate change planning, heritage planning, and green infrastructure

This research falls at the intersection of climate change planning, heritage planning, and green infrastructure. As seen, there are marked relationships between both climate change and heritage as well as climate change and green infrastructure. Since green infrastructure is an approach used to address climate change impacts and heritage sites are impacted by climate

change, then the green infrastructure approach can, in theory, aid heritage sites facing climate change threats.

Climate change and heritage are dynamic; they are not stable or unchanging in their nature (Hall 1980; O'Neill and Smith 2014; Harvey and Perry 2015, 12). While a heritage site may seem unchanging in the sense that it is preserved to reflect its historic nature, the site changes throughout time based on how it is used, the state of preservation, and internal and external threats. Green infrastructure tools are also dynamic. Unlike grey infrastructure that is programmed to address impacts in a static manner, green infrastructure can adapt to the changing circumstances with which it is confronted. Additionally, green infrastructure is multifunctional, meaning that one tool may have many different services. If one service is not needed, the tool still has other benefits. For example, rain gardens planted along the side of a street capture stormwater runoff. Even when it is not raining, the gardens serve as a physical buffer between cars and pedestrians, promoting safety. They also provide aesthetic benefits to the community. Due to its multifunctionality and adaptability, green infrastructure is well suited for a dynamic environment.

Green infrastructure considers the interaction between the natural and built environments. Heritage sites also consider this relationship, as their landscapes are part of their Outstanding Universal Value in many cases (Harvey and Perry 2015, 13). Finally, climate change planning, heritage planning, and green infrastructure all require the involvement of community, organizational, and institutional stakeholders. By working with a wide array of stakeholders, the value of heritage and commitment to building climate change resilience is enhanced through awareness and accountability (Dawson 2015, 251). It should be noted that the institutional, organizational, and community capacity to implement green infrastructure in a heritage site is beyond the scope of this research.

While there is a strong relationship between climate change planning, heritage planning, and green infrastructure, there are also some issues that test the relationship. With heritage planning, there is a focus on maintaining and protecting the Outstanding Universal Value of the site. Within that focus, there are regulations and standards to protect the authenticity and integrity of the site's components, such as its buildings, roads, public spaces, and view corridors. It depends on the site, but for the most part, the standards are strict and do not allow much adaptation from the original state of the site component; therefore, green infrastructure tools must fit within those bounds. This research explores that very challenge.

Chapter 5: Methodology

5.1 *Methodology Framework*

This research is informed by three primary methodologies: case study, interviews, and plan analysis. A complete methodology framework is found in Figure B. Each methodology is expanded upon below. The case study and interview methodologies work in tandem to inform a vulnerability analysis and suitability for green infrastructure intervention analysis of the blocks on the. The plan analysis and the suitability analysis findings contribute to answering the research question: How can infrastructure can be used to build climate resilience in heritage site?

This research used mixed methodologies, based on the method of triangulation in order to answer its research question. Triangulation requires the use of multiple sources of data to inform a comprehensive and well-developed account (Robert Wood Johnson Foundation 2008). Appendix B includes an expanded version of the methodology framework indicating data sources and origins of the methodology. Triangulation allows the researcher to evaluate the findings of different data collection methods to determine consistency, reliability, and validity, or lack thereof. By evaluating findings from different data sources, I was able to validate whether the information presented was unanimously accepted or the opinion of one actor.

Figure B: Methodology Framework

Source: Author

5.2 Methodology I: Case Study of the Île de Saint-Louis

The guiding methodology of this research is the case study of the Île de Saint-Louis. While single case studies are criticized for their inability to create generalized findings (Flyvberg 2006), this case study does not aim to present a generalized finding about green infrastructure in heritage sites; instead it is used to explore the process by which a heritage site would analyze the potential use of green infrastructure. Each heritage site is unique, as is every city. Due to the great

variability of the sites, it would be futile to expect any single case study or collection of case studies to be able to produce a generalized statement.

As seen in the methodology framework, the case study required the collection of important information on the physical, cultural, and environmental aspects of the site. This information was then supplemented and reinforced by interviews. The case study methodology was crafted using a variety of sources related to heritage preservation, cultural landscape management, and green infrastructure planning.

In working with heritage sites, it is important to articulate the values and character of the components in order to ensure that any proposed interventions will not alter the components intended for preservation (Page 2015, 29). To do this, the public use and perception, as well as characteristics of the island's site components, were analyzed. The analysis of the cultural site components was combined with an assessment of the current and future climate risk on the island to create a vulnerability map. Each block's vulnerability was determined. After creating a vulnerability map, a suitability for green infrastructure map was created combining the vulnerability findings with variables that provide opportunity for green infrastructure. The vulnerability and suitability analyses were conducted on a block-by-block basis, rather than parcel-by-parcel. While green infrastructure can be implemented on an individual parcel level, it is more effective if a network of interventions is created. By conducting an analysis on the block level, clusters of blocks can be identified in order to create a network of green infrastructure interventions that reach beyond an individual site.

5.2.1 Cultural Site Components

Five cultural site components were chosen for analysis: residential buildings, non-residential buildings, public spaces, roads, and view corridors. In her book, *Strategic Green Infrastructure*, Karen Firehock recommends identifying important features of the landscape as a first step in green infrastructure planning. Firehock urges the planner to focus on features that may require the support of green infrastructure resources to maintain their existing character (Firehock 2015, 29). These five site components were chosen for a few reasons. First, recommended by Firehock, they may require the support of infrastructure to maintain their character. For example, the structural support of nonresidential and residential buildings may be compromised by poor drainage or exposure to extreme temperatures; green infrastructure can provide better stormwater management to prevent damage. Public spaces may suffer for a dearth

of tree canopy, which dissuades use of the space. As such, green infrastructure, in the form of tree cover, can provide shade and create cooler, more pleasant spaces. Roads can become damaged or unusable due to extreme flooding, which green infrastructure can help mitigate through better stormwater infiltration. Finally, view corridors, important to Saint-Louis' character and charm, may be enhanced by aesthetically pleasing plantings which provide additional ecosystem services, drawing the gaze and attention from more pedestrians.

Map C: Location of the five cultural site components

Source: Author; Ecole d'Architecture de Lille 2005

Beyond identifying these cultural site components, the physical characteristics and the public use and perception of the components were examined through site inventories and literature review. Table C elaborates on the physical characteristics of each site component examined in this case study.

Table C: Physical characteristics of site components needed for case study

Site Component	Physical Characteristics Needed for Case Study
Residential buildings	Materials used in construction, number of floors, location of buildings, amount of buildings on island, condition of buildings, ground cover around the buildings, drainage around buildings
Non-residential buildings	Materials used in construction, number of floors, location of buildings, amount of buildings on island, condition of buildings, ground cover around the buildings, drainage around buildings
Public spaces	Square footage, location of spaces, amount of spaces on island, landscaping materials used, number of plants/trees, public art or street furniture present, signage, drainage on site, condition of space
Roads	Material of road, width of road, location of road, number of roads on the island, drainage on road, condition of the road, materials and width of the space parallel to the road
View corridors	Location of view corridor, desired view, characteristics of buildings/roads/landscaping that contributes to the view corridor

Source: Author

Physical characteristics are important to study because they reveal the current condition of the components, provide a clearer image of the issues facing the components, and illuminate intervention restrictions based on size, construction materials, or location.

While the physical characteristics of the site are important to understand, it is also necessary to look at how the site components are perceived and used by the population. Understanding quantity of use and type of use, and by whom, is key in understanding the conditions of the site components and how they could be adapted in the face of climate change threats.

Both physical characteristics and population use and perception were gathered through various reports, an inventory, and plans of the site. The interviews, as described in Chapter 5.3, supplemented the reports and plans, providing more information regarding the condition and use of the site.

5.2.2 *Current Risk Factors*

The most immediate threats to the island are current climate risk factors. This section of the case study allows for understanding the current climate patterns and what effects they have had on the island thus far. Current risk factors were collected from weather databases, reports, and interviews.

5.2.3 *Future Risk Factors*

As stated in its name, climate change brings about continuously changing weather patterns. While it is important to understand current risk factors, it is also necessary to be forward thinking and anticipate future climate risk factors. Preparations made today must be able to address risks of the future. Just as with current risk factors, future climate risk factors were collected through weather databases and reports.

5.2.4 *Vulnerability Analysis and Map*

When addressing climate change and preservation, it is necessary to assess the site's vulnerability. Climate change might be affecting the entire site; however, resources and time may be limited, so it is important to prioritize sites for preservation (Berenfield 2015, 6). Cultural heritage managers have begun using a vulnerability triage strategy to do so. Using site data on the sensitivity of the site and anticipated climate change risk, cultural heritage managers classify portions of the site as: "unlikely to survive beyond another generation without heroic measures to save them," "could survive for decades or perhaps centuries with thoughtful maintenance, and at a feasible expense," or "important to our national heritage that we will save them at any cost, even in radically different contexts (Berenfield 2015, 6-7)." This research uses similar data (site sensitivity and climate change risks) to determine vulnerability.

The Intergovernmental Panel on Climate Change defines vulnerability as the "propensity to be adversely affected (O'Brien et al. 2014, 107)." To assess vulnerability of the site components, the following equation was used: sensitivity + exposure to climate risks = vulnerability (Berenfield 2015, 6). Sensitivity and exposure are both composite variables composed of two variables each. Sensitivity was determined using two variables: the state of conservation and the type of construction present on the block. In the *Architectural and Urban Inventory* of the island, each parcel on the island was assigned a state of conservation: good, fair, poor, or in danger (Ecole d'Architecture de Lille 2005). The state of conservation for each parcel is a direct contributor to the sensitivity of the block. Rather than use the age of construction as a

variable in determining sensitivity of the block, state of conservation is more fitting. Newer buildings can be more sensitive than older buildings if they use inappropriate materials that trap moisture in the walls or if they are built in a way that does not facilitate air ventilation. Additionally, older buildings can be more resilient to climate change since they were built to facilitate air flow and using climate appropriate materials. However, if these buildings are not maintained or restored in a careful manner then its sensitivity to the elements increases. It is for these reasons, that the state of conservation was chosen as an input variable for sensitivity.

Table D: Sensitivity variable, state of conservation point allocation

Sensitivity Variable 1	5 points	4 points	3 points	2 points	1 point
<i>State of Conservation:</i> % of total parcels in the block that are in a poor state and/or in danger	81-100%	61-80%	41-60%	21-40%	0-20%

Source: Author

The second variable used to determine the sensitivity of the block was the type of construction. The *Architectural and Urban Inventory of Saint-Louis* identified three different types of construction present on the island: hard construction (buildings made of brick, concrete, or a combination of those materials), barrack construction (buildings made of wood), and precarious construction (buildings that are made of a variety of materials, but that are temporary or not as structurally sound as hard construction or barracks) (Ecole d'Architecture de Lille 2005). The type of construction present on the block directly affects the block's sensitivity to climate. For example, if exposed to heavy rains or flooding, wooden barracks or precarious construction would be more sensitive than a concrete building.

Table E: Sensitivity variable, type of construction point allocation

Sensitivity Variable 2	5 points	4 points	3 points	2 points	1 point
<i>Type of construction:</i> % of total buildings on the block that are made of wood and/or made precariously	81-100%	61-80%	41-60%	21-40%	0-20%

Source: Author

Exposure was determined by current and future climate threats as identified through interviews, case studies, and other primary research conducted. The first variable is the block's

exposure to the coast. The literature, data, and interviewees indicated that areas closest to the coasts/docks of the island are most exposed to flooding and rising sea levels, therefore exposure to the coast was chosen as a variable. Exposure to the coast is the only variable in the vulnerability analysis that does not have a one- to five-point system. No block on the island is more than two blocks away from the coast; thus, every block is relatively exposed to the elements and faces the risk of flooding. Since the topography of the island is flat, water moves inward on the island with relative ease. It is for this reason that every block will receive at least three points for the “exposure to the coast” variable.

Table F: Exposure variable, exposure to coast point allocation

Exposure Variable 1	5 points	4 points	3 points
<i>Block’s exposure to the coast</i>	2 sides of the block are adjacent to the coastline	1 side of the block is adjacent to the coastline	Block is inland

Source: Author

Since the island has a high building density, the urban heat island effect is a climate threat that will become more severe with increasing temperatures. Additionally, with an increase in severe rain events, stormwater runoff and flooding is a climate threat. A block with no trees or vegetation intensifies its exposure to both of these threats, therefore the percentage of total parcels with no trees or vegetation was used as an exposure variable.

Table G: Exposure variable, lack of trees or vegetation point allocation

Exposure Variable 2	5 points	4 points	3 points	2 points	1 point
<i>Lack of trees/vegetation: % of total parcels on the block with trees or vegetation</i>	0-20%	21-40%	41-60%	61-80%	81-100%

Source: Author

Each of these variables was assigned a weight relative to its importance in equating the vulnerability of the block. The variable weights are seen in Table H. The greatest weight was assigned to the state of conservation variable. As mentioned, buildings marked as “poor” or “in danger” are very sensitive to daily environmental conditions; when faced with more intense climate change threats, their vulnerability is high. River flooding is one of the most prolific

climate change threats to the island. As such, a weight of 1.5 was assigned to the “exposure to the coast” variable.

Table H: Vulnerability analysis equation variable weights

Vulnerability Variables		Weight
Sensitivity	State of conservation	2
	Type of construction	1
Exposure	Exposure to the coast	1.5
	Lack of trees/vegetation	1

Source: Author

Each block’s vulnerability score was calculated and then assigned a vulnerability rating on an ordinal scale from one to five with five being the most vulnerable and one being the least vulnerable. The score ranges for each rating level were determined using an approximate equal interval classification. The lowest possible score (5.5) was subtracted by the highest possible score (27.5) and then divided by five (for the five ratings). The ranges were adjusted slightly to ensure that at least one block was included in each rating. The score and rating conversion table can be seen in Appendix H. A map indicating each block’s vulnerability rating was created. The purpose of the vulnerability map is to synthesize the information gathered throughout the case study, analyze it, and better understand the location and the level of climate change vulnerability. The location and level of vulnerability is necessary to map in order to make decisions regarding where green infrastructure implementation could help the heritage site to build climate resilience.

5.2.5 Suitability for Green Infrastructure Intervention Analysis and Map

To determine suitability for green infrastructure intervention in a heritage site, both vulnerability and opportunity must be considered. While vulnerability identifies the areas of the island most in need, it does not illuminate areas of opportunity. This suitability analysis combines both a vulnerability input and opportunity inputs to determine which blocks should be considered suitable for green infrastructure (vulnerability + opportunity = suitability for green infrastructure (GI) intervention). Three variables contribute to the suitability for GI intervention, the composite vulnerability score and two opportunity variables: architectural interest and vacant parcels.

The vulnerability rating (one through five) assigned to each block in the vulnerability analysis is input into this suitability equation. The more vulnerable a block, the more it needs green infrastructure intervention for its protection and preservation.

The first opportunity variable is architectural interest. Each parcel with a building was assigned a level of architectural interest in the *Architectural and Urban Inventory of Saint-Louis*: exceptional, significant, average, or none (Ecole d'Architecture de Lille 2005). In addition, some building parcels received designation as an official Senegalese “Historic Monument.” Based on its level of significance, certain standards and restrictions are applied to the building parcel. The more architecturally significant a building is, the less opportunity there is to modify it in any way. Details concerning these standards are included in Chapter 6.1.1. If a building has no architectural interest, then there is more opportunity to modify the site or building to incorporate green infrastructure.

Table I: Exposure variable, architectural interest point allocation

Opportunity Variable 1	5 points	4 points	3 points	2 points	1 point
<i>Architectural Interest</i> : % of total parcels on block with no architectural interest	81-100%	61-80%	41-60%	21-40%	0-20%

Source: Author

The second opportunity variable is the presence of vacant parcels. Vacant parcels act as a blank slate for green infrastructure opportunity, whether the parcel remains vacant or if a new building is built on the land. Vacant land is rare on the dense Île de Saint-Louis, so it is especially notable if a block has vacant land available.

Table J: Exposure variable, vacant parcels point allocation

Opportunity Variable 2	5 points	4 points	3 points	2 points	1 point
<i>Vacant Parcels</i> : % of total parcels on block that are vacant	50% or more	30-49%	20-29%	10-19%	0-9%

Source: Author

Each variable was assigned a weight based on its relative importance in determining suitability for green infrastructure invention. The architectural interest variable received the greatest weight. The standards applied to building parcels with architectural interest that is exceptional, significant, and average are very specific. Having an abundance of building parcels on the block that are not architecturally significant greatly increases the opportunity for green

infrastructure, which is why it is assigned a weight of three, as seen in Table K. While vacant parcels provide opportunity for green infrastructure interventions, green infrastructure can also be designed around pre-existing landscapes and built environments. As such, the vacant parcels variable received a weight of one. The vulnerability variable received a weight of two. Blocks facing more climate vulnerability require interventions for their protection, of which one can be green infrastructure.

Table K: Suitability for intervention analysis equation variable weights

Suitability Variables		Weight
Vulnerability		2
Opportunity	Architectural Interest	3
	Vacant Parcels	1

Source: Author

Like the vulnerability analysis, the suitability for intervention analysis was completed on a block-by-block basis rather than on the individual parcel level in order to identify larger priority areas for GI intervention. Each block's suitability score was calculated then assigned a suitability for intervention rating. The score ranges for each suitability rating were determined using an equal interval classification. The lowest possible score (6) was subtracted by the highest possible score (30) and then divided by three (for the three ratings) to determine the score ranges. The score and rating conversion table can be seen in Appendix I. The ratings are:

- Very Suitable for GI Intervention
- Suitable for GI Intervention with Minor Limitations
- Suitable for Very Limited GI Intervention

Considering that green infrastructure interventions vary in intensity, size, and manner, a variation of green infrastructure can be implemented on each block; no block is completely unsuitable for green infrastructure. The suitability for intervention of each block was combined with the additional two methodologies (interviews and plan analysis) to identify priority areas on the island for intervention and to determine which kinds of green infrastructure would be possible in those areas.

5.3 *Methodology II: Interviews*

As seen in the methodology framework, the intent of the interviews is to supplement the findings from the case study on identified current and future climate risks to the island, as well as the characteristics, public use, and perception of the various cultural site aspects. Due to constraints of geography, time, and distance, a site visit was impossible; therefore, the interviews aimed to provide a ground level assessment of the site, in addition to illustrating the types of daily activities and uses of the site.

5.3.1 *Subject Selection*

Since the interviews act as supplemental site analysis research, it was important to select interview subjects who have knowledge of the current and historical context of the site, through academic, professional, or personal familiarity. Many of the interview subjects were involved in a roundtable discussion on the preservation of the Île de Saint-Louis hosted by the UNESCO West Africa Regional Office on November 15, 2016. Other interviewees assisted with writing the Action Plan for Saint-Louis in 2015 or attended the monitoring mission in March 2014. The following individuals were selected as interview subjects:

- Guiomar Alonso Cano, Head of Culture Unit, UNESCO's West Africa Regional Office;
- Marie-Caroline Camara, President, Association Entre'Vues Saint-Louis
- Ibrahima Thiam, Professor and Researcher of Hertiage, Université de Gaston-Berger
- Fatima Fall, Director, Centre for Research and Documentation, Université de Gaston-Berger

Additionally, Suzanne Hirschi, architect and professor at the National School of Architecture and Landscape of Lille, France, was interviewed. Hirschi has been involved with the preservation of the island since 2001 and has published a considerable amount of work and inventories on the island.² These subjects were chosen to represent a diversity of heritage site stakeholders, including heritage professionals, government officials, researchers and academics, and community organizations.

² Her publications include, but are not limited to: "Saint-Louis of Senegal - From the Battle of the Paillote to the War of the Balcony" in *African Cities and their Heritage* (2011), *Safeguarding and Enhancement Plan for Saint-Louis* (2006), and *Architectural and Urban Inventory of the Île de Saint-Louis* (2005).

5.3.2 *Interview Type*

The interviews were semi-structured qualitative research interviews. The purpose of qualitative research interviews is to garner insights from the interview subject on a given occurrence or space “with respect to interpretation of the meaning of the described phenomena (Kvale 1984; Opdenakkar 2006, 1438).” Rather than interviewing a sample of subjects to create a dataset, these interviews provided qualitative information to support the various data and research that has been collected.

Semi-structured interviews allow the interviewer to ask follow-up questions or supplement the pre-crafted questions with additional questions based on the direction of the conversation and interview. This flexibility is important when collecting qualitative information (Cohen 2016).

Many qualitative research interviews occur when the interviewer and the interviewee are face-to-face. However, due to geographic distance, the interviews undertaken herein required alternative means of communication. Opdenakker explains that face-to-face interviews are the preferred method because they allow for synchronous communication of time and place. For this research, the interviews were prepared to be conducted via Skype, an online application that allows for video chatting, telephone, or e-mail. Skype was the preferred method of communication for these interviews because as in face-to-face interviews, Skype allows for synchronous communication of time and place. Telephone interviews were the second choice as they only provide synchronous communication of time. E-mail interviews were the last method of communication since they provide asynchronous communication of time and place (Opdenakker 2006). Asynchronous communication is not ideal for conducting semi-structured interviews because they force the questions and responses to be written. While follow-up questions can be sent after the initial interview responses are received through email, it is not an ideal way to have insightful dialogue and fully extract qualitative information.

5.3.3 *Pre-testing Questions and Expected Results*

As mentioned, the interviews served to supplement the desk research on current and future climate risks to the island, as well as characteristics of the cultural site aspects (residential buildings, non-residential buildings, public spaces, roads, and view corridors). The interview questions aided in exploring the suitability of green infrastructure on the Île de Saint-Louis, the effects of climate change on the island, areas on the island vulnerable to climate change and

deterioration, and priority sites for protection and green infrastructure implementation. After interview subjects responded to questions regarding climate change effects and the physical aspects of the heritage sites, they were asked to share any data or documents that supported their response. Due to the lack of digitized data available online in Senegal, this question aimed to grant access to important information, such as building inventories and maps, that could support the case study. A complete list of interview questions is found in Appendix C.

The interviews were conducted in French or English, based on the preference of the interview subject. As Senegal is a Francophone country, all interviewees knew at least French. Prior to the interview, interview subjects were asked to read and sign a consent form on which they indicated their desired anonymity (or lack thereof) and if they were comfortable having the interview audio-recorded. The interview questions were pre-tested with a Dr. Racine Ndiath, a former public sector employee in Senegal who has his doctorate in urban planning. Dr. Ndiath was familiar with the Île de Saint-Louis, but not with the concept of green infrastructure, like many of the interview subjects. During the pre-test, I asked each question in French. After reading the question aloud, I asked for feedback on two levels: French grammar and vocabulary accuracy as well as clarity of the question. In testing for clarity, I asked Dr. Ndiath to explain to me what the question is asking and what type of information or response the question solicits.

The pre-test was informative and yielded important feedback on question structure and phrasing. Most of the changes made concerned French grammar and vocabulary; however, there were some important clarifiers added to ensure that the questions were easily understandable to a Senegalese audience. A list of the original questions and the final set of interview questions are included in Appendix C.

These interviews were designed to further strengthen the vulnerability and suitability analyses through ground-truthing the desk research on climate risks and the cultural site components. Additionally, the interviews aimed to supplement written research with anecdotal evidence and opinions of professionals heavily involved in the preservation of the Île de Saint-Louis.

5.4 Methodology III: Plan Analysis

The third aspect of the methodology is the analysis of two site management plans for the Île de Saint-Louis, the *Safeguarding and Enhancement Plan for Saint-Louis* (2006) and the *Action*

Plan for Saint-Louis (2015). The *Safeguarding and Enhancement Plan for Saint-Louis* was released in 2006 and was the joint effort of the Republic of France, UNESCO, the Republic of Senegal, and the City of Saint-Louis. The multi-volume plan's purpose was to present a comprehensive analysis of the existing conditions on the island, including an architectural inventory, and present recommendations for policy, design standards, and zoning. The *Action Plan for Saint-Louis* complements the 2006 plan. In essence, the *Action Plan* is the implementation plan for the 2006 *Safeguarding and Enhancement Plan*. The plan synthesizes the *Safeguarding and Enhancement Plan's* findings and recommendations and presents a series of focused objectives in order to implement the recommendations.

As stated in Chapter 3, site management plans are required for all UNESCO World Heritage site nominations and are encouraged to be maintained on a continual basis. The overall purpose of these plans is to outline how the site will be preserved and how stakeholders will be engaged in the preservation process. Included in the plans are standards and regulations, as well as suggested policy recommendations. All actions taken on the heritage site must, in theory, be in line with the site management plans. As such, it is important to analyze how these plans either support or challenge the implementation of green infrastructure on the island.

5.4.1 Analysis Method: Strengths, Weaknesses, Opportunities, and Threats

A commonly used analytical and evaluative method is SWOT (strengths, weakness, opportunities, and threats) analysis. Strengths and weakness remark on the internal positive and negative aspects of the plan, whereas opportunities and threats remark on the external aspects affecting the plan negatively or positively. In many examples of SWOT analysis for a plan, the SWOT is analyzing the plan itself, rather than the plan's ability to support a specific notion. However, the purpose of the plans analyses undertaken in this research is not to evaluate the site management plans' quality; instead, the SWOT will identify the plans' abilities to promote green infrastructure.

The analysis method used herein is modeled on the previous use of a SWOT analysis used to analyze a policy tool's ability to support sustainable soil protection. The study and SWOT analysis were undertaken by Central Europe Cooperating for Success, the European Union European Regional Development Fund, and Urban SMS Soil Management Strategy (Bory and Dallhammer 2009). The purpose of the study was to evaluate laws, policies, and regulations for their capability to influence the use of soil in an efficient and sustainable way and their

contribution to efficient and sustainable soil protection (Bory and Dallhammer 2009, 5). Like Bory and Dallhammer's study, this plan analysis aims to evaluate the site management plans for their capability to influence the use of green infrastructure, positively or negatively. Due to the similarity, the following analysis questions were modeled from the Bory and Dallhammer study. The questions asked during the SWOT analysis are found in Table L in Chapter 8.

Ultimately, the SWOT analysis was designed to indicate whether the plans adequately support green infrastructure interventions for climate change resilience or hinder the ability to use green infrastructure. It also identified which types of green infrastructure tools are affected in their potential implementation, either positively or negatively, by the plans.

5.4.2 *Plans and Anticipated Contributions*

As set forth in the *UNESCO Operational Guidelines for the Implementation of the World Heritage Convention*, "Each nominated property should have an appropriate management plan or other documented management system which must specify how the Outstanding Universal Value of a property should be preserved, preferably through participatory means (UNESCO 2015, 21)." The current management plan for the Île de Saint-Louis is contained in two documents: the *Plan de Sauvegarde et Mise en Valeur d'Île de Saint-Louis du Sénégal* (PSMV) of 2006, herein referred to as the *Safeguarding and Enhancement Plan for Saint-Louis* or *PSMV*, and the *Plan d'action 2015-2020 pour la mise en œuvre du PSMV de Saint-Louis* (*Action Plan 2015-2020 to Implement the PSMV of Saint-Louis*) of 2015, referred to as the *Action Plan*.

The *Safeguarding and Enhancement Plan for Saint Louis* was officially requested by the government of Senegal. It was written by a group of French-registered architects (DPLG - Diplôme d'architecte diplômé par le gouvernement) as part of the France-UNESCO Convention, a bilateral agreement that leverages French expertise in heritage preservation. The plan, consisting of two volumes, was published in 2006 while three appendices were published in 2007. It is meant to be a planning document that sets forth suggestions for how to protect the island. The document stresses that it aims to present planning solutions and not just restrictions. The first volume provides an in-depth analysis of the site's existing conditions, including its history, urban framework, urban morphology, architecture and institutional architecture, inventory of current buildings, and land use and ownership. The second volume lays out the proposed solutions. These consist of priorities, zoning proposals, and suggested regulations. The appendices contain reference texts and associated documents.

The *Action Plan* is a smaller document of 20 pages which is meant to act as an implementation plan for the *PSMV* of 2006. The *Action Plan* was created by a drafting committee of representatives from the local university, local government (the Division of Urban Development and Housing and the Office of Tourism), civil society, and the regional cultural center. The plan begins with an introductory note reviewing the contents of the *PSMV*. The body of the plan is written in three spreadsheets. Each spreadsheet presents a general objective with subsequent specific objectives. For each specific objective, a responsible party is listed, along with supporting partners and a timeline for implementation. The three general objectives are: managing the site, enhancing the site, and improving communication about the site.

I anticipated finding that the *Safeguarding and Enhancement Plan for Saint-Louis* focuses much of its attention on specific aesthetic and design standards in order to preserve the character of the island; these standards may, however, indirectly support or hinder green infrastructure implementation. Since the *Action Plan* was created nine years after the *Safeguarding and Enhancement Plan* and in response to its lack of implementation, I expected the *Action Plan* to yield more concrete goals and initiatives specifically focusing on the threats facing the historic island. Even the name of the plan harkens a sense of urgency that the 2006 plan does not and rightfully so; at the end of 2016, Senegalese officials met in response to a threat from UNESCO to remove the island from its World Heritage designation (AFP 2016). Additionally, I expected there to be an acknowledgement of the island's grave environmental situation, in the light of climate change, which ultimately affects the integrity of the island's architecture and road network.

Chapter 6: Case Study Findings

The case study of the Île de Saint-Louis examines five site components: residential buildings, non-residential buildings, public spaces, roads, and view corridors. Each of these components is integrally important to the Outstanding Universal Value of the UNESCO World Heritage Site. Additionally, each of these components has the potential to be threatened by climate change. Both the physical characteristics of the component and the public use and perception of the component were studied in order to determine its unique attributes and role on the island. Understanding these components is a critical step in making decisions regarding where and how green infrastructure can be implemented on the island. This chapter presents the findings of the in-depth case study of the island's components, including vulnerability analysis and a suitability analysis for green infrastructure intervention.

6.1 Cultural Site Components

The Île de Saint-Louis is 2 kilometers in length by 400 meters in width (.4 kilometers) totaling 80 hectares (197 acres) in area. The island is divided into three districts: South, Center, and North. The South District is divided further into the sub-districts of Sindoné and Kertian. The North District consists of the Bir N'Dar, Loodo, Khunt, and Bopp Ndar sub-districts, as seen in Map D (Action Plan 2015).

Map D: Map of island districts and sub-districts

Source: Action Plan 2015; translation by Author

There are 184 unique blocks on the island. The roads create strict block formations creating a strong delineation between public and private space, which follows Haussmann's town planning tradition (Martinez-Quintana and Caceres-Morales 2016, 298). The blocks' forms become weaker towards the north end of the island as much the original building occurred from the center of the island and then outward, to the south first (Martinez-Quintana and Caceres-Morales 2016, 295-301).

Five unique site components contribute to the island's form and are comprehensively examined in this case study. The site components are: residential buildings, non-residential buildings, public spaces, roads, and view corridors. It should be noted that some areas of the island can be identified as more than one site component. For example, the docks that line the island are viewed as public space, but also contain a road used for transportation. These multifunctional spaces are elaborated upon below. It should also be noted that three bridges on the island were not considered in this research because bridges are not often able to host green infrastructure.

These findings are the result of studying site documents, inventories, and plans and interviews with professionals. Interview findings are relayed in this chapter as they pertain to the site components. A further discussion on the interviews and subsequent findings are presented in Chapter 7.

6.1.1 Buildings

In this case study, buildings were categorized into residential and non-residential buildings, since there are unique uses and perceptions related to each building type. However, many building characteristics apply to both residential and non-residential buildings and therefore will be covered in this section.

Buildings on the island can vary from three to eight meters in height. 52% of the buildings are less than four meters and 38% of the buildings are between four and eight meters in height. Roof tops are either sloped, flat (terrace), or a mixture of both. 54% of the roofs are flat terrace roofs. Sometimes these roofs are covered with a permanent tent-like structure. 35% of the buildings have sloped roofs and only 10% of buildings have a mixture of sloped and flat roofs (Ecole d'Architecture de Lille 2005, 52). A map of the roof types is found in Appendix F. A plurality of buildings is built with concrete (45%). 42% of buildings are built with brick or with a mixture of brick and concrete. Only 6% of the buildings on the island are constructed with

wood or precarious materials (Ecole d'Architecture de Lille 2005). Wooden buildings are found mostly at the northern end of the island.

Part of the Outstanding Universal Value of the heritage site is its architecture. Important architectural aspects of buildings include covered flat roofs with a tent-like structure, wooden or iron balconies, decorated pillars and columns, wooden shutters, and decorated doors (PSMV 2006). Each building parcel was assigned a level of architectural interest in the *Urban and Architectural Inventory of Saint-Louis*: exceptional interest, significant interest, average interest, or no interest. Figure C illustrates the number of buildings assigned each level of architectural interest. A map of building parcels and their architectural interest level is found in Appendix F.

Figure C: Number buildings by level of architectural interest

Source: Author; Ecole d'Architecture de Lille 2005

The majority of the construction on the island occurred between 1856-1954 as seen in Figure D. As seen in the evolution of Saint-Louis (Map B in Chapter 1.2.2), the construction began in the Center District and then moved outwards, spreading more quickly to the South District and then finally toward the North District of the island. A map showing dates of construction can be found in Appendix F.

Figure D: Date of building construction

Source: Author; Ecole d'Architecture de Lille 2005

The buildings on the island are owned primarily by individual/private owners, which is understandable considering the dominance of residential buildings on the island (see Chapter 6.1.2). The Senegalese government is the second most dominate land owner on the island, owning 39.9% of the total land. Interestingly enough, the City of Saint-Louis government owns only 0.9% of the land on the island. As noted in Chapter 6.1.3, that there are many administrative buildings; however, most of these buildings are for the Saint-Louis regional arm of the national government. The French government owns 0.6% of the land. Their land consists of the French Consulate and its residential component just north of the Center District on the eastern side of the island. The Senegalese military also has a presence on the island. Its presence is primarily a nod to the historic significance of the island as a trade hub for West Africa; however, its geographic location near the mouth of the river remains important for the city's and nation's security efforts (Ecole d'Architecture de Lille 2005).

Figure E: Property ownership

Source: Author; Ecole d'Architecture de Lille 2005

An important characteristic of a building is its state of conservation. The *Architectural and Urban Inventory of Saint-Louis* assigned each building a state of conservation based on its appearance and structure. The states are: “good,” “fair,” “poor,” or “in danger.” More than half of the buildings are in good or fair states of conservations as seen in Figure F (Ecole d'Architecture de Lille 2005). A map showing state of conservation is in Appendix F. Image B shows representative examples of each state of conservation.

Figure F: State of building conservation

Source: Author; Ecole d'Architecture de Lille 2005

Image B: Buildings in varying states of conservation

GOOD STATE

FAIR STATE

POOR STATE

IN DANGER

Source: Ecole d'Architecture de Lille 2005

Both residential and non-residential buildings face similar preservation challenges as outlined in the *Architectural and Urban Inventory*. These building issues are depicted in Figure G. Many of the issues are associated with water and moisture. All of the buildings on the island are situated dangerously close to the water table. As such, no buildings have basements. Many building foundations are fragile (PSMV 2006). This fragility is exacerbated by the fact that the sewer network is not maintained, adding to increased moisture underground. Moisture from the ground seeps up and into the walls. The moisture and high humidity in the walls degrades the building material and cracks the wall coatings. Many 19th and early 20th century buildings were constructed with brick and coated in lime. This material selection was purposeful in that those materials allow moisture to escape from the walls. Additionally, the construction of interior courtyards and galleries facilitated ventilation throughout the entire building so that heat would

not be captured in any certain room. In some of the newer construction, materials are chosen without regard to the climatic challenges. These materials include concrete, tiles, and acrylic paint which are waterproof. As such, they trap moisture in the wall and block it from escaping (Ecole d'Architecture de Lille 2005).

Figure G: Building conservation problems

Source: Ecole d'Architecture de Lille 2005; translation by Author

Additional preservation challenges come from the salt air and heavy winter rains. It is recommended that roof drainage issues be addressed on a regular basis to ensure that water runoff is not pooling on a flat roof or running down the side of the building. Additionally, treating woodwork with natural products rather than synthetic products can help with moisture and salt issues. Lastly, there has been a trend in adding an additional story onto a preexisting building. This unsanctioned addition is not in line with the standards set out in the site management plan and it adds unbearable pressure to historic walls, causing structural problems (PSMV 2006).

As stated, both residential and non-residential buildings have some similar characteristics and suffer from the same set of preservation issues. However, there are additional unique characteristics for residential buildings as opposed to non-residential buildings. Residential

buildings and non-residential buildings are explored in more individualized depth in the following two sections.

6.1.2 Residential Buildings

Map E: Location of residential building lots on the island

Source: Author; Ecole d'Architecture de Lille 2005

There are 1,092 residential buildings on the Île de Saint-Louis (81% of the total building stock) (Ecole d'Architecture de Lille 2005). There are five notable types of residential buildings on the island: barracks (barraques), multi-story houses which include balcony houses (maisons à étage), gallery houses (maison à galerie), low houses (maisons basses), and modernist buildings (architecture de l'époque modern). Multi-story houses and gallery houses were primarily built in the 19th century, whereas the barracks, low houses, and modernist buildings represent heritage of the 20th century. Figure H shows the percentage of each building type present on the island. Appendix G shows diagrams of low houses, barracks, gallery houses, and balcony houses (a type of multi-story house).

Figure H: Percentage of residence by architecture type

Source: Author; Ecole d'Architecture de Lille 2005

The historic multi-story houses are primarily two stories tall and many of them are defined by second floor balconies. These balcony houses are found throughout the Bir Ndar and Loodo sub-districts in the North and the Kertian sub-district in the South. The island's urban image is defined by these houses. Their balconies line the streets, providing a multi-level interaction between residents in their houses and people on the street. Beyond their balconies, the houses are characterized by wooden shutters, ornate doors and thresholds, and brightly colored paint coating. Some of the houses have a covered outdoor penthouse. The houses have double sloped roofs made of terracotta tiles. The buildings were constructed with brick and covered with a lime and concrete coating. The balconies are wooden or made of wrought iron. Unfortunately, only half the number of original balconies still exist today (Ecole d'Architecture de Lille 2005, Volume 1, 31). These multi-story buildings are considered to have average to significant architectural interest according to the *Architectural and Urban Inventory*.

Many of the balcony houses along the north to south roads host commercial activities on the ground floor. In the building use statistics, mixed-use buildings are classified as residential, so there is no accurate count as to how many residential houses have commercial activities on the ground floor. Houses with commercial uses on the ground floor are recognizable based on their ground floor windows and doors. Windows are larger and the doors are often large and wooden for ground-floor commercial activity. Image C shows examples of a balcony houses with and without ground-floor commercial activities.

Image C: A purely residential balcony house (left) and a balcony house with ground-floor commercial (right)

Sources (left to right): Google Earth Panoramio – Alain56700 2011; Google Earth Panoramio - Nicola E Pina 2013

Image D: Characteristics of a multi-story house (left to right) – First Row: wooden shutters, ornate door, sloped roof; Second Row: wooden balcony, iron balcony

Sources (left to right): Suzanne Hirschi 2002; Suzanne Hirschi 2002; ARCAS 2011; Second Row: Suzanne Hirschi 2003; Suzanne Hirschi 2002

The gallery houses are some of the grandest on the island. There are 23 still in existence, spread throughout the South (in the Kertian sub-district), the Center, and the North (in the Bir Ndar, Loodo, and Khunt sub-districts) districts. The majority of them are found in Kertian. These houses were among the first permanent, constructed houses on the island for French colonists. They were built during the early and mid-19th century. They are not immediately recognizable as important from the street; however, their grandiosity is apparent from the interior courtyard. The courtyards are lined with galleries, which help facilitate ventilation throughout the house and provide space for household activities. The courtyards also host a staircase to the second story. The most famous of these staircases is found in the Maison des Soeurs de Saint-Joseph de Cluny, a former convent for the nuns who worked in the adjacent hospital (Image E).

Image E: Courtyard staircase in Maison des Soeurs de Saint-Joseph de Cluny

Sources (left to right): Google Earth Panoramio – Benoitdel 2011; Google Earth Panoramio – gfeonard 2010

Gallery houses on the island are of exceptional and significant architectural interest. Their states of conservation vary greatly. The majority of them are in a good or fair state. However, some of them are in a poor state of conservation. Most notably and unfortunately, the Maison des Soeurs de Saint-Joseph de Cluny in the Kertian sub-district is classified as “in danger;” however, it is also of exceptional architectural interest (Ecole d'Architecture de Lille 2005, Volume 7.2).

Image F: Characteristics of a gallery house (left to right) – two examples of internal courtyards with galleries and courtyard staircase

Sources (left to right): Accomodirect.com 2016; Trip Advisor 2016; Explore-Senegal.com 2015

The low houses are the most numerous of the historic houses on the island. They were built in the late 19th and early 20th centuries to house public officials who worked on the island. They are abundant in the Sindoné sub-district in the South and in the Loodo and Khunt sub-districts in the North. As suggested by their name, they are one-story houses. They are often colorful with decorated doors and a sloped roof made of terracotta tiles or tin. Some of them have verandas or flat roofs. Most of the low houses are classified as having significant to average architectural interest. Their states of conservation vary greatly between good and in danger (Ecole d'Architecture de Lille 2005).

Image G: Examples of low houses

Sources (left to right): Ecole d'Architecture de Lille 2005; Google Earth Panoramio – StefanoAbdou 2014; Google Earth Panoramio – Hans Sterkendries 2014

There are approximately 73 barracks on the island. These are small, one-story houses made entirely of wood with tin or terracotta tile roofs. They were built for workers during the early 20th century when there was a building construction boom on the island. They are built either directly on the ground or on a slightly elevated platform. While they are historic, they are considered of no architectural interest. They are scattered through the Sindoné sub-district in the South and the Loodo, Khunt, and Bopp Ndar sub-districts in the North. Many of them are in a poor state or in danger of being demolished due to structural problems (Ecole d'Architecture de Lille 2005).

Image H: Examples of barracks

Sources: Ecole d'Architecture de Lille 2005 (left); B. Toulhier 2011 (right)

The final notable type of residential architecture is the modernist apartment buildings. These buildings are two to three-stories tall and were built as “collective housing.” They were built in the mid-20th century and follow the principles of modernist architecture: clean structural lines and lack of ornamental detail. These buildings are scattered throughout the island (Ecole d'Architecture de Lille 2005).

Image I: Examples of modernist residential buildings on the island

Sources: Ecole d'Architecture de Lille 2005 (left); Google Earth Panoramio – Cristianoprz 2014 (right)

There are also a few hundred houses that do not conform to any of these classifications and do not have any historic relevance. Many of those houses have flat terrace roofs and are one to two-stories tall. The flat roofs are used for drying clothes due to the direct exposure to the sunlight. In all of the houses, except for the modernist apartment buildings, most of the household activities, such as cooking, washing clothes, and talking/playing games, are completed in the courtyard or backyard (M. Camara, Interview). Most of the people who live on the island are associated with the tourism or institutional (education and government) sectors in a direct or indirect way. Some families have lived on the island for a long time, whereas others are new arrivals (I. Thiam, Interview). In recent years, new families have come to build vacation houses and often value new construction over older buildings (M. Camara, Interview).

Image J: Examples of unclassified residential buildings

Source: Ecole d'Architecture de Lille 2005

6.1.3 Non-Residential Buildings

Map F: Location of the non-residential buildings on the island

Source: Author; Ecole d'Architecture de Lille 2005

While the vast majority of buildings on the island are residential, the non-residential buildings have a strong presence in certain areas of the island. The *Architectural and Urban Inventory of Saint-Louis* identified eight categories of non-residential uses: administrative, commercial, culture and sport, health, military, public works, religious, and school (Ecole d'Architecture de Lille 2005). Figure I shows the number of buildings by each non-residential use. Appendix F includes a location map of the different types of land uses.

Figure I: Number of non-residential buildings by use

Source: Author; Ecole d'Architecture de Lille 2005

The site management plan classified buildings by architectural style, grouping some of the building uses into one category. Schools, administrative buildings, and hospitals are classified

as “institutional architecture.” They are defined by a sense of ostentatiousness and grandness. Some of the buildings are neoclassical in style, boasting symmetry and order (PSMV 2006). Image J shows examples of institutional buildings on the island. Many of these buildings are found along the eastern side of Avenue Mermoz in the North District. The Center District has the most famous administrative building, the Palace of Governance. The land of the Palace of Governance once hosted the first fort on the island and some of the fort’s thick walls can still be seen. The regional administrative offices are within Palace of Governance (PSMV 2006). There are additional schools and administrative buildings surrounding the Palace of Governance, as well as in the South District.

Image K: Examples of institutional architecture (left to right) – Palace of Governance, hospital, Ameth Fall Girls’ High School

Sources (left to right): SaintLouisduSenegal.com 2016; Google Earth Panoramio – Aboundour 2007; NdarInfo.com 2016

Military architecture is considered separate from institutional architecture. The military buildings are primarily barrack-type structures. They are one-story buildings, designed to collectively feed and house soldiers. All of the military buildings are found in the far-north of the island in the Bopp Ndar sub-district (Ecole d'Architecture de Lille 2005).

Image L: Examples of military buildings

Sources: Ecole d'Architecture de Lille 2005

As mentioned before, many commercial activities are co-located with residential uses. However, there are still remnants of larger commercial wholesalers on the island. There are 12 remaining commercial warehouses on the island, along the eastern coast just north of the Center District. These were once bustling hubs for trade and commerce. The stocking side of the warehouse would open to the Senegal River, while the street side of the building was used for retail (Ecole d'Architecture de Lille 2005). Some of the commercial warehouses are still in operation today, but not to the same extent.

Image M: Examples of warehouses

Source: Ecole d'Architecture de Lille 2005

To serve the island's residential population, there are religious institutions scattered throughout the island. Some of the churches and mosques are relatively small and serve a small radius of blocks. The most notable church is the Catholic Cathedral located near the Palace of Governance. It was built in 1828 and was the first church built in West Africa. In fact, Kertian, the sub-district surrounding the church gets its name from the French word for Christian (chrétien). There are also a few large mosques on the island built for the predominant Senegalese Muslim population. The majority of the mosques were built in the mid to late-20th century (Ecole d'Architecture de Lille 2005).

Image N: The cathedral (left) and one of the island's mosques (right)

Sources (left to right): Google Earth Panoramio – Stefano Abdou 2014; Google Earth Panoramio – Didier Dubois 2011

Historically, the island has been associated with administrative power. As mentioned, it currently hosts the administrative activities of the regional government. However, recently, some administrative functions have been moving to mainland Saint-Louis. Marie-Caroline Camara, president of a local community organization, anticipates that this trend will continue as agencies realize the importance and efficiency of being more geographically accessible for their constituents (M. Camara, Interview).

6.1.4 Public Spaces

Map G: Location of public space on the island

Source: Author; Ecole d'Architecture de Lille 2005

Much of the island's land is occupied by buildings; there is not a lot of open, unused space. However, there are parts of the island that belong to the public realm, rather than the private. Public spaces on the island can be classified into one of three categories: public squares, roads, and docks. Map G shows the location of these public spaces on the island.

There are two traditional public squares on the island, the Place Faidherbe in the Center district and the Place Blaise Diagne in the Loodo sub-district of the North district. Place Faidherbe is located in a central area that is routinely passed by many residents and visitors to the island. It is 1,646 square meters (.14 hectares or .36 acres). It is home to the lushest vegetation on the island. The square is situated in front of the Palace of Governance and in between the bridges that connect the island to the Langue de Babarie on the west and the mainland on the east (PSMV 2006). The square is used for informal gatherings, concerts, and protests. Its perimeter is busy with traffic which dims the peaceful ambiance created by the vegetation (M. Camara, Interview). Figure J shows the Place Faidherbe both in an aerial image and figure-ground diagram. The figure-ground map shows private land in black. All buildings, roads, and the public space is in white. As seen, the square is grand as an outdoor space, but it is also lined with sizable buildings.

Figure J: Place Faidherbe

Source (left to right): Google Earth 2016; Ecole d'Architecture de Lille 2005, 27

Place Blaise Diagne is in the Loodo sub-district in the North district. It is located at the entrance of the northern bridge that connects the island to the Langue de Barbarie. It is 400 square meters in size, small compared to Place Faidherbe. It is also not planned like Place Faidherbe. Instead, it is a sandy patch of land. Sometimes it is used for markets, but it is severely underused.

The docks that line the island are important public spaces. In fact, Guiomar Alonso Cano, the Head of the Culture Unit for UNESCO's West Africa Office, stressed the importance of the docks as public space (G. Alonso Cano, Interview). They are used as walking paths and gathering spaces. Historically, they were used by fisherman and commercial traders. Today, some fisherman still use Quai Abdoulaye Mar Diop, the dock on the south west side of the island. There are four docks that line the island. They are all paved and coated in sand. Image N illustrates the characteristics of each dock.

Image O: The four docks on the island

QUAI JAY

QUAI ABDOULAYE MAR DIOP

QUAI ROUME

QUAI GIRAUD

Sources: Google Earth Panoramio – Emmanuel Gabolde 2008 (Quai Jay top), Hans Sterkendries 2012 (Quai Jay bottom), Che Coulibaly Camara 2012 (Quai Roume), Jose Sevilla 2012 (Quai Abdoulaye Mar Diop); Raul Medina 2007 (Quai Giraud)

Map H: Location of docks and images in Image N

Source: Author; Ecole d'Architecture de Lille 2005

Quai Abdoulaye Mar Diop in the southwest is 14 meters in width. It is lined by some houses, but mainly by institutional buildings such as schools and the hospital (Ecole d'Architecture de Lille 2005, Volume 3, 30). Quai Jay is on the southeast side of the island, directly across from Quai Abdoulaye Mar Diop. It is 20 meters wide. There have been some efforts by a neighborhood school to invest in the dock (Ecole d'Architecture de Lille 2005, Volume 3, 26).

Quai Roume, the dock that lines the northeast of the island, used to be very important for trade. Many of the commercial warehouses were (some still are) situated along this dock. It is now, for the most part, abandoned by commercial activity. The dock is maintained as a pedestrian space. The portion of the dock near the Center district is occupied by the Hotel de la Poste and its swimming pool. Opposite the Quai Roume is the Quai Giraud on the northwest side of the island. The northwest of the island was developed over a natural wetland. As such, the dock does not extend to the far north of the island. Instead, the northwest of the island has a natural bank, as seen in Image O. Some families have started small scale gardens along this dock on their own accord; it is not part of any official initiative (Alonso Cano, Interview). Beyond this, there is some spontaneous vegetation along Quai Roume and Quai Giraud (Ecole d'Architecture de Lille 2005).

Image P: The northwest point of the island (left to right) – ground level and aerial image

Sources (left to right): Google Earth Panoramio – Emmanuel Gabolde 2008; Google Earth 2016

In direct contrast to the northwest point of the island, the Southern Point, between Quai Abdoulaye Mar Diop and Quai Jay, is very established and considered a promenade for pedestrians. As seen in Figure K, the Southern Point has been transformed from a vegetated area in 1861 to a densely built area today. This transformation has created a public space for residents and visitors, but has decreased the point's resilience to flooding. There has been an effort to replant trees. The Southern Point has four rows of palm trees (Ecole d'Architecture de Lille 2005).

Figure K: Transformation of the southern point of the island

Source: Ecole d'Architecture de Lille 2005; translation by Author

Image Q: The Southern Point

Sources (left to right): Google Earth Panoramio – Crvzr 2012; Google Earth Panoramio – Pacou 2010

These docks have created an urban façade for the island. The docks add character to the island for those viewing the island from the mainland or further down the river. Marie-Caroline Camara says that the hard edges of the docks make the island appear as though it is a large boat on the Senegal River (M. Camara, Interview). This characteristic is noted by UNESCO as significant for the Outstanding Universal Value of the site and therefore, must be preserved (PSMV 2006).

One of the interviewees challenged the idea that public space on the island could be defined to any certain location. He explained that any space outside the home is used by the public in one way or another. He encouraged this research to look at roads as a public space as well. Many children use streets to play soccer and adults sit on the side of the street and drink tea and converse (I. Thiam, Interview). As such, it is important to consider the roads as public spaces, in addition to transportation paths, as they will be covered in Chapter 6.1.5. The *Architectural and Urban Inventory* agrees with this sentiment, particularly in the case of Mermoz Avenue. Mermoz Avenue extends through the North district's Khunt and Bopp Ndar sub-districts on the eastern side of the island. It is a grand avenue with a vegetated median. The median is used as a public space (Ecole d'Architecture de Lille 2005).

The public spaces suffer from environmental and management problems. Defective rainwater drainage systems in the squares and docks lead to flooding after heavy rains (PSMV 2006). Additionally, there is a lack of management of the public spaces. This has resulted in rundown spaces. In fact, some of the docks are used as residents' trash dump site (G. Alonso

Cano, Interview). Beyond Place Faidherbe and the median on Mermoz Avenue, there is little attention paid to maintaining the appearance of any of the other public spaces. This may change as there is a desire to rehabilitate the docks, which includes Place Blaise Diagne. Place Faidherbe is also slated for maintenance and renovation (G. Alonso Cano, Interview). However, it is unclear when these public space renovations may occur.

Traditionally, public space is thought to be associated with a concentration of vegetation. While there is vegetation present in the trees that line Mermoz Avenue, the Southern Point, and the Place Faidherbe, the majority of vegetation on the island is found on building parcels. There is a map in Appendix F that shows all the parcels with vegetation on the island.

6.1.5 Roads

The orthogonal street network on the Île de Saint-Louis is one of its most defining factors and was established through careful planning during the French colonial period (Martinez-Quintana and Caceres-Morales 2016, 292). The streets help define strict blocks of buildings without any setback. The road layout created three types of blocks: square (30 x 30 meters or 100 x 100 meters), rectangular (from north to south: 45 x 25 meters, 70 x 25 meters, or 75 x 50 meters; from east to west: 20 x 30 meters, 35 x 55 meters, 35 x 75 meters, 35 x 100 meters), and irregular blocks in the north of the island (PSMV 2006). The road pattern and blocks became more irregular in the north as it was the last area on the island to be developed (Martinez-Quintana and Caceres-Morales 2016, 292).

There are four types of road compositions: paved roads with sidewalks, paved roads without sidewalks, unpaved roads with sidewalks, and unpaved roads without sidewalks. Map I shows each road and its type of composition.

The longitudinal streets serve motorized transportation and host most of the commercial and administrative activity. For the most part, they are paved and have sidewalks as seen on the map. Since these streets are paved, there is a lot of runoff during heavy rains. Gutters were installed on the sides of the street between the street and the sidewalk to remove the water to the sewer network. However, these gutters become clogged with litter (M. Camara, Interview). In addition to motorized transportation (cars, motorcycles, and mini-buses), there are horse drawn carriages, bicycles, and pedestrians that use the street. Street vendors with their carts are present on these streets, as well. The most well-known longitudinal street is Mermoz Avenue. It is

Map I: Location of different road types

Source: Author; Ecole d'Architecture de Lille 2005

considered a larger public space due to the amount of people that use it on a daily basis and due to its tree planted median. It is much wider than the other longitudinal streets (PSMV 2006).

There are a multitude of latitudinal streets. Most of them are unpaved sandy streets with sidewalks, but some of them toward the north of the island do not have sidewalks. These streets are narrower and are more residential. They facilitate primarily pedestrian traffic and are quieter than the longitudinal streets (M. Camara, Interview; PSMV 2006).

All of the roads, even the quieter latitudinal roads, are active. People inside their homes engage with the activity on the roads when their balcony doors are wide open. Children play soccer in the street and groups of men sit and drink tea. In fact, the presence of sidewalks does not effect pedestrian activity since many pedestrians use the road itself as a sidewalk.

Image R: Examples of the four road types

PAVED WITH SIDEWALKS

UNPAVED WITH SIDEWALKS

PAVED WITHOUT SIDEWALKS

UNPAVED WITHOUT SIDEWALKS

Sources: Google Earth Panoramio – Purdon 2013 (Paved with sidewalks and Unpaved with sidewalks); Google Street View 2015 (Paved without sidewalks); Claude Thevenas 2011 (Unpaved without sidewalks)

Image S: Examples of road use (left to right) – First row: pedestrians on the road and the road as a gathering space; horse-drawn carriage; Second row: public transportation bus and pedestrian bench; street parking and goats; Third row: Street vendor carts; pedestrians

Sources (left to right): Google Earth Panoramio - First row: Susanne Bommeli 2010, F Olivier 2008, Second row: Alainchoquet 2011, Christianprz 2010, Third Row: Didier Dubois 2011, Erik Godderis 2014

It is no surprise that with the heavy use of the streets there are also maintenance issues. The asphalt coating or pavement has worn over time or cracked due to lack of maintenance. Additionally, since the sewer network is not maintained, there are drainage issues on all the streets that lead to flooding during and immediately following rains (PSMV 2006).

Image T: Examples of road issues

Sources: Google Earth Panoramio – Hans Sterkendries 2012

6.1.6 View Corridors

Map J: View corridors

Source: Author; PSMV 2006

When thinking about the preservation of the Île de Saint-Louis, it is imperative that its Outstanding Universal Value be considered first and foremost. In addition to the architecture and orthogonal street network, the island's geography contributes to its value. It sits in the delta of the Senegal River and is less than 400 meters from the Atlantic Ocean. Maintaining a view from the island to the small arm of the Senegal River onward to the Langue de Barbarie and finally to the Atlantic Ocean is important for the island. There are seven protected views on the western side of the island, all of them directed to the river, Langue de Barbarie, and Atlantic Ocean (PSMV 2006). Many of the view corridors originate approximately halfway into the island, as

indicated in Map J by dotted lines. The protected views on the southern edge of the island are directed towards the sandy beaches to the southwest of the island along the Langue de Barbarie. Finally, the seven protected views on the eastern side of the island are all directed in varying degrees of angle towards the Faidherbe Bridge. It is important to consider these protected views and their associated corridors in any sort of planning on the island, be it hard construction or green infrastructure interventions.

Image U: Examples of protected views

EAST VIEWS

SOUTH VIEW

WEST VIEW

Sources: Google Earth Panoramio – Emmanuel Gabolde 2011 (East View right), Jose Sevilla 2012 (East View left), JLB 2014 (South View), F Olivier 2008 (West View)

6.2 Current Risk Factors

In addition to preservation challenges, the Île de Saint-Louis faces climate risk factors. Saint-Louis is very vulnerable to floods, droughts, sea level rise and heat waves (Climate change and Urban Vulnerability in Africa 2012, 53). Like much of the Sahel region, the island experiences two seasons: rainy and dry. The rainy season lasts from June to October and is characterized by heat, humidity, and storms. The dry season is cool, breezy, and dusty, lasting from November to May (Climate change and Urban Vulnerability in Africa 2013, 68).

The island experiences periods of drought during the dry season and flooding during the rainy season. During the rainy season, the river can overflow causing more severe flooding (Climate change and Urban Vulnerability in Africa 2013, 19). Flooding on the island is caused by the following factors:

- Flooding of the Senegal River,
- Sandbars and silting of the river bed constraining the flow of water,
- Lack of rainwater runoff drainage due to the flat topography of the island,
- Limited rainwater runoff infiltration capacity, and
- Poorly maintained drainage network (Climate change and Urban Vulnerability in Africa 2012, 53).

The Île de Saint-Louis is extremely vulnerable to flooding due to its location in the Senegal River and near ocean currents. The breach in the Langue de Barbarie in 2004 was meant to help reduce flooding, but it has caused more problems as the breach has widened throughout the last decade (Climate change and Urban Vulnerability in Africa 2012, 53).

A study in 2013 identified the island's level of need for four ecosystem services: provisioning, regulating, cultural, and supporting. It was determined that there was a high need for provisioning ecosystem services. Since the island is very built-up, there is little land left to produce food or other environmental products. More related to climate change risks, the study also identified a significant need for regulating and supporting ecosystem services, such as climate regulation and water infiltration (Climate change and Urban Vulnerability in Africa 2013, 73-74).

6.3 *Future Risk Factors*

Climate change creates an uncertain and unpredictable future for weather patterns. Some scientists state that the planet is now facing a departure from all previously experienced climate patterns (National Research Council (U.S.). Committee on Ecological impacts of Climate Change 2008). This uncertainty is what makes climate change planning so difficult and the resilience of a city so important.

While the future climate changes threats to the Île de Saint-Louis cannot be predicted with complete certainty, some future patterns can be assumed based on previous data. The World Bank Climate Change Portal anticipates an increase in the duration of droughts, a rise in annual rainfall, sea level rise, and a rise in temperature on the island (The World Bank Group 2016). The city of Saint-Louis will face a risk of desertification; however, these affects may not be seen in the island. Heat waves are expected to increase from five days per year to 18 days per year between 1970 and 2050 (Climate change and Urban Vulnerability in Africa 2013).

6.4 *Vulnerability Analysis and Map*

Studying each of the five site components, along with the island's current and future climate threats, illuminated important composite variables needed to determine the vulnerability of each of the island's blocks. This vulnerability analysis equated vulnerability as sensitivity of the land and structures plus exposure to climate threats. The first composite variable, sensitivity, was determined by the state of conservation of the block's parcels and the type of construction present on the island. As seen in Chapter 6.1.2, barracks are built with wood and are more sensitive to climate than other structures. The second composite variable, exposure, was based on the block's proximity to the coast and lack of present vegetation. A map of the blocks with vegetation can be found in Appendix F.

Using these variables, the vulnerability of each block was calculated using a weighted equation as described in Chapter 5.2.4. A spreadsheet with the block-by-block vulnerability calculations is found in Appendix H. Map K illustrates the vulnerability findings for each block.

Map K: Vulnerability analysis map

Source: Author; basemap from Ecole d'Architecture de Lille 2005

It should be noted that the vulnerability of the docks, public spaces, and roads were not assessed in this analysis. As mentioned in the suitability for intervention analysis below, docks, public spaces, and roads provide available space and therefore, opportunity for green infrastructure interventions. It is assumed that adjacent docks, roads, and public spaces will be implicated in any actions taken on identified blocks.

The vulnerability analysis found that the majority of the island is at a medium vulnerability level; however, it appears as though the vulnerability of blocks was skewed based on an outlier: the block extension at the far north of the island (seen in Image U). This is a dock extension that hosts an open-air nightclub. It was included in *Architectural and Urban Inventory* as its own block since a structure is placed permanently on the dock. As seen in the photographs, the structure has been battered by the wind and the river. It is extremely vulnerable to the elements and its very existence is compromised if the river floods.

The west coast of the island, along Quai Giraud and Quai Abdoulaye Mar Diop, and the Sindoné sub-district in the South is where the majority of the vulnerable blocks are located. There are clusters of blocks that are classified as vulnerability rating “3” along the west coast of the island. They all received a similar rating because

of their proximity to the coast and similar block composition with buildings in varying states of conservation.

For the most part, the least vulnerable blocks host the hospital, the French consulate, a mosque, and military buildings. There were four blocks that received a vulnerability rating of “4.” These blocks all border the coast, but also are heavily populated by buildings in poor states of conservation or deemed to be in danger. This contributed to their high vulnerability rating.

The vulnerability analysis findings were as expected for the most part; however, I was anticipating more vulnerability in the far north of the island, since it has a more irregular development pattern and was the last part of the island to be settled. Perhaps its abundance of blocks with vegetation helps to make the area less vulnerable.

Image V: Northern Block Extension

Source (left to right): Ecole d'Architecture de Lille 2005; Google Earth Panoramio – Raul Media 2006

The blocks with a higher vulnerability tend to have more buildings with no architectural interest. This makes sense since construction type was a variable for sensitivity.

The buildings of architectural interest are considered “hard construction” whereas buildings made out of wood or precarious materials have no architectural interest. If the vulnerability equation variables included age of construction or level of architectural interest, then the pattern of vulnerability on the island might have changed. If this research was solely focused on the preservation of the architecturally significant building stock on the island, then those variables would have been important. However, this research concerns the entire site as a whole. That is why it is important to consider all buildings that contribute to the overall urban fabric of the island, including those with no architectural interest.

6.5 *Suitability for Intervention Analysis and Map*

The vulnerability level of each block was used as a variable for determining suitability for green infrastructure intervention on the island. Suitability was derived using vulnerability plus opportunity for green infrastructure. Opportunity was calculated by the amount of vacant land included on the block and the number of buildings with no architectural interest. An explanation of those variables and the weighted calculation is found in Chapter 5.2.5. A spreadsheet with each block's suitability for intervention calculation is found in Appendix I.

As in the vulnerability analysis, the suitability analysis does not include docks, public spaces, or roads. All of these spaces are suitable areas for green infrastructure due to their open space and the way in which they connect spaces on the island. If the block is suitable for green infrastructure, then its adjacent docks, public spaces, and roads will be implicated in the intervention.

Not surprisingly, most of the island is only suitable for limited forms of green infrastructure intervention. Due to the historic nature of the site, there are large parts of the island that have strict design regulations that hinder the types of green infrastructure implementation that is allowed. This is why the central district of the island, where many of the architecturally significant and older buildings are located, was found to have suitability for very limited green infrastructure intervention. It should be noted that blocks colored in red are not unsuitable for green infrastructure; they just require more attention paid to design regulations. It is also not surprising that the north of the island has many suitable blocks since it was developed more recently and there is more vacant land. However, there is still considerable suitability in the southwest of the island, as well.

It is interesting to note the differences in the vulnerability map and the suitability map. There are many blocks that received a moderate to high vulnerability rating that were deemed suitable for only limited green infrastructure interventions. Many of these blocks did not offer as much opportunity for green infrastructure due to the presence of buildings with exceptional or significant architectural interest. While this analysis prioritizes blocks on the islands that are both vulnerable and suitable for green infrastructure, it is necessary to ask, "How can vulnerable blocks that are less suitable for green infrastructure receive benefits from green infrastructure in order to further their preservation?" While it may be difficult to design green infrastructure to fit within the inflexible historic design standards, it is worth exploring. In the meantime, these blocks may

Map L: Suitability for GI intervention map

Source: Author; basemap from Ecole d'Architecture de Lille 2005

receive the benefits of green infrastructure if the interventions are placed nearby. Green infrastructure interventions do not exist in isolation. Successful green infrastructure is a network of connected interventions. With that, blocks that may not be as suitable for green infrastructure can still receive the benefits of the connected green infrastructure network around them.

This suitability analysis identified of suitable areas for green infrastructure interventions on the island. The results of this analysis are combined with the interview findings and plan analysis findings to create intervention suggestions for identified areas on the island in Chapter 9.

Chapter 7: Interview Findings

Interviews were conducted with professionals who had worked on the preservation of the Île de Saint-Louis in some capacity. The professionals were chosen to represent a variety of different backgrounds: community associations, academic institutions, foreign government agencies, and international heritage organizations. The interviews helped validate and illustrate the case study findings since a field visit to the site was not feasible due to time and distance. Additionally, these interviews brought personal opinions and insights to the research, whereas the published reports, plans, and inventories are all official documents. Each interview provided unique insights, elaborated upon below. Additionally, some of the interview findings are included in Chapter 6.1 as they pertain to the five site components. In the final section of this chapter, the interview findings are compared and contrasted to illuminate major themes.

7.1 *Heritage Professionals*

UNESCO and ICOMOS are both international heritage bodies that are concerned with the preservation of the Île de Saint-Louis; however, they are not involved in the daily preservation activities. As seen in Chapter 3, international heritage organizations play a supporting role in preservation. Due to this, they approach preservation with different priorities and a different perspective than a local preservation organization.

I interviewed Ms. Guiomar Alonso Cano, the Head of the Culture Unit in UNESCO's West Africa Regional Office. When asked about the main threats facing the island, Alonso Cano read directly from the World Heritage Committee's report (Decision: 40 COM 7B.18) from 2016. The major threats included the poor state of conservation and management, new construction that is not fitting with the style of the island, poor restoration of existing buildings, and the rising levels of the Senegal River. I asked her to elaborate on threats that are related to the changing climate, including the rising levels of the Senegal River. She made it clear that beyond what is listed in the report, UNESCO has not identified any additional threats. However, she has heard that the rising river levels that pose a threat to the island are due to the unintended consequences of the breach in the Langue de Barbarie in 2004.

UNESCO has not been directly related in any climate change projects or studies on the island. In the years since the site received UNESCO designation, site managers and stakeholders have solicited UNESCO for support regarding their preservation priorities. This has led to

monitoring missions and suggestions from the World Heritage Committee. Not once during those years has a stakeholder approached UNESCO concerning climate change on the island. She wonders if this is because stakeholders interested in climate change may seek another organization or ministry's help rather than UNESCO's assistance. Perhaps stakeholders see other organizations' missions as more aligned with environmental or climate change related efforts. This perception may dissuade stakeholders from reaching out to UNESCO; however, it should be noted that UNESCO's World Heritage mission includes providing assistance to World Heritage sites in danger and to ensure the protection of cultural heritage, which can include climate change response efforts (UNESCO World Heritage Center 2016).

She believes that the most vulnerable part of the island is its docks. These docks act as public spaces, but they are exposed to flooding. The foundations of the docks are being compromised. She sees opportunity for green infrastructure through restoring the docks and the Place Faidherbe, but stressed that any green infrastructure intervention undertaken must be in line with the authenticity and integrity of the site. Replanting palm trees would be a good project since it harkens back to the historic state of the island. Throughout the past few decades, the island has lost some of its tree cover. Through restorations of public space, she can see incorporating permeable pavement and rain gardens. She also liked the idea of rain water harvesting, as that is needed during areas of drought. The one green infrastructure tool she cautioned against was green roofs since many of the buildings have restrictions on structure modifications.

While she is not involved with the day-to-day operations of the site, she suggested that the district and sub-district traditional leaders would be good partners in implementing green infrastructure projects on the site.

7.2 *Researchers and Academics*

The University of Gaston-Berger is the only university in Saint-Louis and has a large institutional presence throughout the city and the historic island. The university's students and faculty have been engaged in heritage preservation work. Both the *Action Plan* and the *Architectural and Urban Inventory of Saint-Louis* were supported by the work of Gaston-Berger associates. I interviewed two faculty members at the university who have been involved with heritage preservation activities, Fatima Fall and Ibrahima Thiam.

Fatima Fall is the Director of the University of Gaston-Berger's Center for Research and Documentation of Senegal (CRDS). CRDS works on a wide variety of projects in multiple sectors. They lend project management guidance and house a lot of important documents, such as photographs, maps, and legal documents in their archives. While the university is situated on the outskirts of the city of Saint-Louis, CRDS' office is on the Île de Saint-Louis in the South's Sindoné sub-district. CRDS employees either live on the island or commute to the island every day for work. The Center and its director, Fatima Fall, have played an integral role in providing support and data for projects related to the heritage site. They have been involved with the designation nomination, the seminal *Architectural and Urban Inventory of Saint-Louis* of 2005, the *Safeguarding and Enhancement Plan (PSMV)* of 2006, and the *Action Plan* of 2015. She chaired the *Action Plan* committee and was responsible for creating and coordinating the interdisciplinary group.

Interestingly enough, she did not reference the *Action Plan's* goals or objectives throughout the interview; however, she did stress the importance of abiding by the design and building standards outlined in the *PSMV*. She identified poor communication with the public as one of the top three biggest threats facing the preservation of the island. There are many documents, such as the site management plans, that are not shared with the public. She stated that governmental corruption is an issue and could play a role in the lack of transparency and why documents are not shared with the public. They are available online, but are not easily accessible for people without internet or if someone does not know where to look online. She thinks that if these documents were more readily available, there would be less ignorance regarding heritage preservation, which she identified as another top threat to preservation. She suggested a guide be produced for homeowners on the island, educating them about the importance of proper restoration and maintenance of historic structures. The lack of respect for appropriate construction on the island was her third identified threat to preservation.

She only identified one threat associated with climate change: the Langue de Barbarie's breach and related frequent flooding. In fact, she did not contribute much insight into the climate change threats on the island. She explained that the entire island is vulnerable to flooding, but that the northern and southern ends are slightly more at risk since the building stock is more precariously constructed. She ended in saying that green infrastructure is an idea to consider, but that not many of the tools presented would be feasible on the Île de Saint-Louis. She suggested

focusing on tree planning and green façades. She thought that tree planting could be implemented along the river on the western, northern, and southern sides of the island, but not on the eastern side due to a high frequency of traffic. As for green façades, she believes that its success and acceptance by the local population will depend on the type of plant and what it looks like. Since bougainvillea is present on the island, she suggested using bougainvillea or another plant that looks similar. Examples of bougainvillea on the island can be seen in Image V.

Image W: Examples of bougainvillea on the island

Source (left to right): Trip Advisor 2017; Google Earth Panoramio – Erik Godderis 2014

In addition to Fatima Fall at the university's CRDS, I interviewed Ibrahima Thiam, a researcher and professor at the University of Gaston-Berger. He is a professor of heritage, but focuses primarily on intangible heritage in Saint-Louis. I was interested in interviewing Thiam based on his research focus. While his research focuses heavily upon the built heritage of the island, intangible and tangible heritage should not be thought of as in a silo. How people use the tangible site is linked to intangible heritage, such as the traditions related to long family lineages of fishermen or the works of musicians who have drawn, and continue to draw, inspiration from the historic site.

Thiam also believes that intangible and tangible heritage must work symbiotically. He believes that intangible heritage is threatened when built forms are threatened. He is seeing that people in the Saint-Louis region have had to move due to climate change. They move to seek other jobs or because their land is no longer suitable for building. Due to these migrations, family traditions are lost or diluted. While the loss of intangible heritage to climate change is beyond the

scope of this research, it would be an interesting area to research further. Thiam explained that the University of Gaston-Berger has a strong commitment to serving the local community. The university sees service as one of their core values and will likely continue to play a significant role in future preservation activities. He explained that student associations are very active in physical volunteer events, such as clean-ups on the island, and could be a source of partnership when implementing green infrastructure.

He identified coastal erosion and manmade pressures and destruction as the top threats to the preservation of the island. These later threats were expressed in the same manner as Fall. The public is unaware and ignorant about what constitutes appropriate restoration and construction. Additionally, he placed emphasis on the manmade breach in the Langue de Barbarie, explaining that the breach has altered the natural ecosystem. Formerly, the Langue de Barbarie could act as a barrier from the ocean, insulating the island in the Senegal River. While flooding occurred from time to time, the island was relatively protected. However, after the breach was made during an emergency flood event, it continued to expand creating a new mouth for the Senegal River. This has exposed the island to more flooding, exacerbated by the Atlantic Ocean. Due to this, the ecosystem is fragile and the resilience of the island is weak, according to Thiam. He explained that the blocks touching the coasts of the island are the most vulnerable; however, the entire designated heritage site is relatively vulnerable. When considering climate change resilience of the island, he suggested focusing not only on the protected heritage designation site boundary, but also on the supporting zones around the island which include the Langue de Barbarie, the river, and part of the mainland.

The concept of green infrastructure was new to him and he believed that it would be a new approach for many people who live on the island. He did note, however, that the idea of greenery on the island is centuries old. There used to be a lot of trees and vegetation on the island in the 18th and early 19th centuries, but overtime its presence has been reduced due to lack of maintenance and replanting. He thinks that tree planting may be the easiest entry to implementing green infrastructure on the island since it is familiar to people. People associate trees with history and a pleasing environment. Still, he anticipated the following challenges to implementing green infrastructure:

- Explaining the concept and importance of green infrastructure to the residents on the island: Many people view greenery as important for aesthetics or for producing food.

It would be imperative to educate people on the multifunctionality of green infrastructure so that they respect and maintain it properly. Citizen education is key.

- Managing insects: Many people have a fear of insects near their property because of their ability to spread disease. The green infrastructure chosen could not provide habitat for disease-carrying insects, such as mosquitos and flies or else it will not be accepted by the population.
- The lack of available space: The island is dense with buildings and therefore there is not a lot of space to implement green infrastructure. Identifying areas that could host green infrastructure that is in line with the design standards outlined in the site management plan may be difficult.

He ended in saying that while green infrastructure has the potential to preserve the island in the face of climate change, it cannot encumber the authenticity and integrity of the historic built environment.

7.3 *Community Organizations*

Since green infrastructure is most successful when it engages a variety of stakeholders and members of the community, it was important to interview a local community organization. Marie-Caroline Camara is the President of the Association Entre'vues, an organization that promotes heritage appreciation through programming and education. Some of the association's activities include, "Open Doors Day" and Heritage Clubs at three different high schools on the island. Open Doors Day occurs once a year. During the day, historic buildings on the site open their doors to the public. This day encourages the public to discover and interact with the heritage around them. She is a motivated leader and has an astute view of the island and its future. Her background inspired her to work on issues of heritage preservation. She is half-French and half-Senegalese. During her travels to France, she saw that historic preservation could have great economic and social benefits for the community at-large and she wants that for the Île de Saint-Louis and its community members.

She identified three categories of threats facing the site: internal threats, downward trajectory threats, and ecological/geographical threats. By internal threats, she referred to the lack of understanding and awareness of the importance of heritage preservation as many of the other

interview subjects mentioned. She explained that there needs to be a concerted effort made to raise awareness and inform the public of how they will benefit personally and collectively from preserving the heritage site. Many of the residents on the island are wealthy and well-educated; however, because of their elevated status they believe they are entitled to do whatever they want with their property, including demolition and new construction or inappropriate restoration. Camara stresses the need for incentives to accompany educational programming, so that homeowners are rewarded when they keep their properties adhering to the design guidelines in the site managing plan. Camara also explains that due to the lack of understanding the importance of historic preservation, there is a lack of urgency to implement related policies or programming.

She feels as though the time left to save the integrity of the site is quickly running out. More and more architecturally significant buildings are lost on the island every year due to demolition for new construction or demolition due to a compromised structural state. The downward trajectory is advancing and in order to halt it and reverse it, there needs to be greater attention paid to standards and regulations in the site management plans. Homeowners need to be held accountable when they do not respect the plans.

The third category of identified preservation threats is ecological and geographical threats. She asked the rhetorical question, “Will the island still exist in the future due to sea level rise?” The Langue de Barbarie’s breach continues to widen as its shores continue to erode. At the same time, the Atlantic Ocean’s sea level is rising. Despite these evident climate threats, people continue to remove sand from the Langue de Barbarie to construct new houses or coat roads. While there are certain climate change threats that cannot be reversed (such as sea level rise), humans need to stop exacerbating the threat through ecologically inconsiderate actions.

After elaborating on those threats, I asked her how she imagined the island in the future. Camara explained to me that the strong institutional presence on the island will decrease in the future. Many government offices, local and regional, are moving their operations to the mainland of Saint-Louis in order to be closer to their constituents. Additionally, new homeowners are choosing to look on the mainland rather than the island. They want to build new on the outskirts of town or purchase property in pre-established, modern neighborhoods, aligning with a commonly accepted opinion in Senegal that new is better.

As institutions and homeowners move to the mainland, Camara believes it is important to start thinking about another phase in the island’s life. Camara, a dual citizen of both France and

Senegal, harkens back to her upbringing in France. She envisions the island becoming more like its namesake in Paris, the Île Saint-Louis. Rather than hosting the functions of local and regional government, the Île de Saint-Louis has the potential to become a historic district that provides a retreat from the bustling mainland city. However, she was quick to mention that the island should not become a museum; it should remain active. One suggestion she had on how to keep the island full of activity in the future, even if population levels fall, is to use the old high schools to host university courses for students from the University of Gaston-Berger studying history or heritage-related studies. She stressed the importance of including intangible heritage as part of the site in order to complete a holistic experience for a visitor.

Camara provided excellent insight into the feasibility of green infrastructure tools on the island. She reviewed the following tools:

- Green façades: There are already some green façades on the island in the form of bougainvillea coated fences and houses. The bougainvillea were planted by the French. While they are quite beautiful, some Senegalese people do not like the plant because they think it looks unwieldy and attracts insects. Despite this view, Camara believes that green façades could be feasible on the island. She cautions that the plants used for the façades must be resilient and not require a lot of maintenance. Due to the sandy winds on the island, many plants need to be brushed off to stay healthy. Needing to complete this task for a green façade would present an inordinate amount of work.
- Green spaces/trees: The island used to be known as the “Coconut Tree Town;” however, many of the trees are no longer present. In order to return the island to its historic state, there has been a community effort to plant coconut trees. It is also forbidden to cut trees on the island. Some of the common trees found on the island are coconut trees, baobab trees, and palm trees. Camara thinks it might be interesting to start a tourism initiative around the existing trees on the island. She imagines that the tour could visit the oldest trees on the island and explain the history of the island’s development.
- Green roofs: This green infrastructure tool would be difficult to implement on an entire roof since people use their flat roofs for hanging clothes to dry; however, a portion of the roof could be dedicated to a green roof installation.

- Rain gardens: Camara was concerned about rain gardens holding stagnant water since many people are weary of any place that malaria-carrying mosquitos can breed.
- Community gardens: Camara was intrigued at the idea of community garden projects. She sees them working well in school settings, as they can be used for a learning experience, as well as for food production.

While she sees potential for community gardens, tree planting and green space planning, as well as green façades on the island, she stated that there is more opportunity for such interventions on the mainland. New districts and neighborhoods are being built as the city continues to sprawl which provides more opportunity to plan green infrastructure in the nascent states of development.

In all the positive comments she had about the potential for green infrastructure, she gave two warnings. She reiterated the fact that any intervention that increases the number of disease-carrying insects will not be accepted by the community. She then emphasized that salt may present issues for implementing green infrastructure. The salinized water that surrounds the island causes issues for construction, as seen in Chapter 6.1.1, but it also causes issues with planting greenery that cannot withstand the salt. Camara's feedback on the green infrastructure tools' opportunities and challenges provided great insight in order to make decisions regarding what types of green infrastructure could work on the island and where.

7.4 Foreign Professionals

There are many foreign organizations and agencies from around the world that have a presence in Saint-Louis. Since Senegal was a French colony, there are many French-Senegalese partnership projects and French organizations working in the city. Suzanne Hirschi is a French-registered architect (DPLG - Diplôme d'architecte diplômé par le gouvernement) and architecture professor at the Ecole d'Architecture de Lille. She has been involved in preservation activities on the site since its designation. In 2005, she led the extraordinary effort to produce the 9-volume *Urban and Architectural Inventory of Saint-Louis*. She was also part of the team that wrote the *PSMV* in 2006. She is currently working for the French Agency for Development on building preservation on the site. She is tremendously knowledgeable about the site and passionate about protecting cultural heritage.

When asked about the three major threats facing the preservation of the island, she could not limit herself to just three, although the threats can be categorized into three themes: environmental threats, threats from the public, and threats from institutional stakeholders. The environmental threats include rain, river flooding, sea level rise, the breach in the Langue de Barbarie, and the sandy foundation of the island. The sand causes foundation issues for the buildings. She explained that in other parts of the world with sand as their ground matter, buildings are built elevated or in a way that protects the building from the sand. In Saint-Louis, the buildings are built directly on the sand. As for rain, poor or unmaintained drainage systems on the roofs of the houses cause the rain to drip down the sides of the buildings, slowly deteriorating the structure. Her comments concerning the breach in the Langue de Barbarie were similar to those of other interview subjects. However, she stressed the point that the coastal erosion of the Langue de Barbarie has not only made the Île de Saint-Louis more vulnerable, but it has also threatened the livelihoods of local fisherman. Recently, assistance from the Dutch government has been sought regarding how to build coastal defenses.

Hirschi lamented the lack of interest in new homeowners to preserve historic structures, citing that their money and status makes them feel entitled to do whatever they wish to their property rather than follow the design guidelines outlined in the site management plan. She then said that this lack of interest extends to institutional stakeholders as well. In her opinion, there seems to be a lack of interest and motivation on the part of the government to follow through on important preservation activities. Hirshi said that they do not take advantage of the money, technical expertise, and plans at their disposal. She illustrated the consequences of such inaction: in 2005, 700 buildings were restored through a joint effort involving multiple international and national organizations. A few short years later, 160 of those buildings were demolished for new construction or due to lack of maintenance, against the site management regulations, with no resulting reprimand.

I asked her to geolocate which parts of the island are threatened the most. She explained that the question, in her opinion, was irrelevant. Every building is threatened in its own way. She stated that it is important to build the resilience of each building according to its needs. This suggestion lends itself well to the block-by-block vulnerability and suitability analysis approach taken in this research.

She had many suggestions on how to improve the preservation efforts on the island. First and foremost, the river needs to be managed. This requires a lot of political maneuvering and resources, making it a long term action item. In the short-term, she sees opportunities to manage the mouth of the river (the breach in the Langue de Barbarie) through building up defenses. Perhaps constructed wetlands or barrier islands could help. Additionally, the trash pollution in the small arm of the river needs to be cleaned up to allow for better water flow between the Langue de Barbarie and the Île de Saint-Louis. As for green infrastructure on the island itself, she thinks that rain gardens and tree planting would be the most useful and fit into the urban fabric. She believes that green façades may cause more issues for the some of the historic structures.

Hirschi ended in saying that the island is in danger of having its designation revoked. As an architect, she is primarily concerned with the buildings' states of conservation; however, she realizes that the effort to restore the island needs to be more holistic. She believes that there needs to be widespread urban planning, rather than just preserving structures.

7.5 Discussion of Findings

Similar themes regarding preservation threats and green infrastructure approaches emerged during the interviews. Firstly, it was obvious that a great deal of concern and work has been dedicated to the island throughout the past decade. Every interview subject expressed a desire to preserve the island, although their levels of involvement differed. The interview question that yielded the most impassioned responses was the very first one: "What are the top three biggest threats facing the preservation of the Île de Saint-Louis?" None of the interview subjects hesitated to answer this question and some of them had more than three threats to explain. Many of the interview subjects cited the public as one of the top three threats to the preservation of the island. They saw human activities and actions as detrimental to the site, overall. These activities included inappropriate restoration, demolishing buildings, and not maintaining buildings. Interestingly enough, none of the interview subjects blamed the public themselves. Instead, they blamed the ignorance of the public. They suggested more transparency regarding preservation standards and more targeted public information campaigns so that homeowners know their responsibilities and that the general public understands the importance of preservation. While the public was identified as a threat, only one interview subject stated institutional or organizational capacity as an issue for preservation. I was anticipating inaction on the part of institutional actors to be

highlighted; however, expressing opinions on that matter is controversial and the interview subjects may have wanted to avoid such matters.

Beyond human threats to the preservation of the island, the interview subjects all mentioned the effects of climate before I asked the second interview question concerning the top three climate related threats to the preservation of the island. This proves that climate change is perceived as a veritable preservation threat and not a secondary concern. It is interesting to note that while climate change-related events were seen as major threats to the island, the UNESCO perspective did not report being aware of any specific activities to help address climate change threats. No other interview subject revealed past, present, or future plans to address these threats either. There is a disconnect between the acknowledged understanding of the threats of climate change to the island and subsequent action. Perhaps this results from other non-heritage-related organizations addressing climate change, such as the Dutch government, the Korea International Cooperation Agency (KOICA), and GERM (Research Group for the Study of Migration and Society at the University of Gaston-Berger) (S. Hirschi, Interview). Despite the reasons for the disconnect, one would think that there would be more symbiosis between heritage preservation planning and climate change planning on an island faced with such grave climate change threats.

All of the interview subjects stressed the effect of the Langue de Barbarie's 2004 breach on the island. The breach caused more vulnerability to flooding. In fact, four of the five interview subjects stated that the question of climate change on the historic island cannot be addressed without first looking at the resilience of the Langue de Barbarie.

The final common theme among the interview subjects emerged when discussing the potential for green infrastructure interventions. The interview subjects revealed that there are many potential partners for green infrastructure intervention and programming on the island. Local schools, university student groups, and district and sub-district traditional leaders were all mentioned as potential partners. This suggests that green infrastructure interventions may be more easily implemented on a community-level rather from a top-down initiative.

While there were common themes that emerged from the interviews, there were also illuminating differences. The most notable difference was in the interview subject's ability to provide information and suggestions on preservation activities. I did not explicitly ask interview subjects to explain how green infrastructure could be implemented or how preservation activities could be improved to address the current threats; however, many of them offered suggestions,

unsolicited. These suggestions included potential community partners (such as schools and local leaders, as mentioned above), programming (school community garden programs and community awareness campaigns, for example), and specific intervention considerations (such as, install bougainvillea, but not another type of climbing plant for a green façade). The amount of action-oriented suggestions the interview subject provided was directly correlated to how engaged the interview subject is in the daily activities of the island. Marie-Caroline Camara, the president of a local community organization, provided many suggestions that were framed in an action-oriented manner, whereas Guiomar Alonso Cano of UNESCO provided more general, static information on the site.

Additionally, there were differing opinions on what kinds of green infrastructure could work on the island. Rain gardens, green facades, and green roofs were the green infrastructure tools that received the most conflicting feedback. Alonso Cano and Fall said that rain gardens could work; however, Camara warned against their use due to community perceptions of water and disease. On the other hand, Camara saw green roofs as a possible approach on some buildings if modified to not take up the entire space of the roof, whereas Alonso Cano and Hirschi did not think green roofs would be appropriate at all on the island. Bougainvillea was touted as a green façade possibility by some interview subjects. However, Camara explained that some residents do not like the plant and plants near buildings with insects and potential disease. These varying opinions on possible green infrastructure approaches highlight two important findings. Firstly, community perceptions regarding vegetation varying widely on the island. Some associated vegetation with history and a beautiful aesthetic, whereas others associate it with disease and insects. This illustrates the importance of engaging the community and soliciting input when decided on green infrastructure interventions. Additionally, it also highlights that interventions should be done on a very localized level, based on the desires and needs of the residents, rather than taking an island-wide approach. These varying perspectives also illustrate that the regulations and standards regarding development and intervention on the island are not clear or explicit. The site management plan was mentioned three times in three separate interviews, but there was no common understanding of what kinds of green infrastructure would be allowed or not allowed on the island.

These interviews complemented the case study and provided insight into preservation threats and the possibilities for green infrastructure interventions on the island. There were three major findings that emerged from these interviews:

1. Green infrastructure interventions are possible on the island, but at varying degrees. Tree planting is the most acceptable form of green infrastructure, as it aligns with historic tree planting schemes. Other interventions, such as green facades, green roofs, rain gardens, and permeable pavement may be possible, depending on the location. All interventions must be in accordance with the authenticity and integrity of the site.
2. Community education and involvement is needed to address both preservation threats and climate change threats. As mentioned, communities need to be involved in the planning for green infrastructure in order for the interventions to be accepted and suitable for the neighborhood. On a more general note, there needs to be more communication regarding preservation standards on the island and the importance of heritage preservation.
3. Climate change planning on the heritage site must extend beyond the parameters of the designated protection area. In the case of the Île de Saint-Louis, the Langue de Barbarie's resilience is directly related to the island's resilience. This finding suggests the need for future research that considers the relationship between the Langue de Barbarie and the island.

While these interview subjects provided diverse perspectives regarding the preservation of the Île de Saint-Louis, it would have been beneficial to have a few more professionals, such as a government representative, the site manager, a community development professional, and an environmental science professional or researcher. Government officials were difficult to reach due to the lack of contact information available. I was able to get through to their staff members; however, that contact never manifested into an interview. I was not able to find the contact information for the site manager of the Île de Saint-Louis, nor was it offered to me when I asked other interviewees for the information.

I established contact with eight other professionals involved with heritage planning, community development, and the environment. They all agreed to be interviewed; however, none of them sent the signed consent form. Two of them set up interview times and then did not respond to the interview call. While I do not know for sure why these professionals agreed to be interviewed without following through, I believe some of the reasons may be linked to the

Institutional Review Board process and cultural differences. Some potential interview subjects may not have fully understood or felt comfortable with the consent form and others may not have wanted to be bothered by filling out a form. Additionally, some interview subjects may have wanted to seem affable by agreeing to the interview before considering whether they could honor their commitment. The interview process not only yielded interesting findings, but also provided insight into the challenges of conducting remote research on a foreign site.

Chapter 8: Plan Analysis

The two plans analyzed in this research serve as the site management documents for the Île de Saint-Louis. The plans guide the way that the State Party and its stakeholders aim to protect and preserve the site's Outstanding Universal Value. As such, I anticipated that the plans would focus primarily on the specific design and architectural standards for the site. Since the *Action Plan* of 2015 is the implementation document for the *Safeguarding and Enhancement Plan* of 2006, I thought that it would contain more concrete goals and initiatives than the 2006 plan. Considering that the presence of climate change in the heritage field increased after 2005, I thought the *Action Plan* may have a mention of climate change, especially due to the island's unique geographic location.

The strengths, weaknesses, opportunities, and threats (SWOT) analysis was completed not to analyze the plans themselves, but the plans' abilities to support or prohibit green infrastructure as a climate resilience tool. Table L shows the questions on which the SWOT analysis was based. It should be noted that the SWOT analysis tables in this chapter classify aspects of the plans as strengths, weaknesses, opportunities, and threats as they apply to green infrastructure only. While a regulation or suggestion included in a plan might be beneficial for the preservation of the island or a building, it may be viewed as a weakness or threat to green infrastructure implementation. It is important to view these findings through the lens of the potential to implement green infrastructure.

Table L: SWOT analysis questions

Strengths	Weaknesses
<ul style="list-style-type: none">• What are the strengths of this plan as regards to green infrastructure?• How does it contribute to green infrastructure?• Which aspects of green infrastructure are mentioned?• Which types of climate change impacts are mentioned in the plan?• Other strengths?	<ul style="list-style-type: none">• What are the weaknesses of this plan as regards to green infrastructure?• How does it challenge the use of green infrastructure?• Which types of climate change impacts are ignored in the plan?• For which types of green infrastructure is the plan less suitable?• Other weaknesses?

Opportunities	Threats
<ul style="list-style-type: none"> • What is the potential of the plan to positively encourage the implementation of green infrastructure? • Which types of green infrastructure are supported by this plan and how? • What positive action toward climate change resilience can be achieved with this plan? 	<ul style="list-style-type: none"> • What is the potential of the plan to challenge or threaten the implementation of green infrastructure? • Which types of green infrastructure are prohibited by this plan? • What would happen to climate change impacts if this plan was not implemented?

Source: Author; Bory and Dallhammer, 2009

8.1 *Safeguarding and Enhancement Plan for Saint-Louis (2006)*

The *Safeguarding and Enhancement Plan for Saint-Louis* is a planning document that guides preservation and construction of historic buildings and new construction, renovations to the appearance of a building, changes in use, demolitions, dock maintenance, vegetation, swimming pools, fence installation, and billboards on the Île de Saint-Louis (PSMV Volume 2 2006, 2). The SWOT analysis table in Table M compiles all the identified strengths, weaknesses, opportunities, and threats of the *Safeguarding and Enhancement Plan* for green infrastructure (GI). The parenthetical numbers indicate page numbers. Overall, the plan supports green infrastructure through its strong emphasis on protecting trees and green spaces. However, the plan also outlines strict guidelines regarding what is (or is not) allowed to be altered on buildings of great architectural interest and average architectural interest. These guidelines place limitations on the implementation of certain green infrastructure tools.

Table M: SWOT analysis for the Safeguarding and Enhancement Plan

Strengths	Weaknesses
<ul style="list-style-type: none"> • Protects and urges strengthening and maintaining public and private gardens, trees, and green spaces, especially along Mermoz Avenue and the docks; all tree cutting must be approved (16) • Suggests that new construction projects incorporate local species of vegetation and trees (16) • Mandates that public and private open areas of more than 50m² must be planted with trees (15) • Mandates that parking area perimeters be planted with local trees to create a visual barrier (15) • Suggests that a band of vegetation should be planted around a private parking fence • Requires tree planting along all main roads (16) • States that if a building is setback from the street, a garden must be placed between the building and the fence/sidewalk (16) • Encourages planting the following types of vegetation: baobab trees, palm trees, coconut trees, banana trees, sapodilla trees, bougainvillea, and hibiscus • Directs preferences to natural ventilation in buildings and energy efficient solutions due to climate (13) • Values aspects of the natural landscape, such as open spaces, gardens, green spaces, and trees, seeing them as an asset for tourism • Calls for further studies about green space and architecture on the island 	<ul style="list-style-type: none"> • Requires that public tree planting must be approved (15); bureaucratic approval process may deter from small-scale tree planting initiatives • Prohibits anything other than “light” construction on terraces or verandas (10); may preclude GI, like green façades • Requires maintenance of current road alignment (8); depending on strictness of this regulation, certain planting along streets may not be approved • Forbids changing the structure, façade, colors, etc. of any buildings of architectural interest (5); limits types of GI intervention on buildings • Mandates that buildings of average architectural interest be related to original state (5); limits types of GI intervention on buildings • Requires that any intervention in a public space get approval (14); bureaucratic approval process may deter from community initiatives • Does not mention any climate change impacts specifically • Severely limits the places where GI would be feasible • States that no advertising is allowed on the island (5); has the potential to create challenges for awareness raising through educational signage near GI

Opportunities	Threats
<ul style="list-style-type: none"> • Does not allow coatings on paved roads if they do not promote drainage (15) • Mandates that construction must be connected to rainwater drainage system (5); GI could help supplement the drainage system • Explains that there is lower density in north of island (1); more space/opportunity for GI • Allows buildings of no historical/architectural interest to be demolished (5); potential for rebuilding with GI features • Requires a minimum distance of at least 3 meters between buildings that are newly built (10); less impervious surface and opportunity for planting • States that plots greater than 80m² cannot build on more than 75% of their lot (10); lot space for vegetation • Pays careful attention to the development of the docks, encouraging regular maintenance and that they are oriented to pedestrians (15); opportunities for GI in these waterfront spaces • Requires that a building or fence be constructed in the footprint of a demolished building (7); potential for green façade • Does not allow for curb drains on some streets; potential for alternative drainage systems • Forbids building on docks, freeing up space for alternative development • Has potential to support GI that fits into the current urban fabric • Calls for integrating this site management plan into a larger urban master plan; urban master plan may have goals that support GI or climate change resilience 	<ul style="list-style-type: none"> • Requires that a building or fence be constructed in the footprint of a demolished building (7); promotes replacing a hard surface with another hard surface (in the case of re-building a building) • Allows plots less than 80m² to have 100% build out (10); decreases land for vegetation/GI • Requires that the docks have dominant edges; does not allow for coastal wetlands • Prohibits masking façades (16) • Mandates that fences and walls must be restored/preserved in their original state (14); may prohibit use of green façades

Source: Author

8.1.1 Strengths Supporting Green Infrastructure

As mentioned, green infrastructure has many definitions; however, this research defines green infrastructure as “an interconnected network of green space that conserves natural ecosystem, values and functions and provides associated benefits to human populations (Benedict and McMahon 2006, 12).” Individual pockets of green spaces act as a network on the island since they are all within a relatively small area and connected by planted trees. The plan specifically mentioned protecting gardens, trees, and green spaces, going so far as to forbid tree cutting unless it is approved in advance (PSMV Volume 2 2006, 8 and 17). The plan puts emphasis on planting along a main avenue, Mermoz Avenue, and along the docks (PSMV Volume 2 2006, 16). It also states that public and private open areas more than 50m² must be planted with trees (PSV Volume 2 2006, 15). It is interesting and important that the plan aims to protect both public and private spaces, putting responsibility on both the public sector, but also the private homeowner. Encouraging private homeowners to protect their property’s green infrastructure (in the form of trees, gardens, and green space) allows for more physical space where green infrastructure can be promoted and maintained. Focusing on only public space would severely limit the areas on the island available for green infrastructure promotion or conservation.

The plan also requires vegetation as visual buffers for both public and private parking areas (PSMV Volume 2 2006, 15). Public parking lots must have planted trees along its perimeter, while private parking areas should have a band of vegetation along a fence to provide a visual buffer. These regulations support green infrastructure and will help curb stormwater runoff from the hard surface of a parking lot.

In constructing new buildings, projects should incorporate vegetation (trees and green space of a local species) throughout the site. If the building is set back from the street, a fence needs to go along the edge of the property and a garden must be planted between the house and the fence (PSMV Volume 2 2006, 16).

The plan encourages the use of baobab trees, palm trees, coconut trees, banana trees, sapodilla trees, bougainvillea flowers, and hibiscus shrubs (PSMV Volume 1 2006). However, the required vegetation acting as buffers to private parking, for set-back buildings, or incorporated into open spaces could take on a variety of green infrastructure forms, such as rain gardens, small fruit orchards, vegetable gardens, or drought-resistant xeriscapes.

The plan does not specifically mention climate change impacts. However, the plan has a preference for natural ventilation in buildings and energy efficient construction or renovations due to the hot climate (PSMV Volume 2 2006, 13). Additionally, it prohibits coatings on paved roads unless it promotes drainage (PSMV Volume 2 2006, 15). The plan clearly values the landscape of the site, its open spaces, gardens, green spaces, and trees, and sees the landscape as an asset for tourism (PSMV Volume 1). The plan also calls for further studies on how the green space on the island interacts with the architecture, which shows a commitment to a symbiotic relationship between the natural and built environments (PSMV Volume 1).

8.1.2 Weaknesses Hindering Green Infrastructure

While the strict regulations regarding interventions on green space can be viewed as a strength, since its purpose is to preserve the space, they can also be viewed as a potential weakness for green infrastructure. The plan requires that tree planting and any intervention in a public space must get approval from the State Architect (PSMV Volume 2 2006, 14 and 15). Individual or small scale initiatives may hesitate to implement their plan due to bureaucratic hurdles of the approval process. Since the approval process is not outlined, it is difficult to discern the effort it would take to go through it.

The plan limits construction on terraces and verandas to only “light” construction (PSMV Volume 2 2006, 10). Since there is no definition, it is unclear whether this would preclude green infrastructure, such as green façades. Additionally, the alignment of the roads must be maintained. Once again, certain types of planting along the street may or may not be prohibited depending on the interpretation of this regulation (PSMV Volume 2 2006, 8).

Perhaps the most limiting aspect of the plan is its regulations on buildings of great and average architectural interest. If a building has great architectural interest (indicated on the plan’s map in Appendix E), then no changes can be made to the structure, façade, colors, or other aspects of the building. For buildings of average architectural interest, any changes must be related in a way to the original state of the building (PSMV 2006, 5). These regulations respect the integrity and authenticity of the historic buildings; however, they also severely limit the type of green infrastructure that can be implemented on or around these architecturally and historically significant buildings.

The plan does not allow advertising on the island in the form of signage or billboards (PSMV 2006, 5). Climate change resilience often benefits from community education. One way

this is done with green infrastructure is through educational signage near green infrastructure. It would be important to indicate to the site manager that educational signage should be classified separately than marketing signage. Lastly, the plan fails to mention any climate change impacts directly.

8.1.3 Opportunities Supporting Green Infrastructure

Despite the weaknesses of the plan for green infrastructure implementation, there still rests many opportunities. The north of the island has a lower building density, which allows for more free space to implement green infrastructure (PSMV Volume 1 2006). This lower density may be due to the fact that buildings with “no architectural interest” can be demolished (PSMV Volume 2 2006, 5). If a building is demolished, another building must be built or a fence constructed in its place (PSMV Volume 2 2006, 7), providing the opportunity to use green façades on the fence. If there is new construction on the vacant lot, the plan requires that a minimum of three meters be left between buildings (PSMV Volume 2 2006, 10). This allows an opportunity for green infrastructure to assist in stormwater runoff from the buildings. Additionally, if the plot of land is larger than 80m², the building footprint cannot be more than 75% of the total plot size (PSMV Volume 2 2006, 10). This allows some of the plot to be reserved for planting.

The plan addresses stormwater drainage in two of its regulations. It states that all construction projects must be connected to stormwater drainage systems (PSMV Volume 2 2006, 5). This shows that the plan is aware of the importance of managing stormwater runoff from every property. Green infrastructure can help reduce the stress on the drainage system by capturing some of the rain before it runs off into the system. The plan does not allow for concrete curb drains on the street (PSMV Volume 2 2006, 15); therefore, there is an opportunity to use green infrastructure to help direct and slow runoff to the pre-existing street drains.

The plan references the importance of maintaining the docks of the island so that they remain clean and pedestrian-oriented (PSMV Volume 2 2006, 15). No construction of buildings is allowed on the docks (PSMV Volume 1 2006). Green infrastructure can help create a good aesthetic for the docks and the pedestrians that visit them. Green infrastructure can be implemented in such a way along the docks that it creates a safe, pedestrian-oriented space. For example, a walking trail could be installed along the docks of the island and lined with green infrastructure, providing aesthetic, recreational, and environmental benefits.

Currently, this plan supports green infrastructure that fits into the existing urban fabric. There are more opportunities to implement green infrastructure that resembles traditional planting schemes, than those requiring more engineered tools, such as façades or green roofs. The plan calls for integration with the larger urban master plan (PSMV Volume 1 2006). Integration within a larger urban master plan would be beneficial for the case of green infrastructure; climate change resilience or environmental goals of the urban master plan may encourage green infrastructure on the island in an appropriate manner.

8.1.4 Threats Hindering Green Infrastructure

The main threats of the plan regarding green infrastructure can be categorized in one of two ways: encouraging hardscapes and discouraging green façades. The plan states that no masking façades are allowed; however, it suggests bougainvillea, a climbing plant, as an appropriate type of vegetation (PSMV Volume 1 2006 and PSMV Volume 2 2006, 16). Additionally, it states that fences and walls must be restored or preserved in their original state (PSMV Volume 2 2006, 14). While bougainvillea was planted by French colonists, some fences and walls have never hosted a climbing plant or façade. A green façade that is not directly attached to the wall may not be allowed due to it hiding the historic color palette, consisting of roses, yellows, and ochre, which are encouraged in the plan (PSMV Volume 2 2006).

The plan encourages hardscapes in three ways. When a building is demolished, another building must be built in its place (or at the very least a fence installed). Additionally, plots less than 80m² can build on 100% of their plot, potentially leaving no room for vegetative cover (PSMV Volume 2 2006, 7). Lastly, the plan dictates that the docks must maintain a dominant edge (PSMV Volume 1 2006). This prohibits the implementation of any coastal wetlands on the island since the docks line the entire island.

8.2 Action Plan 2015-2020 to Implement the PSMV of Saint-Louis (2015)

In March 2014, eight years after the *Safeguarding and Enhancement Plan* was released, a joint UNESCO-ICOMOS monitoring mission was sent to the Île de Saint-Louis. The team expressed concern about the state of preservation. In June 2014, the World Heritage Committee issued Decision 38 COM 7B.54 in response to the expressed concern. The decision required that a report be written on how the State party and stakeholders would ensure the protection of the site as outlined in the site management plan of 2006. A multidisciplinary team of government, civil

society, community, and university representatives was assembled in October 2014 to write the report that ended up being the *Action Plan 2015-2020 to Implement the PSMV of Saint-Louis*, released in 2015 (Action Plan 2015). The plan is short in length, as compared to the *PSMV*, consisting of an overview of the *PSMV* followed by three spreadsheets. The spreadsheets correspond to three strategic areas for action: management of the property, maintaining the value of the property, and communication. The spreadsheets include tasks to accomplish each strategic area of action, a timeline, and responsible parties. Table N shows the completed SWOT analysis table for the *Action Plan*. The *Action Plan* does not include page numbers; therefore, no page numbers are associated with the text in the table. However, all information is sourced from the *Action Plan*.

Table N: SWOT analysis for the Action Plan

Strengths	Weaknesses
<ul style="list-style-type: none"> ● Calls for rehabilitating public spaces which could mean planting more vegetation and trees or adding an engineered GI tool in the public space, such as a rain garden, bioswale, or even a green façade. 	<ul style="list-style-type: none"> ● Makes no mention of vegetation, trees, addressing stormwater runoff, or high temperatures, besides reference public space. ● No mention of climate change impacts. ● Does not specifically preclude any type of GI, but it may be difficult to implement GI that requires intensive maintenance since the Action Plan delegates a lot of other specific responsibilities to stakeholders. ● Not comprehensive enough to fully integrate climate change threats and planning.

Opportunities	Threats
<ul style="list-style-type: none"> ● Presence of the Action Plan in general shows desire to implement goals and protect the site which could bode well for GI implementation ● Created by an interdisciplinary team which could be used to help plan GI initiatives. ● Requires monitoring and visits to the area 4 times per year which will allow team to witness climate change threats and perhaps lead to action. ● Suggests updating the site management plan, which could then include climate change resilience and GI. ● Encourages exploring tax incentive strategies for project leaders, which may encourage stakeholders to implement GI/climate resilience initiatives ● Aims to mobilize youth and engage schools which could support GI that includes a participatory aspect, such as community gardens, green spaces, even rain gardens that require maintenance. ● Proposes clean district competitions, health days, and clean-up of the docks which could include a GI aspect (e.g. replace litter dump site with a garden) ● Plans to facilitate 2 workshops on economic factors of site and training with red brick construction company. Both of these events could include a climate change resilience/GI aspect, such as training the construction company on permeable paving methods, or informing business owners on the economic benefits of GI. 	<ul style="list-style-type: none"> ● Does not present a true threat to GI except a lack of urgency to address climate change.

Source: Author

8.2.1 *Strengths Supporting Green Infrastructure*

The plan calls for rehabilitating public spaces, which could include planting more vegetation and trees or creating an engineered green infrastructure in the public space, such as a rain garden, bioswale, or even a green façade (Action Plan 2015). It could also allow for repaving paved areas of the space with permeable pavement, encouraging better drainage. Beyond this goal of rehabilitating public space, no other mention of green infrastructure or climate change impacts was made in the *Action Plan*.

8.2.2 *Weaknesses Hindering Green Infrastructure*

Besides public spaces, the plan makes no mention of vegetation or trees or addressing climate impacts, such as stormwater runoff or temperature (Action Plan 2015). While the plan does not preclude any type of green infrastructure through its regulations, it may be difficult to implement green infrastructure since the plan delegates most responsibilities to community stakeholders (Action Plan 2015). Since green infrastructure is not mentioned explicitly in the plan, stakeholders may not feel motivated to take it on as an additional task. Overall, the plan is not comprehensive enough to fully integrate climate change planning within its goals or tasks. The plan truly serves to implement aspects of the *PSMV* and does not try to elaborate or update the *PSMV* with additional information or priority areas.

8.2.3 *Opportunities Supporting Green Infrastructure*

Green infrastructure implementation is most successful when it is planned by an interdisciplinary team of community stakeholders. The fact that such a team was established to create a concrete action plan creates an opportunity for green infrastructure implementation in the future. It shows that there are committed stakeholders who are working towards achieving a stable conservation status for the site. The plan calls for monitoring site visits to the area four times a year by the team (Action Plan 2015). These frequent monitoring site visits could bring more awareness to the climate change impacts. The plan suggests updating the current site management plan, the *PSMV*. This update could incorporate some observed climate change impacts and potentially incorporate green infrastructure in a more prominent manner. The plan also suggests that tax incentive strategies be explored for project leaders (Action Plan 2015). It is not clear what kind of tax incentives are envisioned or for which projects, but there could be an opportunity to provide tax incentives to projects that incorporate green infrastructure on their site to decrease the burden on air conditioning or stormwater drainage systems.

The third strategic area of the plan focuses on communication and engaging the community in the maintenance of the site. The plan aims to mobilize youth and engage schools through educational opportunities and activities (Action Plan 2015). One such activity could be planting a school garden or planting trees in the schoolyard. The plan suggests hosting a “Cleanest District” competition, which would encourage neighborhoods to pick up litter and clean up the streets. The plan also mentions cleaning up the dock areas, where many people dispose of their trash (Action Plan 2015). Through cleaning up these areas, roads and public spaces appear more welcoming. Once the neighborhood stops seeing those spaces as dump sites, there may be an opportunity to implement green infrastructure on those sites instead. Lastly, the plan states that the island should host “Health Days.” The plan is not clear on what constitutes “Health Days;” however, green infrastructure can provide recreational services, relieve stress, and reduce pollution, contributing to a healthier population.

The plan provides two potential opportunities to work towards climate change resilience. It requires hosting two workshops on the positive economic benefits of the heritage site for the community (Action Plan 2015). This workshop could include the economic benefits of preserving the natural environment on the site as well, encourage maintenance of existing green infrastructure and promoting the implementation of more. Additionally, the plan calls for organizing a technical training with a red brick construction company on sound construction practices for restoring historic buildings and constructing new buildings on the site (Action Plan 2015). This training could incorporate technical information on incorporating green building principles, such as sustainable material use and site planning that allows for natural ventilation. It could cover how green infrastructure can work in tandem with the building to capture stormwater runoff and cool the building. While none of these aspects of the plan directly mention green infrastructure, they provide opportunities to incorporate green infrastructure into the activity.

8.2.4 *Threats Hindering Green Infrastructure*

The plan does not threaten the use of green infrastructure explicitly, nor does it prohibit certain types of green infrastructure (Action Plan 2015). Perhaps, this is due to the fact that the *Action Plan* is a supplementary document to the *PSMV*, which includes more information about design and architectural regulations and standards. The only indirect threat from the *Action Plan* is its very lack of reference to climate change impacts. The plan seems focused on making up for

neglecting the *PSMV* for years, so there is little room for forward thinking. This demonstrates a lack of urgency to address climate change issues compared to the urgency to address issues of traditional building preservation.

8.3 Discussion

One of the most significant findings from this research is that neither climate change nor environmental threats are addressed in a direct manner, even though river flooding is not a new occurrence. This absence was especially noticed in the *Action Plan*, since it was released well after climate change planning had been brought to the attention of the heritage community. However, perhaps this absence should have been anticipated. The World Heritage Committee called on this report to be written after concerns were expressed about the state of the site's conservation. As such, the *Action Plan* focuses on the immediate preservation priorities, of which climate change is not one. Instead, it focuses on strengthening the management capacity, restoring and protecting historic buildings, and communicating the site's importance to the community.

While there is a desire to engage the community in parts of the *Action Plan*, it is clearly meant for internal use rather than for public information. The *PSMV* is written in a manner that encourages the public to read it; however, at times the plan is confusing to read and not clear on its regulations. It would be beneficial to include information about the required approval process for tree planting or working in a public space. Additionally, there are contrasting statements about whether green façades are allowed. A supplemental document for a homeowner outlining approval processes or resources for restoring and protecting their home would be beneficial for homeowners, but also for ensuring that the plans' regulations are respected.

Overall, the plans support green infrastructure as it pertains to aesthetics and more traditional planting schemes. There is an obvious respect for green space, trees, and public space. Green infrastructure projects can capitalize upon this; however, it may be difficult to implement more engineered types of green infrastructure, such as green roofs and green façades, due to the nature and age of the architecture and regulations on altering buildings of great or average architectural interest.

The *Safeguarding and Enhancement Plan* calls for integrating the plan within the larger urban master plan. A further step in this research would be to see how the urban master plan's goals are applied on the Île de Saint-Louis and if the urban master plan has goals that support green infrastructure.

Chapter 9: Discussion

This research yields a variety of findings, was presented with challenges, and faces limitations. However, it also contributes a methodology, recommendations, and potential procedural framework to the fields of planning and heritage preservation. This chapter presents a cumulative analysis of findings in the form of recommendations for identified green infrastructure intervention priority areas in the heritage site. Furthermore, it elaborates on the overall identified opportunities and barriers for green infrastructure in heritage sites and proposes this research as a potential framework to be used by heritage site managers and stakeholders. This research is concluded by remarking on the challenges faced throughout the process, along with research limitations, producing potential areas for further research study.

9.1 *Cumulative Analysis of Findings*

Based on the findings from the in-depth case study, vulnerability analysis, suitability analysis, interviews, and plan analysis, two areas on the island were identified as priority areas for green infrastructure intervention. While many areas on the island present opportunities for green infrastructure, these areas were chosen because they provide the most opportunity and flexibility for green infrastructure and were deemed vulnerable to climate change threats.

The two areas identified are along the western coast of the island and border the small arm of the Senegal River. The small arm of the Senegal River, between the Langue de Barbarie and the Île de Saint-Louis, floods during heavy rain events. The trash pollution in the river exacerbates the problem. Addressing areas on this coast will not only build climate change resilience within the identified areas, but also protect blocks that are further inland.

Furthermore, these priority areas contain significant public space in the form of the docks and in the case of the Quai Giraud, the Place Blaise Diagne. As seen in the plan analysis, the *PSMV* pays careful attention to the development of the dock spaces, stating the importance for consistent maintenance and the desire to keep the docks pedestrian oriented. The *Action Plan* calls for the rehabilitation of public spaces. The affirmed desire to rehabilitate and maintain the public spaces yields support and opportunity for green infrastructure interventions.

While the presence of public space was a driving factor in choosing these priority areas, these areas also contain a mix of buildings and uses which provide another realm of green

infrastructure opportunity. There is a mix of residential compounds that can host home-based green infrastructure, as well as institutions that could be good partners in implementing green infrastructure as mentioned in the interviews.

The two priority areas are shown in Map M. The Southwest Sindoné area includes Quai Abdoulaye Mar Diop, the Southern Point of the island, and five blocks. The Quai Giraud area includes the north portion of the dock, the Place Blaise Diagne, and thirteen blocks. Both of these areas contain significant public space.

Map M: Location map of priority sites overlaid on suitability analysis map

| Source: Author; basemap from Ecole d'Architecture de Lille 2005

9.1.1 Southwest Sindoné Recommendations

The Southwest Sindoné priority area is located in the Sindoné sub-district in the South District. It contains Quai Abdoulaye Mar Diop, a dock that is lined by residential and institutional uses. The narrow beach that lines the dock is still used by some fisherman. To the south, the area contains the Southern Point of the island. The Southern Point of the island faces the mouth of the Senegal River. The five blocks are almost entirely residential, but a commercial building is found on the southwest corner of the southernmost block. A mosque and Koranic school are found in the northernmost block and border the dock. There is a presence of buildings in good or fair states of conservation with flat roofs. The majority of the buildings are of no architectural interest. There is one vacant lot on the southern edge of the southernmost block.

This area presents many opportunities for green infrastructure intervention, both in the public and the private spheres. Within residential parcels, households can protect their structures by setting up rainwater harvesting systems, channeling the water from the roof to a rain barrel.

This water can be used in times of drought. Households can also aid in capturing stormwater runoff during heavy rain events through planting small gardens in their compounds and courtyards. These will help with water infiltration, protecting the water from being absorbed into the walls of the building. Some of the houses can support bougainvillea planting to create a green façade. In addition to the aforementioned suggestions, the mosque and Koranic school can plant fruit trees to provide nourishment for the school children or to provide an income generating activity, as well as providing regulatory ecosystem services. The mosque may also want to explore ways to capture the greywater from ritual ablutions to be used during times of drought for watering vegetation.

Installing permeable pavement would help with water infiltration. To help build resilience to flooding, bioswales should be installed along the Southern Point. They can be installed along the rows of the current palm trees, in the road median and along the interior edge of the dock. These bioswales would capture water that flows over the edge of the dock during heavy rain events. The Southern Point has a lot of potential to be a vibrant public space. Installing walking paths near the bioswales would allow pedestrians to enjoy the aesthetic benefits of the bioswales and trees. To increase the area available for bioswales, the walking path can be elevated above the bioswales as a boardwalk. An example can be seen in Image W. The Ameth Fall School for Girls on the eastern side of the Southern Point can be engaged as a partner in maintaining the bioswales.

Image X: Examples of bioswales and walking paths

Sources (left to right): UDFCD.org 2017; Garrett Rock 2017; Landscaperesources.com 2010

Along the Quai Abdoulaye Mar Diop, impervious surfaces can be replaced with permeable pavement. Better yet, some of the paved area can be replaced by rain gardens or tree planting, as is seen along the Southern Point of the island. Additionally, clean-up and educational efforts are needed along the dock to remove trash and identify areas where household waste can be dumped and processed.

9.1.2 Quai Giraud Recommendations

The Quai Giraud priority area consists of thirteen blocks of varying sizes, the northern part of the Quai Giraud, and the Place Blaise Diagne. The blocks are composed of residential, institutional, religious, and military uses. There is a mosque in the south of the area behind the Place Blaise Diagne. Directly to the north of the mosque is a prison. The north of the area hosts military buildings. Most of the buildings are of average or significant architectural interest, although there are a handful of wood barracks as well. Due to this building composition, most of the green infrastructure in this priority area will not be hosted on a building (like a green roof or façade); however, white roofs are possible on buildings of no architectural significance. There are some vacant parcels in the middle of the site. The most significant characteristic of the area is the natural coastline in the northwest of the island.

Much like in Southwest Sindoné, there are opportunities for harvesting rainwater in the residential compounds. Additionally, Alonso Cano mentioned in her interview that there have been small scale gardening efforts in the northwest of the island. These efforts should be encouraged and expanded upon. Collected rainwater can be used for watering the plants during times of drought.

The Place Blaise Diagne is currently underutilized as seen in Image X. There is an opportunity to create a public space that can host community gatherings, such as markets or cultural celebrations. The public space can use xeriscaping, landscaping that does not require a lot of irrigation, keeping with the area's sandy natural state. However, the xeriscaped public space can also facilitate water infiltration during flooding or heavy rain events. Palm trees or coconut trees can be planted in the square as well.

Image Y: Current state of Place Blaise Diagne

Source: Google Street View 2015

Image Z: Examples of xeriscaping

Source (left to right): Yorkton CA 2017; Santa Fe Gardening 2017; Vielthan.net 2017

The northwest portion of the area is currently a natural marsh. The resiliency of this marsh can be increased by introducing constructed wetland of mangroves. In fact, a Climate Change and Urban Vulnerability in Africa report remarked on the importance of restoring wetlands and mangroves in Saint-Louis and integrating them within the urban landscape in order to protect the island against climate change threats (Climate Change and Urban Vulnerability in Africa, 2013,

79). As seen in Image Y, a boardwalk can also be built throughout the marsh and wetlands creating recreational opportunities for residents and visitors.

Image AA: Examples of mangrove wetlands

Sources (left to right): Neal Jennings 2012; Pumpsea 2005

It is important to clarify that these proposed green infrastructure interventions will need to be implemented on a relatively small-scale. The island itself is not large. It is also very dense. Many of the photographs included in Images X, Y, and Z show green infrastructure on a much larger scale than would be possible on the Île de Saint-Louis. The images are for illustrative and conceptual purposes only.

9.2 Conclusions and Applications of Research

This research answers the question, “In light of the climate change threats facing heritage sites, how can climate change planning in heritage sites use green infrastructure?” The aforementioned priority area recommendations demonstrate the results of this research for one heritage site, the Île de Saint-Louis. Through the in-depth case study, consisting of a vulnerability and suitability analysis, the supplemental findings from informant interviews, and an analysis of the site management plans, informed decisions were made about how the heritage site can build climate change resilience using specific types of green infrastructure. In theory, this process can be replicated for other heritage sites and used as a framework for assessing how the site might

use green infrastructure. The research also presented overarching opportunities for, and barriers to, green infrastructure on the Île de Saint-Louis and in heritage sites, in general.

9.2.1 Opportunities for Green Infrastructure on the Île de Saint-Louis

There were a few identified opportunities for green infrastructure on the island that emerged throughout the research. First and foremost, there is respect for the landscape and vegetation, especially trees. This respect is formalized in the site management plans and their guidelines, but also in the perceptions and beliefs of the residents. This respect aids in protecting the vegetation that is existing on the island and provides opportunities to enhance the vegetation or install green infrastructure.

There is also an opportunity in the fact that climate factors are seen as major threats to the island. All of the interview subjects stated that climate-related risks threaten the island's future. This urgency and awareness of the climate threats provide an opportunity for green infrastructure interventions. The interview subjects also noted that there are potential programming and implementation partners on the island, such as schools and local leaders. These partners are key in implementing and maintaining green infrastructure.

Lastly, the island is lined by docks which act as public spaces. They provide open and pedestrian-oriented spaces, offering opportunity for green infrastructure interventions that provide a variety of ecosystem benefits.

9.2.2 Opportunities for Green Infrastructure in Heritage Sites

While each heritage site is unique in its form, environmental context, and system of management, there are commonalities that all heritage sites share. They all must conform to the *World Heritage Convention* standards and fulfill the reporting requirements. Additionally, they are all concerned with the preservation of their Outstanding Universal Value. As mentioned in Chapter 4.1, a World Heritage Committee working group published a report in 2006 called *Predicting and Managing the Effects of Climate Change on World Heritage and a Strategy to Assist State Parties to the Convention to Implement Appropriate Management Responses* (UNESCO World Heritage Centre 2006). The report reviewed the effects of climate change on heritage sites and then presented recommendations on how heritage sites should respond to climate threats in order to protect their Outstanding Universal Value. It called for cultural heritage sites to:

- Incorporate climate adaptation into their management plans and system. This includes

continual monitoring and vulnerability assessment of the site.

- Involve the local community and other stakeholders in identifying adaptation interventions.
- Use a landscape-based approach by viewing the entire site rather than focusing on individual significant buildings (UNESCO World Heritage Centre 2006, 19-34).

Since all heritage sites must protect their Outstanding Universal Value to keep their designation, it is in their best interest to consider the recommendations of the World Heritage Centre's working group. Based on these recommendations and the findings from this research a few opportunities for green infrastructure in heritage sites were identified:

- Community stakeholder partnerships: Within the heritage management system, State Parties rely on local stakeholders to manage the daily operations and preservation of the site. These stakeholders include the site manager, local government bureaus, and community organizations and institutions. Community organizations and institutions are well suited as partners in green infrastructure implementation. Green infrastructure is most successful when it includes members of the community. Schools, religious institutions, healthcare facilities, community development associations, and local traditional leaders can not only provide insight into best ways to introduce green infrastructure to the site, but they can also be partners in implementing and maintaining the green infrastructure. This opportunity aligns with the World Heritage Centre's recommendation that the heritage managers involve the local community in planning for climate change adaptation.
- Protection of landscape and landscape values: Since heritage sites are situated in a particular landscape that contributes to their Outstanding Universal Value, their site management plans often protect significant landscape attributes, such as open space or trees. This protection of greenery provides opportunities to maintain and enhance green infrastructure in heritage sites. Additionally, some sites may assign historic or cultural significance to their greenery, elevating the greenery's value.
- Various levels of entry: Heritage sites are, themselves, diverse. Within a heritage site, there are varying levels of architectural significance, states of conservation, and land use. This diversity allows there to be multiple entryways for green infrastructure intervention. Where a rain garden may not work, a median of trees may be appropriate; where there is a dearth of available land, green or white roofs may be appropriate. Since green

infrastructure tools come in many forms, varying land and built environment variables may constrain one type of green infrastructure, but provide an opportunity for another type.

9.2.3 Barriers to Green Infrastructure on the Île de Saint-Louis

While there were opportunities for green infrastructure on the Île de Saint-Louis, there were also barriers that have the potential to deter green infrastructure. Although the interview subjects identified climate risks as major threats to the preservation of the site, the site management plans failed to address climate change. The plans do not possess the same urgency to protect the island against climate change. This lack of resolution can be a barrier to implementing green infrastructure.

The site management plans tend to focus on the preservation of buildings rather than looking at the site holistically. Strict design guidelines protect architecturally and historically significant buildings. The guidelines do not allow for changes to the structure or appearance of the structure creating barriers for green infrastructure interventions on or near buildings.

Lastly, while there is a respect for vegetation and the landscape, there is also a notion among residents that vegetation can have unwanted effects. The fear of disease-spreading insects in stagnant water near vegetation or bunches of flowers may cause residents to reject certain types of green infrastructure. This presents a barrier to green infrastructure on the island and would require community educational programming.

9.2.4 Barriers to Green Infrastructure in Heritage Sites

Just as there are common opportunities for green infrastructure in heritage sites, there are also shared barriers that were illuminated through this research. The common barriers to green infrastructure intervention in heritage sites are:

- Regulations on design and site modifications: As mentioned above, site management plans may have protective regulations for vegetation in the heritage site. Just as there are protections for vegetation, the plans also present many protections for the structure and form of the heritage site. The regulations ensure that the site will maintain its Outstanding Universal Value and not have its authenticity and integrity violated. These regulations come in the form of design guidelines for new construction and restoration and maintenance standards for existing buildings. Every aspect of the heritage site from paint colors used on a building to the height of fences can be regulated. While these regulations

preserve the heritage site, they also provide some barriers for green infrastructure. Some types of green infrastructure may alter the existing condition of a building or a parcel of land, making it unsuitable for that particular site. It is important to note that the site management plans do not prevent green infrastructure *overall*, but may provide barriers for certain types of green infrastructure.

- A pre-existing urban fabric: All heritage sites have pre-existing form and structures. When planning a new neighborhood, planners can incorporate green infrastructure into their design and master plan, providing more flexibility for the location of green infrastructure. However, in heritage sites, the site must be retrofitted with green infrastructure, providing some barriers for the types and amount of green infrastructure intervention possible.
- Community perception: This barrier is not unique to heritage sites, but it is a barrier nonetheless. The perception of the community living in the heritage site may provide a barrier for green infrastructure interventions. Perceptions about stagnant water, the appearance of certain types of vegetation, and other cultural attitudes toward greenery may hinder the opportunity to implement green infrastructure or the ability to maintain green infrastructure on the site.

It should be noted that economic barriers for green infrastructure intervention are not included on this list as it was beyond the scope of this research.

9.2.5 *Procedural Framework*

As mentioned, each heritage site is unique and as such there is not one single green infrastructure approach that can be applied to every site. However, this research provides a framework for heritage site managers and stakeholders to use if they are interested in building climate change resilience using green infrastructure. This framework presents stakeholders with a methodology allowing them to analyze their site's components, assess the vulnerability of their site, and identify areas on the site most suitable for green infrastructure intervention. Furthermore, this research provides a site management plan analysis methodology that allows for identification of the strengths, weaknesses, opportunities, and threats of the plans as they relate to green infrastructure implementation.

This framework is a helpful starting point when considering green infrastructure for a heritage site. It identifies priority sites and synthesizes the site plan's ability to support or hinder green infrastructure. It also identifies which types of green infrastructure may be suitable.

Following this, stakeholders can engage local community leaders and institutions on further planning and implementation of green infrastructure, with this framework's findings as a foundation.

This framework can be situated to have an even greater positive effect if the process is completed during the beginning of an overall strategic planning process rather than as an afterthought. If this framework is incorporated into the beginning stages of strategic planning or goal setting for a site, then its findings can be integrated in the determined goals or actions steps. This integrated approach will not only allow more opportunity for green infrastructure, but also allow site managers to identify how green infrastructure can best be leveraged to meet multiple goals, such as those concerning climate change resilience, economic development, and recreation.

9.3 *Research Limitations and Challenges*

During this research, challenges arose and limitations of the study were identified. Both the challenges and limitations are primarily linked to the location of the case study, the Île de Saint-Louis in Senegal. While some of these challenges could not have been avoided, it is important to acknowledge them. It is also vital to acknowledge the research limitations, so that later researchers can learn from this study and improve their methodology and focus area.

9.3.1 *Research Challenges*

This research combined three aspects of planning: climate change, heritage, and green infrastructure. The literature review demonstrates that there has been some research at the intersection of heritage and climate change; however, it is not exhaustive, nor has it addressed the green infrastructure approach. As such, there were some challenges associated with finding tested, comprehensive methodologies on which to model for this research. I combined various methodology types used in the past and adapted them to work for this research. The result was successful, although creating the methodology framework was more time intensive than expected.

The other major challenges stemmed from the location of the chosen case study, the Île de Saint-Louis. The heritage site was chosen due to its vulnerability to climate change threats based on its geographic location in a river delta, near the Atlantic Ocean, and in the hot Sahel region. It was also selected because the heritage site is expansive, rather than a few parcels or blocks, and remains an active area of the city. However, its distant location posed some research challenges. Due to distance and time, I was not able to conduct a site visit and collect information

through fieldwork. While I was fortunate to receive access to the *Architectural and Urban Inventory of Saint-Louis* and collection of maps and photographs from Suzanne Hirschi, an interview subject, it would have been beneficial to be able to collect my own data on the site in the most recent year.

A site visit would have also allowed for more ease in conducting and arranging interviews. I was able to conduct five interviews, but as was mentioned in Chapter 7.5 it was difficult to initiate contact with government officials. Navigating cultural differences was challenging and emerged when arranging interviews and having potential interview subjects complete the Institutional Review Board (IRB) consent form. The IRB protocol is very rigid and does not allow for much flexibility in language or tone. As such, some of the materials, such as the email to recruit interview subjects and the consent form, offended or confused potential interview subjects.

Lastly, conducting research in a foreign language was challenging. While I possess advanced proficiency French language skills, I was tested on my technical writing and professional presentation skills while arranging and conducting interviews. Additionally, I had to learn new vocabulary related to heritage preservation and climate change.

9.3.2 *Research Limitations*

Just as with the research challenges, the research limitations are rooted in the case study's location. In order to keep the research focused and manageable, the boundaries of the case study were determined based on those of the Île de Saint-Louis' designated World Heritage Site. However, as the research advanced, it became apparent that in order to address the resilience of the island, it is important to address the resiliency of a broader geographic area which includes the Langue de Barbarie, the Senegal River, and part of the mainland.

This research is also limited in its scientific understanding of the site. The soil composition, drainage conditions, and other important environmental site factors were not examined in depth before making recommendations on potential green infrastructure interventions. An environmental report would need to be conducted on the identified green infrastructure intervention priority sites to identify specific information regarding the engineering of the green infrastructure and the types of vegetation. In the same sense, a cost-benefit analysis would need to be conducted in the context of the site's available finances.

The final identified limitation is that the research findings lack the ability to be applied without a better understanding of the institutional capacity of stakeholders on the island. All of these limitations can be addressed through expanding upon this research in future studies.

9.4 *Areas for Future Research*

It is my hope that this research will contribute to the collection of research on climate change and heritage and introduce green infrastructure as a suitable tool for building climate change resilience in heritage sites. In assessing the potential of green infrastructure for heritage sites, the findings have the possibility to be applied to designated historic districts, as well. There are opportunities to expand upon this research beyond this primarily physical assessment of green infrastructure intervention in a heritage site.

Further research on the institutional capacity of heritage site managers, stakeholders, or entire national heritage management systems to implement green infrastructure would be complementary to this research. While this research identifies the “what” and the “where” of green infrastructure on a heritage site, the “who” and the “how” are necessary details in order to see green infrastructure implemented in reality. It should be noted that this research also provides insight on *how* to conduct a suitability for green infrastructure assessment on a heritage site.

Another area of further research would be to approach the issue from the grassroots, exploring the potential for green infrastructure on a community level rather than a site scale. The interview subjects spoke about potential partners in green infrastructure implementation: schools, local sub-district traditional leaders, and university students. It would be interesting to assess each of those groups’ perceptions of green infrastructure, identify the most suitable course of intervention for each partner group, and then review how their interventions could be linked together to form a network of green infrastructure across the heritage site.

Additionally, it would be noteworthy to examine the behavior and thought-change barriers that exist for some of the new and existing residents on the island. It was mentioned by multiple interview subjects that many people move to the island and want to construction new buildings or do not feel as though they need to follow the design guidelines in the site management plans. Why do these residents choose to act in a destructive manner and what would motivate them to change their behaviors and act collectively to preserve the island? Answering these questions

would provide important insight on how to mobilize all the residents on the island to build climate change resilience.

Lastly, as noted above, this research lacks context since it is solely concerned with the built environment within designated heritage site boundaries. Further research should consider the supporting areas, such as the Langue de Barbarie, the Senegal River, and portions of mainland Senegal.

The variety of routes available for further research speak to the complexity and multifaceted nature of this research topic. However, more so than its complexity, is its necessity. Research that falls at the intersection of climate change and heritage planning is needed to illuminate how preservation efforts can be strengthened and climate change resilience can be built in heritage sites now and into the future.

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Appendices

Appendix A: Glossary of Important Terminology

Cultural Heritage: “The following shall be considered as "cultural heritage":

- monuments: architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science;
- groups of buildings: groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science;
- sites: works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view (UNESCO 1972).”

Green façade: “A green façade is created by growing climbing plants up and across the façade of a building, either from plants grown in garden beds at its base, or by container planting installed at different levels across the building. Climbing plants can attach directly to the surface of a building, or they can be supported on a structure independent of the building (Growing Green Guide).”

Green Infrastructure: “An interconnected network of green space that conserves natural ecosystem, values and functions and provides associated benefits to human populations.” (Benedict and McMahon 2006, 12).”

Green Roof: “A green roof is a layer of vegetation planted over a waterproofing system that is installed on top of a flat or slightly-sloped roof. They fall into three main categories—*extensive*, *intensive*, and *semi-intensive*. Although there are no precise definitions of them, an extensive green roof has a shallow growing medium—usually less than six inches—with a modest roof load, limited plant diversity, minimal watering requirements, and is often not accessible. Intensive green roofs have more soil and a deeper growing medium—sometimes several feet—

that can support a more diverse plant selection, including small trees. Thus, they have more substantial structural loads and need more frequent maintenance and watering. They are usually accessible. Semi-intensive green roofs include features of both types. The appropriate depth of any green roof depends on the roof structure, the plants chosen, annual rainfall, and stormwater performance requirements (National Park Service, Technical Preservation Services).”

Permeable Pavement: “Permeable surfaces consist of a variety of types of pavement, pavers, and other devices that provide stormwater infiltration while serving as a structural surface (University of Florida).”

Rain Garden: “Rain gardens are depressional areas landscaped with perennial flowers and native vegetation that soak up rainwater. They are strategically located to capture runoff from impervious surfaces, such as roofs and streets. Rain gardens fill with a few inches of water after a storm and then water filters into the ground, rather than running off to a storm drain (U.S. Department of Agriculture, Natural Resources Conservation Service).”

View Corridor: “A view corridor is a three-dimensional area extending out from a viewpoint (City of Portland).”

Wetlands: “Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species (EPA).”

White Roof: “A white roof is painted with solar reflective white coating and reflects up to 90% of sunlight (as opposed to traditional black roofs which reflect only 20%). White roofs' benefits are measured partly according to the solar reflectance index, or SRI. A roof's SRI is a measure of a surface's ability to reflect solar heat. SRI measures reflectance (reflecting the sun's rays) and thermal emittance (the roof's ability to radiate absorbed heat) (White Roof Project).”

Xeriscape: “Landscape designed to reduce or eliminate potable water use in irrigation through the planting of native and adapted species of vegetation (McCombs 2015) and the use of other water-conserving techniques (McCombs 2015, 247).”

Appendix B: Expanded Methodology Framework

METHODOLOGY	Case Study & Interviews				
SOURCE OF METHODOLOGY	<ul style="list-style-type: none"> • Firehock (2015) informed the site component choices (roads, public spaces, residential buildings, non-residential buildings, and view corridors) • Berenfield (2015) informed the vulnerability map • Cohen (2016) and Opdenakkar (2006) informed the interviews 				
INPUTS	Physical characteristics of site components	Perceptions of site components	Current and future risk factors		
SOURCES OF INPUTS	Interviewees	Site plans & Inventories	Journal and news articles	UNESCO documents	World Bank Climate Portal
OUTPUTS	Vulnerability Map	Suitability for Intervention Map			

METHODOLOGY	Plan Analysis			
SOURCE OF METHODOLOGY	Bory and Dallhammer informed the SWOT analysis			
INPUTS	Strengths	Weaknesses	Opportunities	Threats
SOURCES OF INPUTS	Safeguarding and Enhancement Plan for Saint-Louis			Action Plan for Saint-Louis
OUTPUTS	SWOT analysis findings			

Appendix C: Interview Questions

Question 1		
Pre-Test	What are the top three biggest threats facing the preservation of the Île de Saint-Louis?	<i>Quels sont les trois plus grandes menaces qui face the préservation d'Île de Saint-Louis ?</i>
Post-Test	No change	<i>Quels sont les trois plus grandes menaces que fait face l'Île de Saint-Louis pour sa préservation ?</i>
Notes	This question is straightforward and required no changes beyond grammatical edits. The question was understood by the test interviewee, Racine Ndiath. Ndiath said this question would solicit responses such as, “the climate,” “desertification,” “corruption,” “lack of funding,” and more.	
Question 2		
Pre-Test	What are the top three biggest climate threats facing the preservation of the Île de Saint-Louis?	<i>Quels sont les trois plus grandes menaces du changement climatique qui face the préservation d'Île de Saint-Louis ?</i>
Post-Test	What are the top three biggest climate threats that you have faced in preserving Île de Saint-Louis?	<i>Quels sont les trois plus grandes menaces de changement climatique que vous faites face pour la préservation d'Île de Saint-Louis ?</i>
Notes	Ndiath explained that the original question might evoke responses that were repetitive to the responses in Question 1. In order to make the question clearer, Ndiath suggested that the question be edited to solicit a more personal response. By asking the interviewee about the climate threats they have witnessed in their preservation work, the interviewee will be more likely to divulge detailed responses and anecdotes related to their work regarding climate threats rather than just listing climate threats, such as flooding or desertification.	
Question 3		
Pre-Test	Do you have any information or data regarding historic or future climate trends?	<i>Avez-vous aucun d'information ou données sur les tendances climatique, historiques ou en l'avenir?</i>
Post-Test	No changes	<i>Avez-vous des informations ou des données sur les tendances climatiques, historiques ou à venir?</i>

Notes	This question was clear to Ndiath and only grammatical edits were made. He did note that while the question is clear, the interviewees may not have access to data.	
Question 4		
Pre-Test	What components of the island (components: non-residential buildings, residential buildings, roads, public spaces, view corridors, etc.) are at most risk to these climate threats?	<i>J'ai identifié cinq aspects d'île pour étudier en plus détail : les rues, les bâtiments résidentiels, les bâtiments non résidentiels, les espaces publiques, et les corridors de vue. Quels aspects d'île sont plus à risque par les menaces du changement climatique?</i>
Post-Test	No change	<i>J'ai identifié cinq aspects dans l'île pour lesquels je voudrais qu'on fasse une étude détaillée a savoir; les rues, les bâtiments résidentiels, les bâtiments non résidentiels, les espaces publiques et les corridors de vue. Quels sont les aspects de l'île qui sont les aspects les plus menacés par le changement climatique ?</i>
Notes	Ndiath explained that the question will solicit responses regarding the climate threats that each of the five identified aspects faces. He made grammatical corrections and explained that the question was clear, but that there may be a need to give examples of public spaces (football fields, squares, etc.) and non-residential buildings (churches, mosques, schools, government buildings, etc.) if the interviewee asks.	
Question 5		
Pre-Test	Where (geographically) are these threats occurring (north, south, east, west, etc.)?	<i>Où sont situées les menaces sur l'île (nord, sud, est, ouest ou autre)?</i>
Post-Test	No change	<i>No change</i>
Notes	Ndiath explained that this question seems like a natural continuation from Question 4 and will allow the interviewee to provide more specific information about where the threats and components are located.	
Question 6		
Pre-Test	What is the current condition of: Roads? Residential buildings? Non-residential buildings? Public spaces? View corridors?	<i>Quel est l'état actuel de : les rues, les bâtiments résidentiels, les bâtiments non résidentiels, les espaces publiques, et les corridors de vue.</i>

Post-Test	No change	<i>Quel est l'état actuel des rues, des bâtiments résidentiels, des bâtiments non résidentiels, des espaces publics et des corridors de vue.</i>
Notes	A slight grammatical change was made to the French version of the question. Ndiath said that this question will solicit responses regarding the status of the aspect's condition, such as "The roads are now very flat and smooth because they are paved now, whereas in the past they were bumpy and hard to navigate." A follow up question regarding the specific materials used may be necessary.	
Question 7		
Pre-Test	How do people use these site components on a regular basis? By whom are they used? How are they used? At what frequency or intensity are they used? Are they maintained?	<i>Comment les gens utilisent les aspects (les rues, les bâtiments résidentiels, les bâtiments non résidentiels, les espaces publiques, et les corridors de vue) en base quotidien ? Quels types des gens utilisent l'aspect ? Comment les aspects sont utilisés ? A quelle fréquence est l'aspect utilise ? Est-ce que l'aspect est maintenu ?</i>
Post-Test	How do people use these site components on a regular basis? By whom are they used (age, sex, income status/profession)? How are they used? At what frequency or intensity are they used? Are they maintained?	<i>Comment les gens utilisent les aspects que sont les rues, les bâtiments résidentiels, les bâtiments non résidentiels, l'espace public, et les corridors de vue, en base quotidien ? Quels types de personnes l'utilisent, âge, sexe et statut ? Comment sont ils utilisés ? A quelle fréquence sont ils utilisés ? Est-ce qu'ils sont maintenus ?</i>
Notes	Ndiath understood why these questions were grouped, but said that they should be asked one at a time, rather than all at once. He suggested adding clarifying characteristics regarding who uses the site components.	
Question 8		
Pre-Test	Do you have any information or data that supports your report of the current conditions (maps, photographs, reports, etc.)?	<i>Avez-vous aucun d'information ou données qui soutenir votre rapport de l'état actuel des aspect d'île (comme les cartes, les photographes, les rapport, ou autre)?</i>
Post-Test	No change	<i>Avez-vous des informations ou des données sur l'état actuel des aspects de l'île (comme les cartes, les photographies, les rapports, ou autres)?</i>

Notes	This question was clear to Ndiath. Only grammatical edits were made.	
Question 9		
Pre-Test	What actions have been taken in the past by your organization or others to address the climate threats to the island? What current actions are taking place? Are there any planned actions?	<i>Quelles mesures ont été pris en le passée par ton organisation ou autres pour répondre à les menaces du changement climatique ? Quels sont les mesures actuelles ? Quels sont les mesures planifiées?</i>
Post-Test	What actions have been taken in the past by your organization or others to address the climate threats to the island? What current actions are taking place? Are there any planned actions, in the short and long term?	<i>Quelles mesures ont été prises dans le passé par votre organisation ou autres pour répondre aux menaces du changement climatique ? Quelles sont les mesures actuelles ? Quelles sont les mesures planifiées à court et moyen termes?</i>
Notes	Ndiath understood and was able to articulate the responses solicited by this question. He suggested asking about short and long term planned actions, rather than just about planned actions in general, in order to divulge more detailed information regarding future plans.	
Question 10		
Pre-Test	What is your familiarity with green infrastructure? [If the interviewee is not familiar with the term, provide the following explanation: Green infrastructure is a connected network of natural spaces that conserve the natural ecosystem and provide vital functions for the environment, such as stormwater drainage. We typically have looked to traditional infrastructure, such as pipes and sewers to provide this service. Using green infrastructure to manage stormwater would mean installing a rain garden with plants that help retain and absorb the water, increasing the tree canopy, installing permeable paving (more a more absorbent paving system), or managing larger scale mangrove swamps. These green infrastructure	<i>Quel est votre connaissance d'infrastructure verte ? L'infrastructure verte est un réseau connecté d'espaces naturel qui conserve l'écosystème naturel et fourni des fonctions vitales pour l'environnement, comme le drainage des eaux pluviales. Nous avons généralement eu recours aux infrastructures traditionnelles, telles que les canalisations et les égouts, pour fournir ce service. L'utilisation de l'infrastructure verte pour gérer les eaux pluviales impliquerait l'installation d'un jardin de pluie avec des plantes qui aident à retenir et à absorber l'eau, à augmenter le couvert forestier, à installer un revêtement perméable (un système de pavage plus absorbant) ou à gérer des mangroves à plus grande échelle. Ces mesures d'infrastructure verte non seulement protègent l'environnement, mais</i>

	measures not only protect the environment, but also preserve important residential, commercial, and cultural spaces.]	<i>aussi préservent les importants espaces résidentiels, commerciaux et culturels.</i>
Post-Test	<p>What is your familiarity with green infrastructure?</p> <p>[If the interviewee is not familiar with the term, provide the following explanation: Green infrastructure is a connected network of natural spaces that conserve the natural ecosystem and provide vital functions for the environment, such as stormwater drainage. We typically have looked to traditional infrastructure, such as pipes and sewers to provide this service. Using green infrastructure to manage stormwater would mean installing a garden with plants that help retain and absorb the water, increasing the tree canopy, installing permeable paving (more a more absorbent paving system), or managing larger scale mangrove swamps. These green infrastructure measures not only protect the environment, but also preserve important residential, commercial, and cultural spaces.]</p>	<p><i>Quel est votre connaissance de l'infrastructure verte ?</i></p> <p><i>L'infrastructure verte est un réseau connecté d'espace naturel qui conserve l'écosystème naturel et fournit des fonctions vitales pour l'environnement, comme le drainage des eaux pluviales. Nous avons généralement eu recours aux infrastructures traditionnelles, telles que les canalisations et les égouts, pour fournir ce service. L'utilisation de l'infrastructure verte pour gérer les eaux pluviales impliquerait l'installation d'un jardin avec des plantes qui aident à retenir et à absorber l'eau, à augmenter le couvert forestier, à installer un revêtement perméable (un système de pavage plus absorbant) ou à gérer des mangroves à plus grande échelle. Ces mesures d'infrastructures vertes non seulement protègent l'environnement, mais aussi préservent les importants espaces résidentiels, commerciaux et culturels.</i></p>
Notes	<p>As a professional who does not know about green infrastructure, Ndiath said this explanation was easy to follow. He changed “rain gardens” to just “gardens.” The explanation states that the garden absorbs water, which explains its purpose. Using the term “rain gardens” might confuse the interviewee. He also explained that providing the key terminology in advance will be a great assistance to the interviewee.</p>	
Question 11		
Pre-Test	<p>[Refer to the Climate Change Threat Matrix and Glossary of Key Terminology that was sent in advance of the interview.] Which green infrastructure approaches seem best suited to build climate resilience and preserve the Île de Saint-Louis?</p>	<p><i>Vous avez reçu la matrice des menaces de changement climatique et le glossaire de terminologie. Quelle infrastructure verte est la mieux adapté pour bâtir la résilience climatique et préserver l'Île de Saint-Louis?</i></p>

Post-Test	No change	<i>No change</i>
Notes	Ndiath explained that the question was clear, but that it may take time for the interviewee to respond since there are many options and considerations. He strongly suggested that all interview questions be sent in advance so that the interviewee can prepare.	
Question 12		
Pre-Test	What is the role of your organization in the preservation of the Île de Saint-Louis? [Only asked to those interviewees who do not want to remain confidential]	<i>Quel est le rôle de votre organisation sur la préservation d'Île de Saint-Louis ?</i>
Post-Test	No change	<i>No change</i>
Notes	Ndiath said that this questions should be asked first if the interviewee does not wish to remain confidential.	

Appendix D: Block Map

North Blocks

South and Central Blocks

Source: Ecole d'Architecture de Lille 2005

Appendix E: Map from Safeguarding and Enhancement Plan for Saint-Louis (2006)

Source: PSMV Volume 1 2006; Legend translation by Author

Appendix F: Thematic Maps

Source: Ecole d'Architecture de Lille 2005; Legend translation by Author

Appendix G: Residential Architecture

BALCONY HOUSE

Without Retail on Ground Floor

With Retail Ground Floor

GALLERY HOUSE

BARRACK

LOW HOUSE

Source: Ecole d'Architecture de Lille 2005; Translation by Author

Appendix H: Vulnerability Equation Spreadsheet

Block Number	Sensitivity of Lots and Structures				Exposure to Climate Threats				Total of Weighted Scores	Vulnerability Rating
	State of Conservation		Type of Construction		Exposure to Coast		Lack of Vegetation			
	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted		
SA1	2	4	1	1	4	6	3	3	14	2
SA2	1	2	1	1	4	6	5	5	14	2
SA3	3	6	1	1	4	6	3	3	16	3
SA4	3	6	1	1	4	6	4	4	17	3
SA5	1	2	1	1	4	6	5	5	14	2
SA6	2	4	1	1	4	6	5	5	16	3
SA7	2	4	1	1	4	6	5	5	16	3
SA8	2	4	1	1	4	6	3	3	14	2
SA9	2	4	1	1	4	6	4	4	15	3
SA10	3	6	1	1	4	6	5	5	18	3
SA11	4	8	1	1	4	6	5	5	20	4
SA12	1	2	1	1	5	7.5	3	3	13.5	2
SB1	5	10	1	1	3	4.5	1	1	16.5	3
SB2	1	2	1	1	3	4.5	5	5	12.5	2
SB3	4	8	1	1	3	4.5	5	5	18.5	3
SB4	1	2	1	1	3	4.5	4	4	11.5	2
SB5	3	6	1	1	3	4.5	5	5	16.5	3
SB6	4	8	1	1	3	4.5	5	5	18.5	3
SB7	3	6	1	1	3	4.5	5	5	16.5	3
SB8	2	4	1	1	3	4.5	4	4	13.5	2
SB9	2	4	1	1	3	4.5	4	4	13.5	2
SB10	2	4	1	1	3	4.5	5	5	14.5	2
SB11	1	2	1	1	3	4.5	5	5	12.5	2
SB12	1	2	1	1	3	4.5	5	5	12.5	2
SB13	2	4	1	1	3	4.5	5	5	14.5	2
SB14	4	8	1	1	3	4.5	4	4	17.5	3
SB15	3	6	1	1	3	4.5	4	4	15.5	3
SB16	1	2	1	1	4	6	5	5	14	2
SC1	1	2	1	1	3	4.5	5	5	12.5	2
SC2	2	4	1	1	3	4.5	5	5	14.5	2
SC3	1	2	1	1	3	4.5	5	5	12.5	2
SC4	2	4	1	1	3	4.5	4	4	13.5	2
SC5	3	6	1	1	3	4.5	5	5	16.5	3
SC6	2	4	1	1	3	4.5	4	4	13.5	2
SC7	1	2	1	1	3	4.5	5	5	12.5	2
SC8	4	8	1	1	3	4.5	5	5	18.5	3
SC9	3	6	1	1	3	4.5	5	5	16.5	3
SC10	1	2	1	1	3	4.5	5	5	12.5	2
SC11	2	4	1	1	3	4.5	5	5	14.5	2
SC12	2	4	1	1	3	4.5	5	5	14.5	2
SC13	3	6	2	2	3	4.5	5	5	17.5	3
SC14	3	6	1	1	3	4.5	5	5	16.5	3
SC15	3	6	1	1	4	6	4	4	17	3
SD1	3	6	1	1	3	4.5	3	3	14.5	2
SD2	1	2	1	1	3	4.5	5	5	12.5	2
SD3	3	6	1	1	3	4.5	5	5	16.5	3
SD4	2	4	1	1	4	6	5	5	16	3
SD5	1	2	1	1	4	6	4	4	13	2
SD6	1	2	1	1	4	6	1	1	10	1
SD7	1	2	1	1	4	6	4	4	13	2
SD8	2	4	1	1	4	6	4	4	15	3
SD9	3	6	1	1	4	6	4	4	17	3
SD10	2	4	1	1	4	6	4	4	15	3
SD11	3	6	2	2	4	6	4	4	18	3
SD12	3	6	1	1	4	6	5	5	18	3
SD13	2	4	5	5	4	6	5	5	20	4
SD14	2	4	3	3	5	7.5	4	4	18.5	3

Block Number	Sensitivity of Lots and Structures				Exposure to Climate Threats				Total of Weighted Scores	Vulnerability Rating
	State of Conservation		Type of Construction		Exposure to Coast		Lack of Vegetation			
	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted		
SE1	1	2	1	1	4	6	1	1	10	1
SE2	4	8	1	1	4	6	5	5	20	4
SE3	2	4	1	1	4	6	5	5	16	3
CA1	2	4	1	1	4	6	2	2	13	2
CB1	1	2	1	1	3	4.5	4	4	11.5	2
CC1	5	10	1	1	3	4.5	1	1	16.5	3
CC2	1	2	1	1	4	6	1	1	10	1
CD1	1	2	1	1	4	6	5	5	14	2
NA1	1	2	1	1	4	6	5	5	14	2
NA2	2	4	1	1	4	6	4	4	15	3
NA3	4	8	1	1	4	6	5	5	20	4
NA4	2	4	1	1	4	6	5	5	16	3
NA5	1	2	1	1	4	6	4	4	13	2
NA6	1	2	1	1	4	6	4	4	13	2
NA7	1	2	1	1	4	6	5	5	14	2
NA8	1	2	1	1	4	6	4	4	13	2
NA9	3	6	1	1	4	6	5	5	18	3
NA10	2	4	2	2	4	6	5	5	17	3
NA11	3	6	1	1	4	6	4	4	17	3
NA12	2	4	1	1	4	6	5	5	16	3
NA13	2	4	1	1	4	6	4	4	15	3
NA14	1	2	1	1	4	6	1	1	10	1
NA15	1	2	1	1	4	6	1	1	10	1
NA16	1	2	1	1	4	6	1	1	10	1
NA17	1	2	1	1	4	6	3	3	12	2
NA18	3	6	1	1	4	6	3	3	16	3
NA19	1	2	1	1	4	6	3	3	12	2
NA20	3	6	1	1	4	6	2	2	15	3
NA21	2	4	1	1	5	7.5	1	1	13.5	2
NB1	3	6	1	1	3	4.5	5	5	16.5	3
NB2	1	2	1	1	3	4.5	1	1	8.5	1
NB3	2	4	1	1	3	4.5	5	5	14.5	2
NB4	1	2	1	1	3	4.5	5	5	12.5	2
NB5	2	4	1	1	3	4.5	5	5	14.5	2
NB6	3	6	1	1	3	4.5	5	5	16.5	3
NB7	4	8	1	1	3	4.5	5	5	18.5	3
NB8	2	4	1	1	3	4.5	5	5	14.5	2
NB9	3	6	2	2	3	4.5	5	5	17.5	3
NB10	3	6	2	2	3	4.5	3	3	15.5	3
NB11	2	4	1	1	3	4.5	5	5	14.5	2
NB12	2	4	3	3	3	4.5	5	5	16.5	3
NB13	4	8	2	2	3	4.5	3	3	17.5	3
NC1	1	2	1	1	3	4.5	5	5	12.5	2
NC2	1	2	1	1	3	4.5	5	5	12.5	2
NC3	5	10	1	1	3	4.5	1	1	16.5	3
NC4	1	2	1	1	3	4.5	5	5	12.5	2
NC5	3	6	1	1	3	4.5	5	5	16.5	3
NC6	3	6	1	1	3	4.5	5	5	16.5	3
NC7	1	2	1	1	3	4.5	5	5	12.5	2
NC8	2	4	1	1	3	4.5	5	5	14.5	2
NC9	3	6	2	2	3	4.5	4	4	16.5	3
NC10	2	4	1	1	3	4.5	5	5	14.5	2
NC11	3	6	1	1	3	4.5	5	5	16.5	3
NC12	2	4	1	1	3	4.5	5	5	14.5	2
NC13	3	6	1	1	3	4.5	4	4	15.5	3
NC14	3	6	1	1	3	4.5	5	5	16.5	3
NC15	4	8	1	1	3	4.5	3	3	16.5	3
NC16	2	4	2	2	3	4.5	4	4	14.5	2
NC17	1	2	2	2	3	4.5	3	3	11.5	2
NC18	3	6	2	2	3	4.5	4	4	16.5	3
NC19	3	6	4	4	3	4.5	3	3	17.5	3

Block Number	Sensitivity of Lots and Structures				Exposure to Climate Threats				Total of Weighted Scores	Vulnerability Rating
	State of Conservation		Type of Construction		Exposure to Coast		Lack of Vegetation			
	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted		
NC20	1	2	1	1	3	4.5	1	1	8.5	1
NC21	1	2	1	1	3	4.5	1	1	8.5	1
NC22	5	10	1	1	3	4.5	1	1	16.5	3
NC23	1	2	1	1	4	6	2	2	11	2
NC24	1	2	1	1	5	7.5	3	3	13.5	2
ND1	1	2	1	1	3	4.5	4	4	11.5	2
ND2	1	2	1	1	3	4.5	5	5	12.5	2
ND3	2	4	1	1	3	4.5	5	5	14.5	2
ND4	2	4	1	1	3	4.5	4	4	13.5	2
ND5	1	2	1	1	3	4.5	3	3	10.5	2
ND6	2	4	1	1	3	4.5	5	5	14.5	2
ND7	3	6	1	1	3	4.5	5	5	16.5	3
ND8	1	2	1	1	3	4.5	5	5	12.5	2
ND9	2	4	1	1	3	4.5	5	5	14.5	2
ND10	1	2	1	1	3	4.5	5	5	12.5	2
ND11	3	6	2	2	3	4.5	5	5	17.5	3
ND12	1	2	1	1	3	4.5	5	5	12.5	2
ND13	3	6	2	2	3	4.5	5	5	17.5	3
ND14	2	4	1	1	3	4.5	4	4	13.5	2
ND15	2	4	2	2	3	4.5	4	4	14.5	2
ND16	2	4	2	2	3	4.5	5	5	15.5	3
ND17	1	2	2	2	3	4.5	3	3	11.5	2
ND18	2	4	1	1	3	4.5	4	4	13.5	2
ND19	2	4	1	1	3	4.5	2	2	11.5	2
ND20	1	2	1	1	3	4.5	1	1	8.5	1
NE1	1	2	1	1	4	6	4	4	13	2
NE2	1	2	1	1	4	6	5	5	14	2
NE3	2	4	1	1	4	6	4	4	15	3
NE4	2	4	1	1	4	6	5	5	16	3
NE5	3	6	1	1	4	6	4	4	17	3
NE6	2	4	1	1	4	6	4	4	15	3
NE7	3	6	1	1	4	6	4	4	17	3
NE8	2	4	1	1	4	6	4	4	15	3
NE9	2	4	1	1	4	6	4	4	15	3
NE10	4	8	1	1	3	4.5	4	4	17.5	3
NE11	2	4	1	1	3	4.5	4	4	13.5	2
NE12	2	4	2	2	3	4.5	5	5	15.5	3
NE13	3	6	2	2	3	4.5	5	5	17.5	3
NE14	1	2	3	3	3	4.5	5	5	14.5	2
NE15	2	4	1	1	3	4.5	5	5	14.5	2
NE16	2	4	2	2	3	4.5	5	5	15.5	3
NE17	2	4	4	4	3	4.5	3	3	15.5	3
NE18	1	2	1	1	3	4.5	3	3	10.5	2
NE19	1	2	1	1	3	4.5	1	1	8.5	1
NE20	1	2	1	1	3	4.5	1	1	8.5	1
NE21	1	2	1	1	3	4.5	1	1	8.5	1
NF1	3	6	1	1	4	6	5	5	18	3
NF2	2	4	2	2	4	6	5	5	17	3
NF3	1	2	1	1	4	6	5	5	14	2
NF4	1	2	1	1	4	6	5	5	14	2
NF5	2	4	2	2	4	6	4	4	16	3
NF6	3	6	3	3	4	6	4	4	19	3
NF7	3	6	3	3	4	6	3	3	18	3
NF8	2	4	2	2	4	6	3	3	15	3
NF9	1	2	2	2	4	6	2	2	12	2
NF10	2	4	2	2	4	6	4	4	16	3
NF11	2	4	2	2	4	6	3	3	15	3
NF12	2	4	1	1	4	6	1	1	12	2
NF13	3	6	1	1	4	6	1	1	14	2
NF14	2	4	1	1	5	7.5	1	1	13.5	2
NF15	2	4	1	1	5	7.5	4	4	16.5	3

Block Number	Sensitivity of Lots and Structures				Exposure to Climate Threats				Total of Weighted Scores	Vulnerability Rating
	State of Conservation		Type of Construction		Exposure to Coast		Lack of Vegetation			
	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted		
NQ1	1	2	1	1	5	7.5	1	1	11.5	2
NQ2	1	2	1	1	5	7.5	5	5	15.5	3
NQ4	1	2	1	1	5	7.5	2	2	12.5	2
NQ5	1	2	1	1	5	7.5	5	5	15.5	3
NQ6	2	4	1	1	5	7.5	2	2	14.5	2
NQ7	5	10	1	1	5	7.5	5	5	23.5	5

Input Weights

State of Conservation – 1

Type of Construction – 1

Exposure of Coast – 1.5

Lack of Vegetation – 1

Vulnerability Rating Based on Weighted Score

Score of 23.5 – 27.5 – Vulnerability Rating of 5

Score of 19.3 – 23.4 – Vulnerability Rating of 4

Score of 14.7 – 19.2 – Vulnerability Rating of 3

Score of 10.1 – 14.6 – Vulnerability Rating of 2

Score of 5.5 – 10 – Vulnerability Rating of 1

Appendix I: Suitability for Intervention Equation Spreadsheet

Block Number	Vulnerability		Opportunity				Total of Weighted Scores	Suitability Rating
			Vacant Lots		No Architectural interest			
	Score	Weighted	Score	Weighted	Score	Weighted		
SA1	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SA2	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations
SA3	3	6	1	1	2	6	13	Suitable for Very Limited Intervention
SA4	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
SA5	2	4	3	3	3	9	16	Suitable for Intervention with Minor Limitations
SA6	3	6	2	2	2	6	14	Suitable for Intervention with Minor Limitations
SA7	3	6	1	1	2	6	13	Suitable for Very Limited Intervention
SA8	2	4	2	2	3	9	15	Suitable for Intervention with Minor Limitations
SA9	3	6	1	1	2	6	13	Suitable for Very Limited Intervention
SA10	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
SA11	4	8	1	1	4	12	21	Suitable for Intervention with Minor Limitations
SA12	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SB1	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
SB2	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SB3	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
SB4	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SB5	3	6	3	3	2	6	15	Suitable for Intervention with Minor Limitations
SB6	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
SB7	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
SB8	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
SB9	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
SB10	2	4	2	2	3	9	15	Suitable for Intervention with Minor Limitations
SB11	2	4	2	2	2	6	12	Suitable for Very Limited Intervention
SB12	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
SB13	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations
SB14	3	6	2	2	1	3	11	Suitable for Very Limited Intervention
SB15	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
SB16	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SC1	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SC2	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
SC3	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SC4	2	4	4	4	3	9	17	Suitable for Intervention with Minor Limitations
SC5	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
SC6	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SC7	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
SC8	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
SC9	3	6	3	3	1	3	12	Suitable for Very Limited Intervention
SC10	2	4	3	3	2	6	13	Suitable for Very Limited Intervention
SC11	2	4	3	3	3	9	16	Suitable for Intervention with Minor Limitations
SC12	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
SC13	3	6	2	2	2	6	14	Suitable for Intervention with Minor Limitations
SC14	3	6	1	1	2	6	13	Suitable for Very Limited Intervention
SC15	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
SD1	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
SD2	2	4	4	4	3	9	17	Suitable for Intervention with Minor Limitations
SD3	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
SD4	3	6	2	2	3	9	17	Suitable for Intervention with Minor Limitations
SD5	2	4	2	2	4	12	18	Suitable for Intervention with Minor Limitations
SD6	1	2	1	1	1	3	6	Suitable for Very Limited Intervention
SD7	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
SD8	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
SD9	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
SD10	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
SD11	3	6	2	2	3	9	17	Suitable for Intervention with Minor Limitations
SD12	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
SD13	4	8	1	1	3	9	18	Suitable for Intervention with Minor Limitations
SD14	3	6	2	2	5	15	23	Very Suitable for Intervention
SE1	1	2	1	1	5	15	18	Suitable for Intervention with Minor Limitations
SE2	4	8	2	2	3	9	19	Suitable for Intervention with Minor Limitations
SE3	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
CA1	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
CB1	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
CC1	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
CC2	1	2	1	1	1	3	6	Suitable for Very Limited Intervention
CD1	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
NA1	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
NA2	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
NA3	4	8	1	1	1	3	12	Suitable for Very Limited Intervention
NA4	3	6	1	1	1	3	10	Suitable for Very Limited Intervention

Block Number	Vulnerability		Opportunity				Total of Weighted Scores	Suitability Rating
			Vacant Lots		No Architectural interest			
	Score	Weighted	Score	Weighted	Score	Weighted		
NA5	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
NA6	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
NA7	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
NA8	2	4	3	3	2	6	13	Suitable for Very Limited Intervention
NA9	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
NA10	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
NA11	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
NA12	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
NA13	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
NA14	1	2	1	1	1	3	6	Suitable for Very Limited Intervention
NA15	1	2	1	1	1	3	6	Suitable for Very Limited Intervention
NA16	1	2	1	1	1	3	6	Suitable for Very Limited Intervention
NA17	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations
NA18	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
NA19	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations
NA20	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
NA21	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
NB1	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
NB2	1	2	1	1	1	3	6	Suitable for Very Limited Intervention
NB3	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
NB4	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations
NB5	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
NB6	3	6	2	2	1	3	11	Suitable for Very Limited Intervention
NB7	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
NB8	2	4	2	2	4	12	18	Suitable for Intervention with Minor Limitations
NB9	3	6	1	1	2	6	13	Suitable for Very Limited Intervention
NB10	3	6	2	2	3	9	17	Suitable for Intervention with Minor Limitations
NB11	2	4	2	2	2	6	12	Suitable for Very Limited Intervention
NB12	3	6	4	4	5	15	25	Very Suitable for Intervention
NB13	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
NC1	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
NC2	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
NC3	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
NC4	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
NC5	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
NC6	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
NC7	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
NC8	2	4	2	2	3	9	15	Suitable for Intervention with Minor Limitations
NC9	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
NC10	2	4	3	3	2	6	13	Suitable for Very Limited Intervention
NC11	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
NC12	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
NC13	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
NC14	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
NC15	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
NC16	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
NC17	2	4	1	1	5	15	20	Suitable for Intervention with Minor Limitations
NC18	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
NC19	3	6	1	1	5	15	22	Suitable for Intervention with Minor Limitations
NC20	1	2	1	1	1	3	6	Suitable for Very Limited Intervention
NC21	1	2	1	1	2	6	9	Suitable for Very Limited Intervention
NC22	3	6	1	1	1	3	10	Suitable for Very Limited Intervention
NC23	2	4	5	5	3	9	18	Suitable for Intervention with Minor Limitations
NC24	2	4	2	2	3	9	15	Suitable for Intervention with Minor Limitations
ND1	2	4	4	4	1	3	11	Suitable for Very Limited Intervention
ND2	2	4	1	1	2	6	11	Suitable for Very Limited Intervention
ND3	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
ND4	2	4	1	1	1	3	8	Suitable for Very Limited Intervention
ND5	2	4	5	5	1	3	12	Suitable for Very Limited Intervention
ND6	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
ND7	3	6	1	1	2	6	13	Suitable for Very Limited Intervention
ND8	2	4	2	2	4	12	18	Suitable for Intervention with Minor Limitations
ND9	2	4	2	2	3	9	15	Suitable for Intervention with Minor Limitations
ND10	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
ND11	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations
ND12	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations
ND13	3	6	1	1	2	6	13	Suitable for Very Limited Intervention
ND14	2	4	2	2	4	12	18	Suitable for Intervention with Minor Limitations
ND15	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations
ND16	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations
ND17	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations
ND18	2	4	1	1	5	15	20	Suitable for Intervention with Minor Limitations

Block Number	Vulnerability		Opportunity						Total of Weighted Scores	Suitability Rating
			Vacant Lots		No Architectural interest					
	Score	Weighted	Score	Weighted	Score	Weighted				
ND19	2	4	1	1	2	6	11	Suitable for Very Limited Intervention		
ND20	1	2	1	1	3	9	12	Suitable for Very Limited Intervention		
NE1	2	4	1	1	1	3	8	Suitable for Very Limited Intervention		
NE2	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations		
NE3	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations		
NE4	3	6	2	2	2	6	14	Suitable for Intervention with Minor Limitations		
NE5	3	6	2	2	4	12	20	Suitable for Intervention with Minor Limitations		
NE6	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations		
NE7	3	6	1	1	2	6	13	Suitable for Very Limited Intervention		
NE8	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations		
NE9	3	6	1	1	2	6	13	Suitable for Very Limited Intervention		
NE10	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations		
NE11	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations		
NE12	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations		
NE13	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations		
NE14	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations		
NE15	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations		
NE16	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations		
NE17	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations		
NE18	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations		
NE19	1	2	1	1	5	15	18	Suitable for Intervention with Minor Limitations		
NE20	1	2	1	1	1	3	6	Suitable for Very Limited Intervention		
NE21	1	2	4	4	3	9	15	Suitable for Intervention with Minor Limitations		
NF1	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations		
NF2	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations		
NF3	2	4	5	5	5	15	24	Very Suitable for Intervention		
NF4	2	4	1	1	1	3	8	Suitable for Very Limited Intervention		
NF5	3	6	2	2	5	15	23	Very Suitable for Intervention		
NF6	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations		
NF7	3	6	2	2	4	12	20	Suitable for Intervention with Minor Limitations		
NF8	3	6	1	1	3	9	16	Suitable for Intervention with Minor Limitations		
NF9	2	4	1	1	5	15	20	Suitable for Intervention with Minor Limitations		
NF10	3	6	1	1	4	12	19	Suitable for Intervention with Minor Limitations		
NF11	3	6	1	1	5	15	22	Suitable for Intervention with Minor Limitations		
NF12	2	4	1	1	5	15	20	Suitable for Intervention with Minor Limitations		
NF13	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations		
NF14	2	4	1	1	3	9	14	Suitable for Intervention with Minor Limitations		
NF15	3	6	1	1	5	15	22	Suitable for Intervention with Minor Limitations		
NQ1	2	4	1	1	5	15	20	Suitable for Intervention with Minor Limitations		
NQ2	3	6	1	1	5	15	22	Suitable for Intervention with Minor Limitations		
NQ4	2	4	1	1	5	15	20	Suitable for Intervention with Minor Limitations		
NQ5	3	6	1	1	1	3	10	Suitable for Very Limited Intervention		
NQ6	2	4	1	1	4	12	17	Suitable for Intervention with Minor Limitations		
NQ7	5	10	1	1	5	15	26	Very Suitable for Intervention		

Input Weights

Vulnerability – 2

Vacant Lots – 1

No Architectural interest – 3

Suitability Rating Based on Weighted Score

Score of 23 – 30 – Very Suitable for Intervention

Score of 14 – 22 – Suitable for Intervention with Minor Limitations

Score of 6 – 13 – Suitable for Very Limited Intervention