Ecosystem Services and Coastal Adaptation to Climate Change: An Interdisciplinary Science-Based Application in The Gambia

A DISSERTATION

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Dedication

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Abstract

This dissertation focuses on the intersection of climate change policy, natural resource economics, and environmental sustainability in The Gambia. The dissertation has four chapters. Chapter one assesses islanders' perception of climate change risk as well as their willingness to migrate (WTM) from the island city capital of Banjul, The Gambia. Chapter two conducts a site suitability analysis for building a new climate-resilient capital city, using remote sensing and GIS-based multi-criteria decision-making (MCDM) procedures. Chapter three detects land-use land cover (LULC) change from 1985-2020 and project by 2050, LULC composition, carbon storage, sequestration, and valuation in Southwestern Gambia, under three different development scenarios. Chapter four elicits people's willingness to pay (WTP) for improved coastal protection against climate change impacts (coastal erosion) in The Gambia. The abstracts below summarize the findings of each chapter.

Abstract By Chapter

Chapter One: Assessing the Risk of Climate and Environmental Migration: Islanders' Response

Several studies explore the nexus between migration, climate change, and other environmental challenges. However, few studied have used a mixed approach– qualitative and quantitative methods in establishing the above relationships based on households' risk perception. I find that unlike most cities in Africa, Banjul is experiencing net out-migration. The reason does seem to be environmental and climate-related factors, not economic, as mainly claimed to be the root causes of migration (from laws of migration by Ravenstein (1889) to the micro model of neoclassical theory). This makes Banjul an outlier among cities in sub-Saharan Africa. I learn that avoiding climate and environmentally-induced migration requires a pro-active attempt to reduce households' risk and vulnerability levels. Using a household survey approach and anchored on the New Economics Theory, I discover that households in The Gambia's capital city, Banjul, are employing migration as an early avoidance behavioral strategy to avert current extreme precipitation inundations and projected climate change impacts

(e.g., rising sea levels) threatening the island city. When presented with a willingness to migrate (WTM) scenario, 64% of households in Banjul express a positive migration intent by 2050 if current conditions remain constant. On average, they are 25% more likely to migrate if they perceive climate and environmentally-induced factors had influenced the city's high out-migration rate relative to other contributing factors, all else constant. I recommend that The Gambia government and the city of Banjul consider internal migration as a risk-reduction and a climate adaptation strategy for sustainability purposes. This chapter points to the conclusion that investing in hard-engineering solutions for protecting the city could mitigate the potential growth of the out-migration rate in Banjul.

Chapter Two: A New Climate-Resilient Capital City: Site Suitability Analysis using Remote Sensing and a GIS-based Multicriteria Decision-making (MCDM) Procedure

Climate change impacts (e.g., rising global mean sea-level) have threatened the existence of The Gambia's current island capital city, Banjul. A recently concluded research project recommends the identification of a strategic location for building a climate-resilient capital city (Coates & Manneh, 2015). In an attempt to identify the most 'suitable' site, I conducted this analysis using both remotely sensed satellite imagery and a public opinion survey of nearly 500 Gambians. I applied a geographic information system (GIS) based multicriteria decision-making (MCDM) analysis of several input data layers to output a final suitability map. Predetermined policy objectives define what 'suitability' means in the study. On the one hand, the MCDM result identifies the most suitable site (~9000 ha) for constructing a new capital city in Kiang West District, Lower River Region (LRR). On the other hand, the public opinion survey result points to the West Coast Region (WCR) for a new capital city development. Overall, I conclude that building a city in the WCR is undeniably a public preference. However, the development has the potential to destroy over 65% of the country's remaining closed and open forest ecosystems. Consequently, ecosystem service functions and benefits thereat will also be grossly impacted. To avoid relatively more ecological damage and promote environmental sustainability, the study recommends a site in the LRR for building a climate-resilient capital city. The tradeoff is that the transaction cost will be higher in the LRR relative to the WCR.

Chapter Three: Change Detection (1985-2020): Projections on Land-use Land Cover, Carbon Storage, Sequestration, and Valuation in Southwestern Gambia

This study assessed land-use land cover (LULC) change in the southwestern region of The Gambia. I used remotely sensed satellite data derived from the US Geological Survey (USGS) and the European Space Agency's open-access databases. The LULC maps were created using the ArcGIS Pro software. The maps were used as part of the input parameters required to run the Integrated Valuation of Ecosystem Services & Tradeoffs (InVEST) Carbon Storage and Sequestration model. Results show that LULC change is primarily driven by increasing urbanization attributed to the growing urban population associated with the accelerating estate development and infrastructure expansion projects. Overall, this analysis reveals a forest cover loss of 22,408 ha (18% decrease) from 1985 to 2020 in the study area. The land-use change between 2003 and 2020 has contributed to the emissions of 21,824 metric tons of carbon. The carbon loss is equivalent to an economic value ranging from US$521,526 to US$6,899,830. I also present an analysis of three LULC projection scenarios, namely, a business-as-usual (BAU), a new capital city (NCC) development, and a sustainability (SUST) pathway. Consideration of the study recommendations will not only minimize deforestation but will lead to a higher rate of carbon sequestration with urban flood mitigation co-benefit amongst others.

Chapter Four: Eliciting People's Willingness to Pay (WTP) for Improved Coastal Protection against Climate Change Impacts (Coastal Erosion) in The Gambia

The economic value of coastal beaches remains either underestimated or poorly understood by policymakers in developing countries, especially in Africa. The costs and benefits of coastal ecosystem services (ES) are required to inform public finance investment decisions for coastline protection and restoration in ensuring sustainable tourism, among other functions. I address this research and policy gap using a contingent valuation (CV) survey method to elicit willingness-to-pay (WTP) for improved coastal protection in The Gambia. Contrary to the assertion that people in developing countries often express limited WTP, evidence from this case-study reports the opposite. The study finds that 90% of Gambians and 88% of non-Gambians express positive WTP for coastal protection, with aggregate welfare or WTP value of US$14.5 million (D668 million). Given the overall project cost of US$13 million, from Coates & Manneh, 2015, for protecting the Senegambia beach area, my cost-benefit analysis result generates a positive net present value (NPV). The findings of this research support government's investment in protecting the coastline against climate change impacts such as coastal erosion.

Research Contributions

This research contributes to the advancement of knowledge in the following ways. First, this dissertation enhances our understanding of migration as an adaptative strategy to mitigate environmental and climate risk factors. It informs us of people's willingness to migrate (WTM) from coastal settlements due to current environmental challenges and perceived climate change impacts (see chapter one). Second, the study advances the applicability of the GIS-based multicriteria decision-making approach for site identification– for a new capital city (see chapter two). Third, the study contributes to land-use land cover (LULC) assessment and ecosystem service valuation (e.g., carbon sequestration) in the developing world– the first LULC change detection study in The Gambia (see chapter one). Fourth, this study enhances our understanding of willingness to pay (WTP) for climate change mitigation projects among people in the least developed countries– The Gambia as a case study. The argument that poor people have limited or zero WTP for restoration/mitigation projects due to liquidity constraints may not necessarily be true. Gambians' express high WTP for beach protection despite being poor. It contributes to quantifying the monetary value for coastal ecosystem services provided by nature to a developing country's economy (see chapter four). Finally, beyond academia, the research would help policymakers to understand the economics of natural resources and climate change adaptation options in their decision-making processes.

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Chapter One

Assessing Risks of Climate & Environmental Migration: - Islanders' Response

1.1 Introduction

The Gambia's island capital city, Banjul, is projected to be underwater by 2100 if the global mean sea level rises by 1.0 meter (Jallow et al., 1996; Brown et al., 2011; Amuzu, Jallow, Kabo-Bah, & Yaffa, 2018a). A meter rise in sea levels is likely under the IPCC's Representative Concentration Pathway (RCP) scenarios 6.0 and 8.5 (IPCC, 2007). What should be done to adapt to sea-level rise in Banjul? Why are people migrating? Should the capital be relocated? Will the government protect the island? This chapter investigates the perception of islanders (residents in Banjul) on these questions. It also predicts islanders' willingness to migrate (WTM) or stay considering the prevailing environmental conditions and projected climate change impacts.

Research has shown that climate change and extreme weather-related hazards such as intense flooding and sea-level rise (SLR) would severely affect coastal resources, communities, and livelihoods in ways that would undermine their socioecological functioning. Such climate change impacts may include damage to private properties and public infrastructures, injuries and fatalities, structural loss of island nations (e.g., The Maldives, Kiribati, Tuvalu), economic losses to coastal cities (like Banjul, Lagos, Accra, Durban, Mombasa, Monrovia, Venice, Mumbai, Hong Kong, London, Miami, New York); environmentally-induced population movement (from Somalia, Kenya, South Sudan, Uganda to small island nations); loss of revenue to governments and businesses, especially in Africa, Asia, & Latin America; and loss of cultural, sacred and historical sites (Jallow et al., 1996; Castles, 2002; Beauchemin and Bocquier, 2004; McLeman and Smit, 2006; Raleigh et al., 2009; Black et al., 2011; Kebede & Nicholls, 2011; Horowitz, 2013; McLeman, 2014; Monterroso and Conde, 2015; Serdeczny et al., 2016; Fu and Song, 2017; Feingold and Thornton, 2018). For example, according to McLeman (2015), over 56 million people in developing countries will be affected by a meter rise in the global mean sea-level.

Globally, most of the United Nations High Commissioner for Refugees' (UNHCR) “population of concern (~60 million)”, as per the UNCHR's definition, are living in climate hotspots mainly in the developing nations (Türk et al., 2015). Almost 50% of internally displaced persons (IDPs) (~20 million) around the world are in Africa (Black, Crush, Peberdy, & Ammassari, 2006), a significant proportion of which can fit into the definition of environmentally displaced persons (EDPs). According to the UNCHR, globally, nearly 80 million people were forcibly displaced in 2019 (UNCHR, 2020). Approximately 85% are hosted by developing and fragile states (World Bank-UNHCR Joint Data Center, 2020).

Several studies stress that climate and environmental hazards will increase migration, especially in resource-poor countries (Afsar, 2003; Perch-Nielsen, 2004; Hunter, 2005; Myers, 2005; IPCC, 2007; Perch-Nielsen et al., 2008; Piguet, 2008; Morrissey, 2009; Massey et al., 2010; Black et al., 2011; Türk et al., 2015; Nawrotzki and DeWaard, 2016; Nawrotzki et al., 2016; Nawrotzki and Bakhtsiyarava, 2017; Stapleton, Nadin, Watson, & Kellett, 2017). Note that people and communities respond to climate and environmental hazards by either doing nothing, modifying exposure, sensitivity, and vulnerability levels, or migrating to seek sanctuary elsewhere (Martine, McGranahan, Montgomery & Fernandez-Castilla, 2008; Perch-Nielsen et al., 2008; Raleigh et al., 2009; McLeman, 2014; Fu and Song, 2017; Stojanov et al., 2017).

The first IPCC report (1990) stressed that “the gravest effects of climate change may be those on human migration as millions will be displaced" (Piguet, 2008). These migrants are commonly referred to as “environmental refugees” (ERs) (R. McLeman, 2012); El-Hinnawi 1985 cited in Black, 2001), “climate refugees” (CRs) (Jermendy, 2014; Piguet, 2008) “environmental migrants”(EMs) (Grassani, 2013), “ecological migrants” (Wood, 2001). Others use phrases such as “environmentally-induced population movements” (EIPM) and “environmentally displaced persons” (EDPs)

(Piguet, 2008). In this chapter, I interchangeably use these terms as they fit the context and the definition of each term. In general, these names are widely used to describe people who lost or are expected to lose their habitats and secured livelihood sources due to disruptive environmental or climate change-related disasters (e.g., floods, SLR) and remain desperate and choiceless except to migrate temporarily or permanently from their homelands in search for survival and reservation either internally or across sovereign borders (El-Hinnawi 1985 cited in Black, 2001; Perch-Nielsen, 2004; Myers, 2005; Perch-Nielsen et al., 2008; Piguet, 2008; McLeman, 2012; Jermendy, 2014; Oudry et al., 2016)

The phenomenon of environmentally-induced population displacement is postulated to be one of the worst humanitarian crises of our generation. In 1990, the IPCC scientific report predicted that 150 million people will be displaced by climate change by 2050 (IPCC, 1990; Bronen, 2012). Recently, a study commissioned by the World Bank concluded that, if no action is taken, there will be more than 143 million internal climate migrants by the mid-21st century, including 86 million from Sub Saharan Africa, 40 million from South Asia, and 17 million from Latin America (Rigaud et al., 2018). Other estimates range from 200 million to nearly a billion people (Tacoli, 2009). When EDPs cross their national borders, they become environmental or climate refugees with no internationally recognized legal status (Myers, 2005; Perch-Nielsen, 2004; Nansen Initiative Secretariat, 2016). Lack of data on the socio-economic conditions and the limited knowledge of adaptation options for people in fragile communities and conflict-affected regions poses a severe policy challenge to in terms of understanding their needs and improving their welfare conditions (World Bank, 2019; Corral, Irwin, Krishnan, Mahler, & Vishwanath, 2020). This study will contribute to our understanding of islanders' response strategy to mitigate current environmental and future climate risk factors in the city of Banjul, The Gambia.

The Gambia is not just heavily exposed but highly vulnerable to climate change hazards such as sea-level rise (SLR). The country's climate risk factors are also exacerbated by its lack of resilient infrastructure, insufficient financial resources, weak institutional capacity, and lack of social safety nets (Jallow et al., 1996; Drammeh, 2013; UNDP, 2013; IPCC, 2014; Coates and Manneh, 2015). Extreme and severe annual precipitation and riverine flood events continue to damage properties and claim lives in residential areas of the city such as Half-die and Tobacco Road areas. Between 1993 and 2013, 375 households have out-migrated from Banjul, leading to over 25% reduction in the city's population (Gambia Bureau of Statistics (GBoS, 2013a)). Evidence suggests that economic and social conditions are not severely strained in Banjul to trigger such swift out-migration relative to the other regions, at least within the country (see Map 1.1, chapter one). On what grounds are islanders in Banjul out-migrating at such an alarming rate? Could it be environmental or climate related factors? Will the trend continue? These are the underlying research questions that motivated this study.

It is crucial to recognize that migration does not necessarily imply what McCarthy et al., (2001) call 'reactive adaptation' to a negative shock (Banerjee, Black, & Kniveton, 2014). Sometimes, migration is an 'anticipatory adaptation' strategy to adapt to various climate and environmental stressors as well as alleviating poverty, fighting against social and economic injustice, and promoting household empowerment (Zhu cited in Bilsborrow, 1998; Banerjee et al., 2014; McLeman, 2014; Raleigh et al., 2009; Oudry et al., 2016; Stojanov et al., 2017). As one of the earliest migration researchers, Ravenstein, rightly stated, migration means life and progress (Perch-Nielsen, 2004). In this chapter, migration is understood as both a passive response and a proactive strategy for risk reduction. However, the chapter focuses on migration as an adaptation response to mitigating the growing climate change threats confronting the inhabitants of Banjul.

The chapter is divided into seven sections. Section one briefly introduces the theoretical underpinnings and summarizes the nexus between climate change and migration. Section two highlights the study area and study objectives. Section three presents the study methodology. Section four reports the descriptive statistics of the survey data used. Section five focuses on the econometric model and provides a qualitative analysis to support the regression results. Section six discusses the overall study findings and offers a detailed review of the induced factors of migration as well as a discussion on internal migration dynamics in The Gambia and elsewhere. Section seven presents key policy recommendations, conclusions, and areas for further research.

1.1.1 Theoretical Framework of Migration

Social scientists study migration based on competing theoretical views informed by various disciplines and regional experience (Perch-Nielsen, 2004). In general, each theory contributes to explaining the factors responsible for the increasing trend in internal and international migration patterns. This study conducted a review of the following migration models and theories: Neoclassical Economics model (both micro & macro theories); Gravity Model, Dependence Theory, Dual Labor Market Theory, World Systems Theory, Social Capital Theory and Network Model (Chain migration), the Transnational theory of migration, and the New Economics Theory of migration (Massey et al., 1993; Lericollais 1989 cited Black, 2001; Perch-Nielsen, 2004; UN/POP/EGM-URB, 2008; Castles & Miller, 2009; Drammeh, 2013; UNDP, 2013; McLeman, 2014; Davis, 2014; Banerjee et al., 2018). Refer to Appendix A. below for a detailed description of the above migration theories and models.

Amongst all these theories of migration, the New Economics theory of migration provides the most compelling theoretical foundation for the migration behavior and trend observed in my study site. The theory was derived from Stark and Bloom, 1985 (Davis, 2014). It perceives migration as an 'income diversification' and 'risk reduction strategy' employed by households instead of isolated individual actors (Lericollais 1989 cited in Black, 2001; Bilsborrow, 1998; Massey et al., 1993; Castles and Miller, 2009; McLeman, 2014; Banerjee et al., 2018). The theory assumes that risk avoidance strategy can be as dominant, a motivation for migration by households, as is the incentive to migrate for wealth or income acquisition. This type of movement is common in places where other risk reduction options, such as home insurance, are often unavailable (Massey et al., 1993; McLeman, 2014). The Gambia is one of those places where home insurance schemes and flood mitigation and response mechanisms are unavailable. Given the annual flood disasters exacerbated by a lack of adaptation solutions, households in Banjul seem to migrate for mitigating persistent flooding and other environmental risk factors.

1.1.2 Climate Change & Migration Nexus

Several studies published in the last two decades projected that climate change impacts could serve as ‘push factors’ or what Hunter calls “hazards or disamenities” for individual and household migration (Myers, 2005; Hunter, 2005; Perch-Nielsen et al., 2008; Black et al., 2011; Neil Adger et al., 2014; Davis, 2014; Khan et al., 2015; Nawrotzki and DeWaard, 2016; Nawrotzki et al., 2016; McLeman et al., 2016; Stojanov et al., 2017; Rigaud et al., 2018). The majority of the displacement will be internally displaced (Türk et al., 2015), especially in developing countries (McLeman, 2014; Raleigh et al., 2009; Perch-Nielsen, 2004). For example, flood and mean sea level rise (MSLR) impacts are reported to be mostly responsible for the permanent displacement of 5 million people annually (Raleigh et al., 2009; Perch-Nielsen, 2004). Perhaps worse than political refugees, environmental refugees have low agency and less bargaining power for negotiating their living conditions (McLeman, 2014). They experience socio-economic impoverishment, marginalization, exploitation, and disempowerment within and across sovereign boundaries (Raleigh et al., 2009; McLeman, 2014).

The relationship between climate change and migration can be complicated, considering the possibility of human adaptation strategies (Black et al., 2011; Tacoli, 2009; Perch-Nielsen et al., 2008) and limited empirical knowledge (Perch-Nielsen, 2004). Migration in the climate change context can be seen as a proactive measure for risk reduction, especially in the most vulnerable countries (Neil Adger et al., 2014). The modified climate change vulnerability formula, ‘MESA’ coined by McLeman (2014), better explains the nexus between migration and adaptation in a climate change adaptation context.

$$\mathrm{M} = \mathrm{f}(\mathrm{E}, \mathrm{S}, (\mathrm{A} - \mathrm{M})$$

Where:

$M =$ Migration in the context of vulnerability

is a function of

$E =$ exposure to a climate hazard

$S =$ sensitivity of the exposed population to the hazard

$A - M =$ adaptation options other than migration

As illustrated, the propensity to migrate increases with the severity of a climate or environmental impact (extreme flood), factoring the sensitivity of the exposed population and decreases as the exposed population's adaptive or resilience capacity gets stronger (McLeman, 2014). The MESA formula informs the conceptual relationship between climate change and migration as per the evidence collected from Banjul. I conducted a detailed review of the literature and further discussed how climate change influences forced migration and voluntary migration decisions in Appendix A.

1.1.3 Country Context

The past two decades registered the fastest human migratory trends in the history of The Gambia, including both emigration and immigration. Of the total national population in 2013 (1,856,181), 110,705 were immigrants, mainly from Senegal (49%), Guinea Conakry (20%), Guinea Bissau(5%), Mali (3%), Sierra Leone (3%), and others (20%) (GBoS, 2013a). The immigrant population includes 3,500 non-Africans (World Population Review, 2018). In terms of emigration, an estimated 200,000 Gambian born migrants reside in the diaspora, including in other Sub-Saharan African countries. Internally, nearly 60% of 2.1 million people of the population are now concentrated in urban areas (WB DataBank, 2018). The urban population density ranges from over 4500 to 300 people living within a square kilometer (see Map 1.1).

As a developing country, poverty and unemployment rates in The Gambia are both over 35%. National per capita income stands at US$500 – the Greater Banjul Area

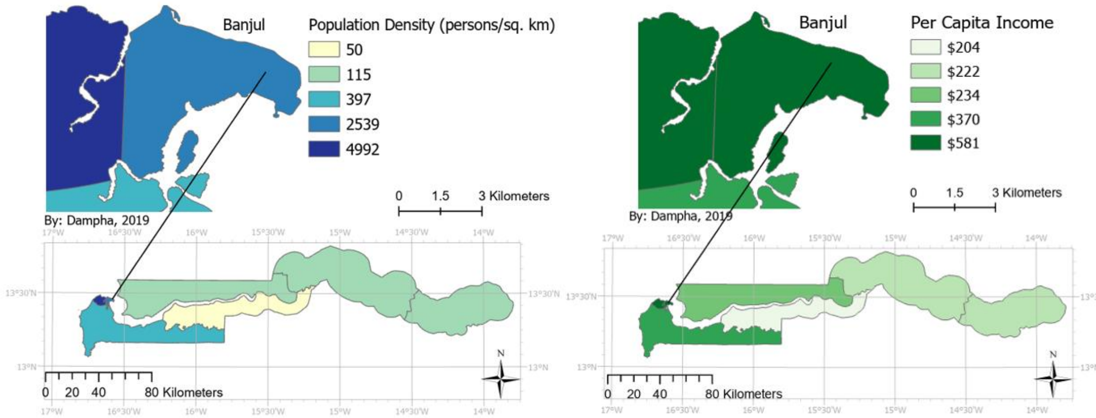
(GBA) records the highest (GBoS, 2010) (see Map 1.1). Access to quality education and primary healthcare remains inadequate across the country, also relatively better in the Greater Banjul area (GBoS, 2010; WB DataBank, 2018; World Population Review, 2018). The gravest threats to the environment and its ecosystem functions and services are attributed to human activities and institutional weaknesses (e.g., deforestation, mining, overfishing, etc.). Climate change impacts such as intense precipitation, severe droughts, and rising sea levels exacerbate current environmental challenges and socioeconomic hardships in the country.

1.2 Study Area (Banjul)

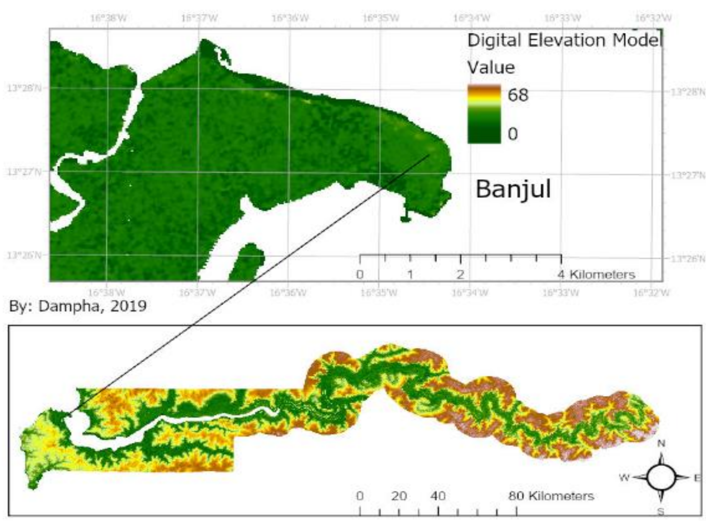
With a total land area of 2,200 km^2, the 200-year old island city, Banjul (formerly known as Bathurst), became the capital city of The Gambia after the country gained its independence from Britain on February 18, 1965 (Gomez & Ceesay, 2018). Since then, Banjul houses nearly 70% of key government ministries and departments. As the center for economic growth and development in The Gambia, Banjul is not only a regional and international trading hub but also a tourist destination for many decades. The city symbolizes the country's rich culture and history owing to its traditional heritage.

However, Banjul is built on low-lying, erodible sediments (Jallow et al., 1996). As climate change impacts intensify, the city will be increasingly prone to coastal erosion and seasonal flood risk (e.g., flash and riverine flooding). The city has the lowest elevation level for any human settlement across the country (Derek, 2019) (see Map 1.2). Climate change impacts in the form of coastal erosion have contributed to structural damage of land and physical infrastructure along the shorelines of Banjul since the 1990s (Jallow et al., 1996; Hill & Manneh, 2014; Coates & Manneh, 2015). In fact, according to colonial records, Banjul's physical environment was described as a "water-logged island," a "miserable site for human habitation," and "one of the worst tropical slums in Africa" (Jarrett, 1951, cited in Gomez & Ceesay, 2018 p. 224-5).

Map 1.1. Population Density (Left Side) Per Capita Income (Right Side)

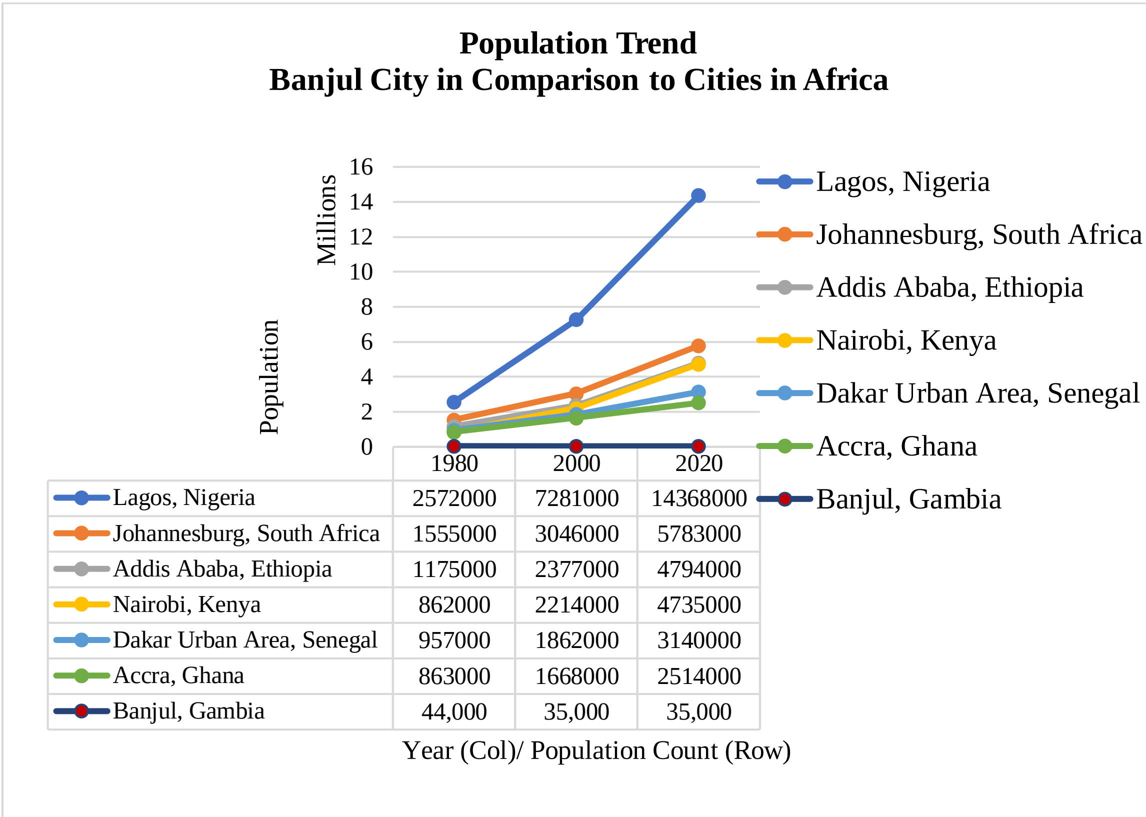


Map 1.2. Digital Elevation Model (Banjul, The Gambia)



The rate of out-migration from The Gambia's island capital city Banjul is unusual across major cities in Sub-Saharan Africa and beyond. Figure 1.1 presents recorded data on population trends in several African cities in comparison with Banjul. Early theorists such as Ravenstein and others stated that often people migrate to political and economic centers (Bilsborrow, 1998). The opposite is rarely evident based on empirical records on migration patterns. One of the rare cases of such occurrences is evident in Banjul. Banjul's rapidly out-migration pattern makes it an outlier among sub-Saharan African cities. Between 1983 and 2013, 31,069 residents in Banjul had out-migrated, according to census data compared to 3,201 in-migrants. In terms of housing units, 375 households had left since 1993. Proportionately, the city dropped from settling 6% of the total national population in 1983 to 1.7% in 2013 (GBoS, 2013b). Today, an estimated 35,000 people live in Banjul, of which roughly 17% are immigrants. As of 2013, 6,657 households existed in Banjul. The average household size also declined from 6 to 4 people (GBoS, 2013).

Figure 1.1. City Population Trends: Banjul Compared to Cities in sub-Saharan Africa



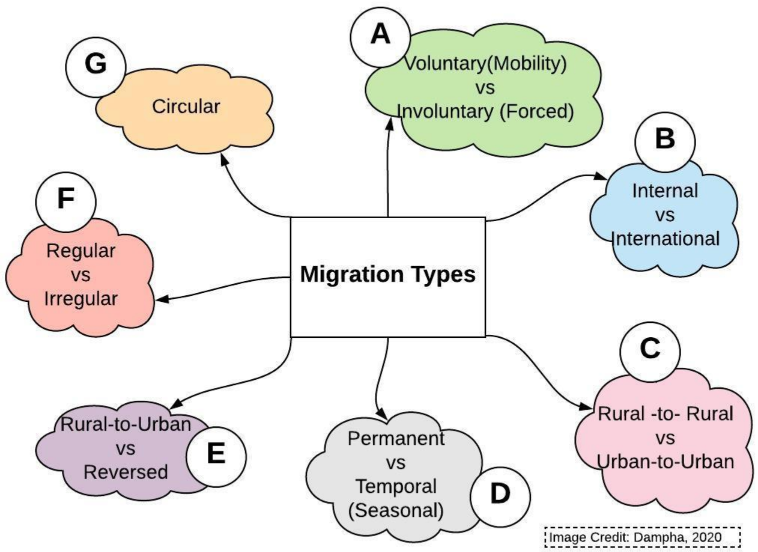
	1980	2000	2020
Lagos, Nigeria	2572000	7281000	14368000
Johannesburg, South Africa	1555000	3046000	5783000
Addis Ababa, Ethiopia	1175000	2377000	4794000
Nairobi, Kenya	862000	2214000	4735000
Dakar Urban Area, Senegal	957000	1862000	3140000
Accra, Ghana	863000	1668000	2514000
Banjul, Gambia	44,000	35,000	35,000

Data source: United Nations - World Population Prospects, reported by (Macrotrends, 2020)

I present my summarized classification of migration types in Figure 1.2. According to my analysis of migration data from The Gambia Bureau of Statistics, I find, as in Figure 1.2, that out-migration from Banjul is predominantly voluntary mobility (A), although conditional on other elements such as climate and environmental factors. The out-migration from the city is also primarily internal (B), urban-to-urban (C), permanent

(D), and regular (F). Over 97% of out-migrants from Banjul moved to West Coast Region and the Kanifing Municipality. Only a small percent of Banjulians venture into reversed rural-to-urban (E) migration as well as circular migration (G) between rural and urban areas.

Figure 1.2. Categorization of Migration Types



1.2.1 Study Objectives & Research Questions

This study investigated the perceptions of Banjul residents about the current resilient challenges and opportunities confronting the capital and predicts their willingness to migrate (WTM) or stay considering the prevailing environmental conditions and projected climate change impacts. This chapter attempts to answer the following research questions:

Research Question 1. *What factors are influencing households' decision to migrate from Banjul – investigating both push and pull factors?*

Research Question 2. *How will Islanders respond to current and projected environmental realities of the city, in terms of their Willingness to Migrate (WTM) with or without government intervention to facilitate their migration/relocation?*

1.3 Methodology

1.3.1 Survey Design & Data Collection Methods

The data used for this analysis was collected in September 2018. Nine (9) undergraduate social sciences students from the University of The Gambia administered the survey following a week-long training on survey implementation. Immediately after the training, my research team and I pretested the survey instrument and modified some questions for clarity. The target population was households located in Banjul at the time of the study. The survey design used a proportionate stratified random sample of households from the three wards of the city (North, Central, and South). A representative sample of 212 households was drawn from a total of 6,657 households. 46% of the sampled population resides in Banjul North, while 29 and 24% live in Banjul South and Central, respectively. We conducted one-on-one interviews with the household head; if absent, a senior member of the family was interviewed. A response rate of 96% was registered. I conducted initial screening, coding, and logical consistency checks before running econometric statistical analysis.

1.3.2 Description of Questionnaires

The household survey administered in Banjul in September of 2018 had five different sections. Section one introduces the study by stating its objectives, institutional affiliations, and some basic facts about the city (e.g., 25% drop in population since 1993, and also highlighted essential landmarks such as the presidential palace, seaport, market, schools, the only teaching hospital, etc.). Section two gathers data on respondent's perception of why Banjulians have been relocating from the city since the 90s. The migration drivers applied in the study include economic, social, security, political, environmental, and demographic factors, as outlined by McLeman (2014) and Black et al. (2011). It furthers collects data on the importance of the city to the islanders, and their perception of climate change impacts and institutional trust and responsibilities in addressing those challenges. Section three investigates households' willingness to relocate or continue living in Banjul based on its current challenges and projected climate change impacts such as sea-level rise, leading to coastal erosion and potential flooding of specific city locations. Before reading the willingness to migrate scenario, all respondents were provided with additional information about the current status of the city, from its high exposure and vulnerability levels to its demographic alterations. A colored printed google map was also presented to visually show the spatial position of the city vis-à-vis the Atlantic Ocean. Eventually, a relocation or willingness to migrate (WTM) scenario was read to all respondents for their responses. Section four collects demographic and socioeconomic characteristics of all respondents for econometric analysis. And section five questions and evaluates respondents' attitude towards the proposed WTM scenario as well as their general view of the survey. The survey instrument is attached as Appendix F.

1.3.3 Data Analyses

I used the STATA software package and Qualtrics (Stats IQ) for analyzing the survey data. Qualtrics is an online survey design tool that provides descriptive statistics of the input data (Qualtrics, 2020). STATA is a statistical software package that allows advanced econometric analysis of various kinds of data, including survey data (STATA, 2020).

1.4 Descriptive Statistics

1.4.1 Household Characteristics

The study collected data on key demographic and socioeconomic household characteristics such as gender, age, ethnic identity, estimated annual household income, and highest education level completed. 58% of household respondents are male, and about 51% are above thirty-five years old. In terms of household's ethnic identity, 34% identifies as Wolof, 28% Mandinka, and 38% others. For estimated household income, 63% reports having an annual household income of less than 100,000 Dalasi ($1=D47). Note that the average household size in Banjul is four members (GBoS, 2013b). For details on other descriptive statistics, see Table 1.1.

Table 1.1. Descriptive Statistics

Respondent's characteristics	N[1]	Freq %	Respondent's characteristics	N	Freq %
Region of Resident in BJL			**Annual HH Income Bracket**		
North	93	46	Low-Income (<$2200)	118	63
South	59	29	Middle-Income ($2201-8700)	47	25
Central	50	24	High-Income (>$8700)	23	12
Sex (Respondent)			**Main Source of Primary HH Income**		
Male	110	58	Income Source (Earned Wages)	110	60
Female	81	42	Income Source (Remit.)	54	30
Age Bracket			**Highest Level of Education Completed**		
Under 35 yrs	94	49	Primary & Middle Sch.	62	33
Above 35yrs	97	51	High Sch.	59	31
Ethnic Identity			Never Enrolled in Sch.	28	15
Wolof	64	34	College & Vocational Training	21	11
Mandinka	55	28	BA/BSc	14	7
Others	72	38	Ma/MSc	5	3

1.4.2 Induced Factors or Causes of Migration

The first objective of this study is to examine the factors that influence the rapid household migration from Banjul. Several studies indicated economic, social, political, environmental, demographic, security drivers influencing human migration from old to

[1] *Total sample size 202*

new settlements (Arnell et al., 2011; Hunter, 2005; Lucas, 2015; Massey et al., 1993a; R. A. McLeman & Hunter, 2010; Morrissey, 2009; Myers, 2005; Piguet, 2008; Stockdale & Catney, 2014; Türk et al., 2015). Islanders in Banjul were asked to rank among a list of factors the three most significant ones that influence their neighbors' out-migration. I use the induced factors of migration from previous studies as my guiding framework (see Figure 1.3).

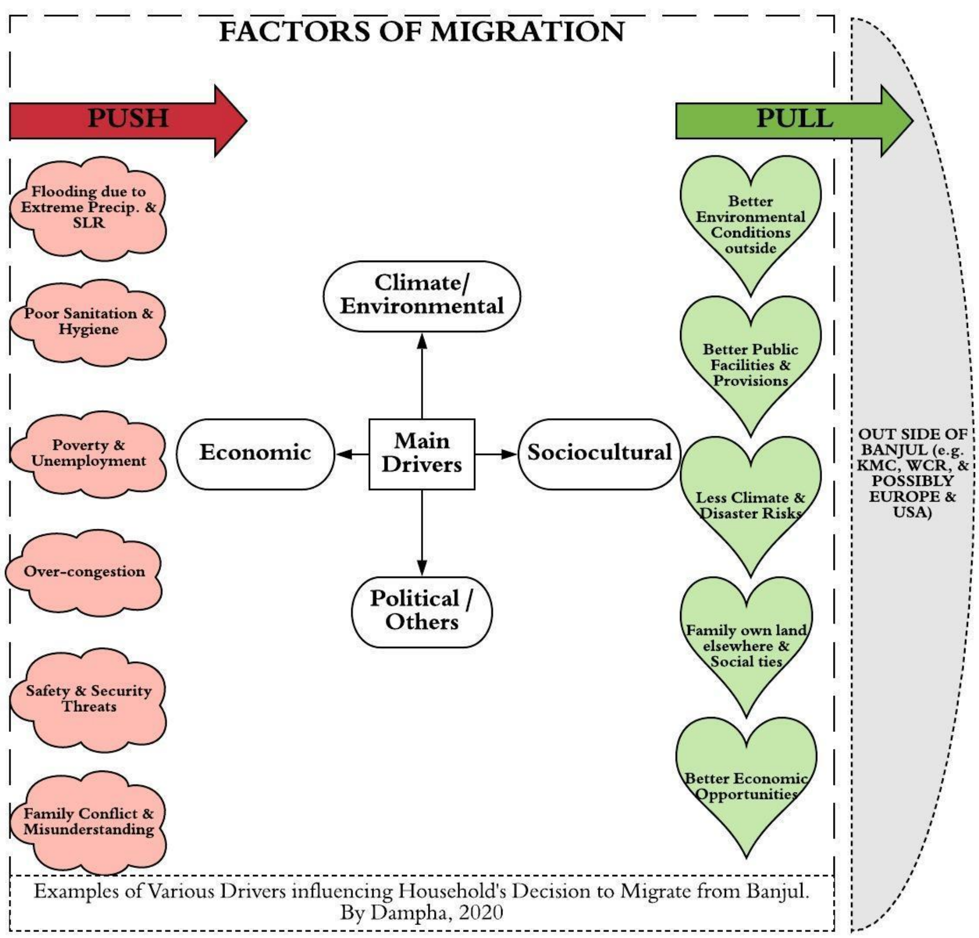
Overall, the survey results show that "push" (i.e., hazards, disamenities, undesirable or unattractive) factors of migration are the most dominant drivers of household mobility rather than "pull" (i.e., amenities, desirable or attractive) factors. In Figure 1.3, I also categorized the induced drivers of migration into push and pull factors. Besides, over-congestion, the majority of Banjulians attribute the city's high out-migration rate to environmental and climate-induced factors such as poor environmental conditions (e.g., waste problems, poor hygiene, and sanitation, lack of drainage systems), seasonal inundation and periodic riverine flood events due to rising sea levels and extreme precipitation events. I present further details on factors determining out-migration from Banjul in Table 1.2.

Table 1.2. First, Second, & Third-Order of ranking the most Influential Drivers of Migration from Banjul

Drivers	1st Order of Ranking	2nd Order of Ranking	3rd Order of Ranking
Over-congestion	41%	5%	6%
Poor Environmental Conditions (e.g. sanitation & hygiene)	17%	15%	7%
Season Flooding due to heavy rains	14%	15%	4%
Lack of economic opportunities	5%	8%	
Others (gentrification, high rents, etc.)	4%	4%	4%
Family conflict & Understanding	4%	13%	4%
Built a second compound due to increase wealth	4%	7%	21%
Riverine flooding due to Sea Level Rise	4%	5%	3%

Lack of safety and security	3%	5%	3%
Poor drainage systems	1%	-	-
Mosquitoes	1%	-	-
Better environmental conditions	1%	15%	23%
The emergence of new & attractive settlements outside of Banjul	1%	8%	12%
Better economic opportunities outside of Banjul			4%
Better public services			9%
Total	100%	100%	100%

Figure 1.3. Highlights on Induced Factors of Migration



1.4.3 Willingness to Migrate (WTM) (with/out Government Intervention)

The secondary objective of the study was to investigate islanders' willingness to either continue dwelling in or migrating from Banjul based on current and projected climate change impacts such as frequent and intense precipitation events. The study results show that 64.2% of households express positive WTM to a suitable location of their choice by 2050, through a government-funded project, compared to 35.3% of those without migration intent, and 0.5% are undecided. Even without any planned government intervention (i.e., managed retreat) in relocating current residents, findings reveal that 55% of households are still willing to migrate before 2050.

1.4.4 Use and Non-Use Values

The study also attempted to qualitatively assess the significance or value of various structures, facilities, activities, socioeconomic and ecological services, located/undertaken in Banjul using a Likert scale 1-5 on importance. Results show that both use and non-use values of various facilities and services are rated quite high (over 80% strongly agree) in terms of their importance to current residents. In other words, Banjulians value the existing assets and cultural relevance of the island for the use of the present and future generations. Upon assessing the significance of each use and non-value item, respondents were asked to rank in order of first, second, and third most important structure, service, facility, or activity located/available in the city (see Table 1.3 for more details).

Table 1.3. First, Second & Third Order of Ranking the Most Important Services, Activities, Structures & Facilities in Banjul

Facilities/Services/Activities	**1st Order-Ranking**	**2nd Order-Ranking**	**3rd Order-Ranking**
Housing the Statehouse	26%	8%	8%
Healthcare Provision & Services	18%	21%	18%
Business & Trade	13%	15%	7%
Educational Purpose	9%	22%	10%

Family Living in BJL	6%	4%	7%
Biodiversity Protection	6%	2%	9%
Job Seeking/Employed in BJL	6%	7%	4%
Accommodating key govt institutions	5%	9%	7%
Religious and spiritual reasons	3%	2%	10%
Community & Social Networking	2%	3%	2%
Sports	2%	3%	7%
Recreational Purposes	2%	1%	3%
Traditional & Cultural Reasons	1%	2%	7%
Music & Entertainment	1%	1%	1%
Total	100%	100%	100%

1.4.5 Sustainability & a New Capital City Proposal

I investigated islanders' perceptions of the viability of Banjul and gauge their opinion about the need for developing a second capital city for The Gambia. The results show that the majority of Banjulians (~60%) doubt the future economic vibrancy and environmental sustainability of Banjul if current trends continue. However, islanders are divided in their opinions about building a new capital city for The Gambia. Overall, they slightly disapprove of the idea (51 vs. 46%), but the difference is not statistically significant. Among the 46% of Banjulians who at least favor the proposal, 53% vote for Kanifing Municipality (KM) as a strategic location for the new city, 31% vote for West Coast Region (WCR), 9% for North Bank Region (NBR), 6% for Lower River Region (LRR), 1% for Upper River Region (URR) while Central River Region (CRR) receives no vote.

1.4.6 Institutional Trust & Responsibility

I also assessed public trust in legally mandated government institutions responsible for protecting and maintaining the livability in Banjul. I find public trust in government institutions somewhat weak. As of the time of this study–the beginning of the Barrow administration, islanders slightly trust the central government over the city council. As reported, about 43, 43, and 32% of islanders do not respectively 'trust' Banjul City Council (BCC), National Environment Agency (NEA), and the Barrow Administration. In terms of institutional responsibility in enhancing the city's adaptive and resilient capacities, the majority (54%) stresses that the government, including the city council, should be solely responsible. Only 22 % call for collaboration amongst stakeholders to fix the ills of the city.

1.5 Econometric Statistical Analysis

1.5.1 Estimation Strategy (Modeling Household WTM)

I used a multivariate probit regression analysis approach to estimate households' willingness to migrate (WTM) from Banjul by 2050. To ensure robustness and consistency of estimates, I compared Probit results to other standard econometric specifications such as logistic regression and Ordinary Least Square (OLS). The OLS model on a household's willingness to migrate (WTM) from Banjul has the general form:

$$Y_i = \beta_0 + \beta_1 x_1, + \cdots + \beta_n x_n + \varepsilon_i \qquad \text{Eq. (1)}$$

Where Y_i is the dependent variable representing the household's WTM, x_1 through x_n are the independent variables representing demographic, household characteristics, and respondent's perception of environmental, climatic, economic, social factors, political and institutional factors associated with the decision to consider migration. $\beta_0 + \beta_1$ through β_n are the regression coefficients, and ε_i is the residual term.

Since WTM is determined by the presence or absence of a household's intent to migrate by 2050, according to this study, the dependent variable Y is a binary one. OLS estimation does not provide the best fit when dealing with a dichotomous dependent variable. Using OLS, in this case, may lead to potentially violating some of the classical assumptions V and VII (the error term has a constant variance, presence of homoscedasticity) and (that the error term is normally distributed (randomness)), respectively. Therefore, using OLS will likely generate inaccurate estimates of the standard error of the coefficients (Studenmund, 2014; Russell & Rives, 1979).

One solution to OLS estimation is to use multivariate probit regression and compared results to logistic regression outputs (Russell & Rives, 1979). Probit and logit models are conceptually similar since they both use nonlinear procedures and often present comparable results but use a different distribution. The former is based on the cumulative normal distribution, while the latter is based on the cumulative logistic distribution. Theoretically, the logit model has a stronger specification, while probit has a more significant parameter estimation cost (Russell & Rives, 1979).

Probit regression relates the probability P_i of a dichotomous dependent variable (yes or no) to the independent variables (Griffiths, Hill & Judge, 1993). The coefficients of the probit model are estimated using maximum-likelihood procedures (Russell & Rives, 1979).

The probit model is represented as $\Pr(Y = 1|X) = F(X'\beta)$ Eq. (2)

Where:

Pr(Y = 1|X) is the probability that the dependent variable, Y, takes a value of 1 given the vector of independent variables,

X, X' is the transpose of X (so that it has dimension 1xN), and

β is a vector of coefficients.

In the probit model, the cumulative density function F(.) is assumed to have a normal distribution.

The parameters of the models were estimated using the survey data. I chose the household as the unit of analysis, considering migration as a household-level adaptation strategy (see Nawrotzki et al., 2016). Variables included in the econometric analysis have been reported in several studies as determinants of migration (Russell and Rives, 1979; Akin et al., 1979; Afsar, 2003; Myers, 2005; Perch-Nielsen et al., 2008; Kainth, 2009; Morrissey, 2009; Massey et al., 2010; Black et al., 2011; de Brauw et al., 2014; Decisions et al., 2014; IPCC, 2014; Liu et al., 2016; Nawrotzki et al., 2016; Sahota, 2016; Stojanov et al., 2017). I present the included variables, their definitions, and descriptions in Table 1.4.

Since I could not find and interview those who had already migrated from Banjul to know the root causes of their migration, I surveyed the perception of current residents as my proxy to explain the factors they believe were responsible for their neighbors' out-migration. I assumed that the same factors that caused observed migration of their neighbors would also influence the migration intentions of current residents. Thus, I included variables on the environment, social, and economic factors presumed to have contributed to the increasing out-migration rate in Banjul, especially between 1983 and 2013. Other covariates included in the model range from household characteristics such as annual household income, the ethnicity of the respondent, the respondent's age, gender, educational attainment, and the primary source of household income. Also, I included variables on the perception of institutional trust and responsibility. I assumed that people who distrust institutions responsible for their protection perhaps would have a high propensity for considering migration. Most explanatory variables included in the model are transformed into dummy variables (see Table 1.4).

In formulating the probit models, I built from model 1 to my final well-specified model 3 (see Table 1.5). In model 1, I regressed WTM on variables, including socioeconomic, demographic, and respondent's perception about the root cause of recorded migration from Banjul. The model uses 176 observations to run the analysis. In model 2, I maintained all variables from model 1 and added other variables on institutional trust and government responsibility in protecting the city. In model 3, I combined demographic and socioeconomic variables with some variables on the respondent's perception of the need to construct a new capital city and the urgency for the government to invest public funds in protecting Banjul.

I omitted other covariates in model 3 when compared to model 2 due to the substantial drop in the number of observations. I lost nearly half of the observations in model 2 compared to models 1 and 3. I ran the variance inflation factor (VIF) to check for multicollinearity. Although to significant concern for multicollinearity, model 2 has the highest mean VIF of 1.41 compared to 1 models 1 and 3. In the social sciences, VIF less than 5 raises no cause for alarm. Also, in model 2, I find a high correlation between the trust variables concerning the functions of critical public institutions (i.e., trusting the government versus trusting the National Environment Agency (NEA) and Banjul City Council (BCC). Given the above reasons, my discussion mainly focuses on probit model 3 (i.e., the primary model). For robustness and consistency test of estimates, in Table 1.6 below, I compare probit results to logistic regression and ordinary least square (OLS).

Table 1.4. Variables, their definitions, descriptions, and types

VARIABLE	**DEFINITION**	**DUMMY VARIABLE (1)**
WTM [2]	If the respondent has migration intent by 2050	Yes
Env_Factors	If the respondent says the following environmental factors are mainly responsible for the rapid out-migration from Banjul	Environmental factors include "seasonal Flooding," "Riverine Flooding due SLR," "Poor Environmental Conditions such as (poor sanitation, open drains, and stinky sewer flows, poor waste management), Better Environmental elsewhere (e.g., new estates with improved environmental infrastructures such as trees and drainage for stormwater management)
Eco_Factors	If the respondent says the following economic factors are mainly responsible for the rapid out-migration from Banjul	Include but not limited to Lack of Economic Opportunity, Better Employment Opportunity outside, High Rent Cost, New Businesses Taking-over

[2] *The dependent variable*

Soc_Factors	If the respondent says the following social factors are mainly responsible for the rapid out-migration from Banjul	Mainly include Family Conflict & Misunderstand, Family Demanded to Move, Built a Second Compound, Population Declining
Over_Congestion	If respondents say that over-congestion is mainly responsible for the rapid out-migration from Banjul	Over-congestion
Education	Respondent's highest level of education completed	Above High Sch. (Vocational, college & university)
Ethnicity	Respondent's ethnic identity	Mandinka[3]
Low_Income	Total household income[4]	Below D100,000 ($1 to D47)
Middle_Income	Total household income	D100001- 400,000
High_Income	Total household income	Above D400,000
Gender	Respondent's gender	Male
Remit_Income_Source	Whether a household's primary source of income is from remittances	Household's primary source of income is from remittances
Age	Respondent's age bracket	35years & Above
New_City	Respondent's agreement or disagreement for a new capital city for The Gambia	Strongly Agree & Agree[5]
Trust_Govt	Respondent's trust level of the Barrow Administration	Strongly Agree & Agree
Trust_NEA	Respondent's trust level of the National Environment Agency (NEA)	Strongly Agree & Agree
Trust_BCC	Respondent's trust level of the work of the Banjul City Council (BCC)	Strongly Agree & Agree
Global_North_Pay	Respondent's view about the developed paying for loss & damage attributed to climate change impacts	Strongly Agree & Agree

[3] *Compared to Wolof*

[4] *Note: average household size in Banjul is ~4 people*

[5] *Neutral observations were excluded from the analysis*

Worth_Slr_Protection	Respondent's perception about spending money today to protect Banjul against SLR	Strongly Agree & Agree
Gov't_Capable	Respondent's perception about whether the government can execute future planned relocation of Banjulians	Strongly Agree & Agree
Slr_Cont	Respondent's perception of whether sea-level rise (SLR) will continue to affect Banjul	Yes
Govt-Resp	Respondent's perception of who is solely responsible for protecting & developing BJL	Government alone

1.6 Quantitative and Qualitative Results

The probit marginal results are presented in Table 1.5. Given the null hypothesis that the actual coefficients are equal to zero, four coefficients of the marginal effects in the model are statistically significant at the 1% level. Two other variables are, respectively, significant at the 5% and 10% levels. The signs of the marginal effects are interpreted as increments or decrements to the probability of the dichotomous dependent variable (Russell & Rives, 1979). Therefore, the probit marginal results (in Table 1.5) shows that households are more likely to consider migration at a certain level of probability if:

I. they agree that environmental and climate-related factors are mainly responsible for the high out-migration rate in Banjul (25%) relative to those who disagree;
II. they agree that The Gambia needs to strategically identify and develop a second capital city for the benefit of current and future generations yet unborn (26%) relative to those who disagree;
III. they agree that the government should be solely responsible for maintaining and protecting Banjul against current city resilient challenges (22%) compared to those who disagree; and

IV. they identify as belonging to Mandinka ethnic group (32%) in contrast to their Wolof counterparts (the two main ethnic groups)

V. they identify as male (16%) compared to their female counterpart

VI. they are from a high-income earning household (25%) compared to others.

Table 1.5. Probit Regression Results (Heteroscedasticity-Corrected Standard Error Test, Robust Applied)

(DUMMY) VARIABLES[6]	(Model 1) Marginal effects	(Model 2) Marginal effects	**(Model 3) Marginal effects**
Env.-factors	0.235***	0.112	**0.254*****
	(0.0764)	(0.0862)	**(0.0725)**
Eco.-factors	0.109	-0.0964	**0.121**
	(0.0799)	(0.0932)	**(0.0771)**
Soc.-factors	0.0864	0.134	**0.105**
	(0.0713)	(0.0831)	**(0.0678)**
Over-congestion	0.163**	0.0277	**0.0984**
	(0.0736)	(0.0791)	**(0.0682)**
New City		0.164**	**0.259*****
		(0.0660)	**(0.0634)**
Trust NEA		0.346***	
		(0.103)	
Trust BCC		-0.330***	
		(0.0980)	
Trust Govt.		0.0775	
		(0.101)	
Global North pay for Loss		0.213***	
		(0.0679)	
Worth SLR-Protection		-0.0170	**-0.0944**
		(0.122)	**(0.163)**
Flood-BJL /yr		0.172	
		(0.124)	
SLR Cont.		-0.121	
		(0.0890)	
Gov't Resp. (Only)		0.232***	**0.215*****
		(0.0734)	**(0.0628)**
Gov't-Capable		0.157	
		(0.108)	

[6] *The option 1 is active for all dummy variables*

Education-Above High Sch	0.0672		**-0.00841**
	(0.0845)		**(0.0815)**
Gender-Male	0.0825		**0.158****
	(0.0703)		**(0.0696)**
Middle-income	0.0289		**-0.0122**
	(0.0807)		**(0.0730)**
High-income	0.188		**0.254***
	(0.124)		**(0.131)**
Age-(35yrs & Above)	0.0193		**0.0314**
	(0.0694)		**(0.0673)**
Ethnicity (Mandinka)	0.189**		**0.315*****
	(0.0789)		**(0.0799)**
Remit. (Main Income Source)	0.113		**0.0598**
	(0.0720)		**(0.0701)**
Observations	176	90	**167**

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 1.6. Functional Form Comparison

DUMMY VARIABLES	(Model 3) **OLS**	**(Model 3) probit**	(Model 3) **logit**
Env.-factors	0.258***	**0.254*****	0.262***
	(0.0889)	**(0.0725)**	(0.0749)
Eco.-factors	0.101	**0.121**	0.122
	(0.0821)	**(0.0771)**	(0.0789)
Soc.-factors	0.101	**0.105**	0.111
	(0.0737)	**(0.0678)**	(0.0690)
Over-congestion	0.0727	**0.0984**	0.0996
	(0.0748)	**(0.0682)**	(0.0670)
High Education	0.00990	**-0.00841**	-1.15e-05
	(0.0915)	**(0.0815)**	(0.0840)
Gender-Male	0.119	**0.158****	0.155**
	(0.0731)	**(0.0696)**	(0.0732)
Middle-income	0.00498	**-0.0122**	-0.0112
	(0.0823)	**(0.0730)**	(0.0724)
High-income	0.217*	**0.254***	0.271*
	(0.110)	**(0.131)**	(0.149)
Age-(35yrs & Above)	0.0281	**0.0314**	0.0367
	(0.0740)	**(0.0673)**	(0.0677)
Ethnic (Mandinka)	0.246***	**0.315*****	0.312***
	(0.0730)	**(0.0799)**	(0.0835)

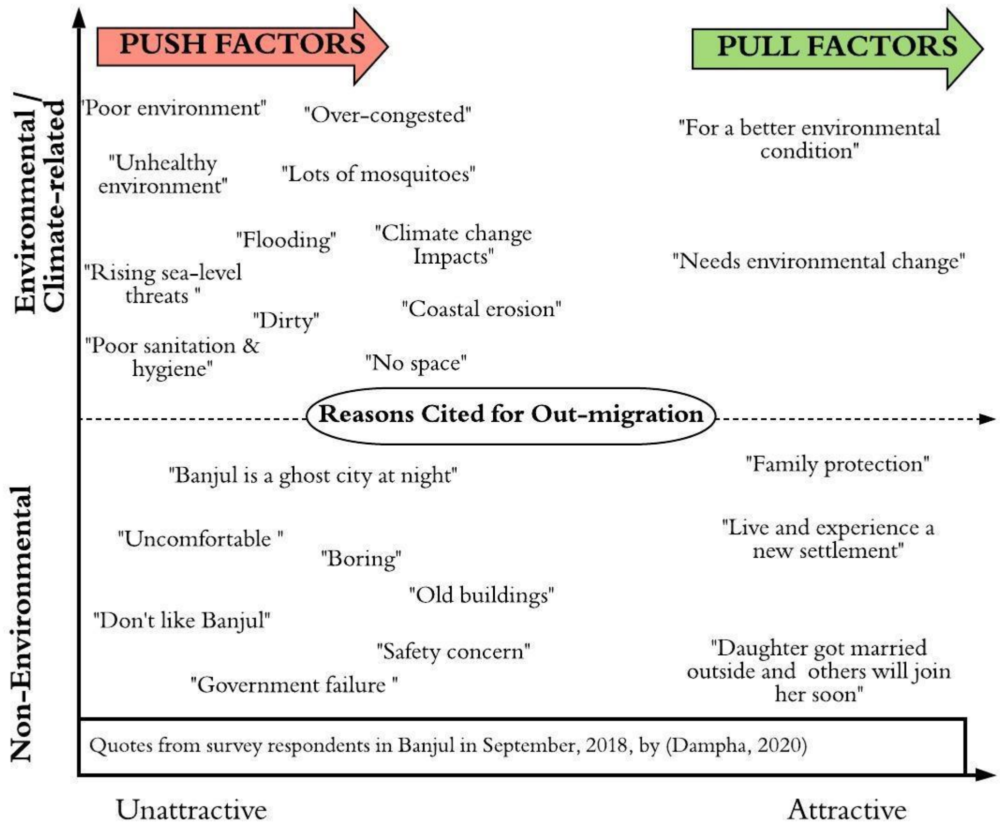
Remit (Main Income)	0.0660	**0.0598**	0.0626
	(0.0737)	**(0.0701)**	(0.0718)
New City	0.239***	**0.259*** **	0.257***
	(0.0698)	**(0.0634)**	(0.0644)
Worth SLR-Protection	-0.0976	**-0.0944**	-0.0897
	(0.177)	**(0.163)**	(0.152)
Gov't Resp. (Only)	0.187***	**0.215*** **	0.210***
	(0.0706)	**(0.0628)**	(0.0639)
Constant	-0.0598		
	(0.172)		
Observations	167	**167**	167
R-squared	0.233		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

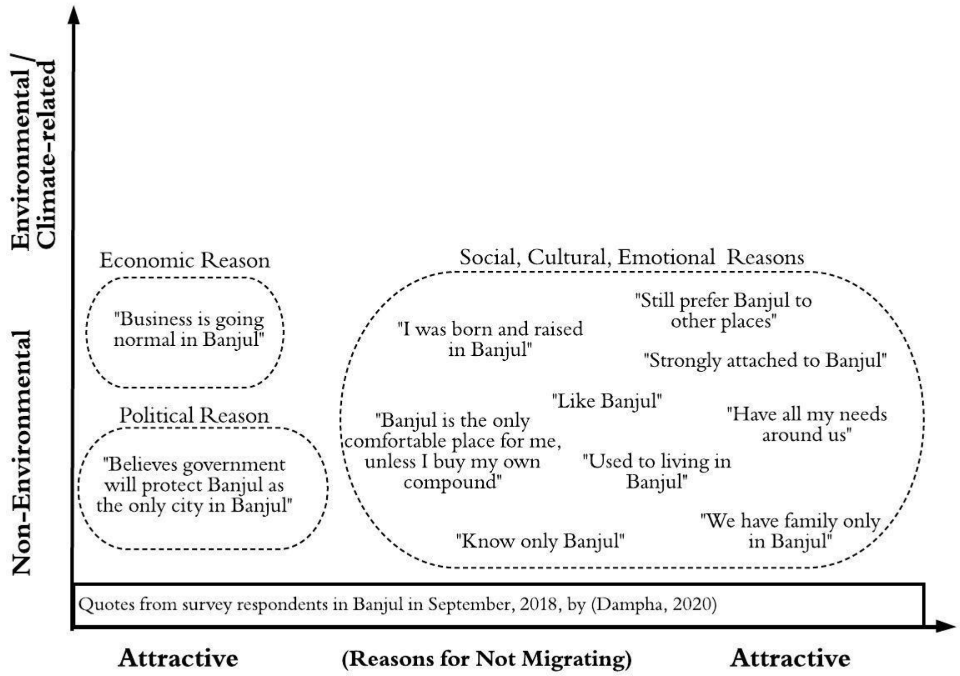
I also collected some qualitative data (descriptive notes recorded by the interviewers) to understand further aspects of WTM that the quantitative analysis is limited to explaining. First, among the respondents who express positive WTM (64%), some have been quoted by saying that Banjul is "dirty" and that the city suffers from annual "flooding" among a list of others. Others elaborate by indicating that they will migrate from Banjul due to the government's failure to address climate change impacts. These include reducing flood risk and fixing the city's enduring sanitation and hygiene conditions (see Figure 1.4). The majority of these citations are associated with environmental and climate-related variables. The evidence strongly supports the econometric findings from the quantitative analysis component. Likewise, in the quantitative analysis, respondents do not reference economic reasons as a contributing factor to out-migration in their citations.

Figure 1.4. Verbatim of Reasons Why Households Express Positive Willingness to Migrate from Banjul



The 35% of Banjulians who reject the idea of relocation as an option mainly cited social and psychological reasons for not considering any possible migration at least by 2050. Islanders without migration intent alluded to the fact that they are "strongly attached to Banjul," "know only Banjul," "have family only in Banjul," etc. One of my respondents is quoted by stating that Banjul "is the only comfortable place for me unless I buy my own compound" elsewhere. Another respondent reassures us that she "believes the government will protect Banjul as the only capital city." (for more quotes see Figure 1.5).

Figure 1.5. Verbatim of Reasons Why Households No Out-migration Intent from Banjul



1.7 Discussions

1.7.1 Discussion on Survey Findings

1.7.1.1 Socioeconomic and Household Characteristics

Ethnic identity is one of the household characteristics found to be highly statistically significant in explaining WTM from Banjul. Consistent results across the three econometric functional forms show that Mandinkas (an ethnic group) are 32% more likely to migrate from Banjul compared to their Wolof (another ethnic group) counterparts, ceteris paribus. Perhaps, recent political rhetoric shortly before the survey might influence the WTM difference between the two main ethnic groups who have lived together for decades in Banjul. For instance, during a 2018 political rally in the city, the Mayoress of Banjul, Rohey Malick Lowe, who is identified as a Wolof, humorously said, “Mandinkas make Banjul dirty” and that they should “go back” to where they came from (“Badibou and Jarra”). Some interpreted the statement as a ‘joke,’ while others consider it as ‘misleading’ and ‘divisive.’ Perhaps, highly political assertions like that could explain why so many Mandinkas express affirmative WTM.

Second, men are 16% more likely to consider out-migration from Banjul that women (see model 3 in Table 1.5 above). In a patriarchal African society, this result is not surprising. In The Gambian context, men possess central household decision-making powers. Hence, one would expect that women would be more hesitant to specify that their household would be willing to migrate than their men counterparts.

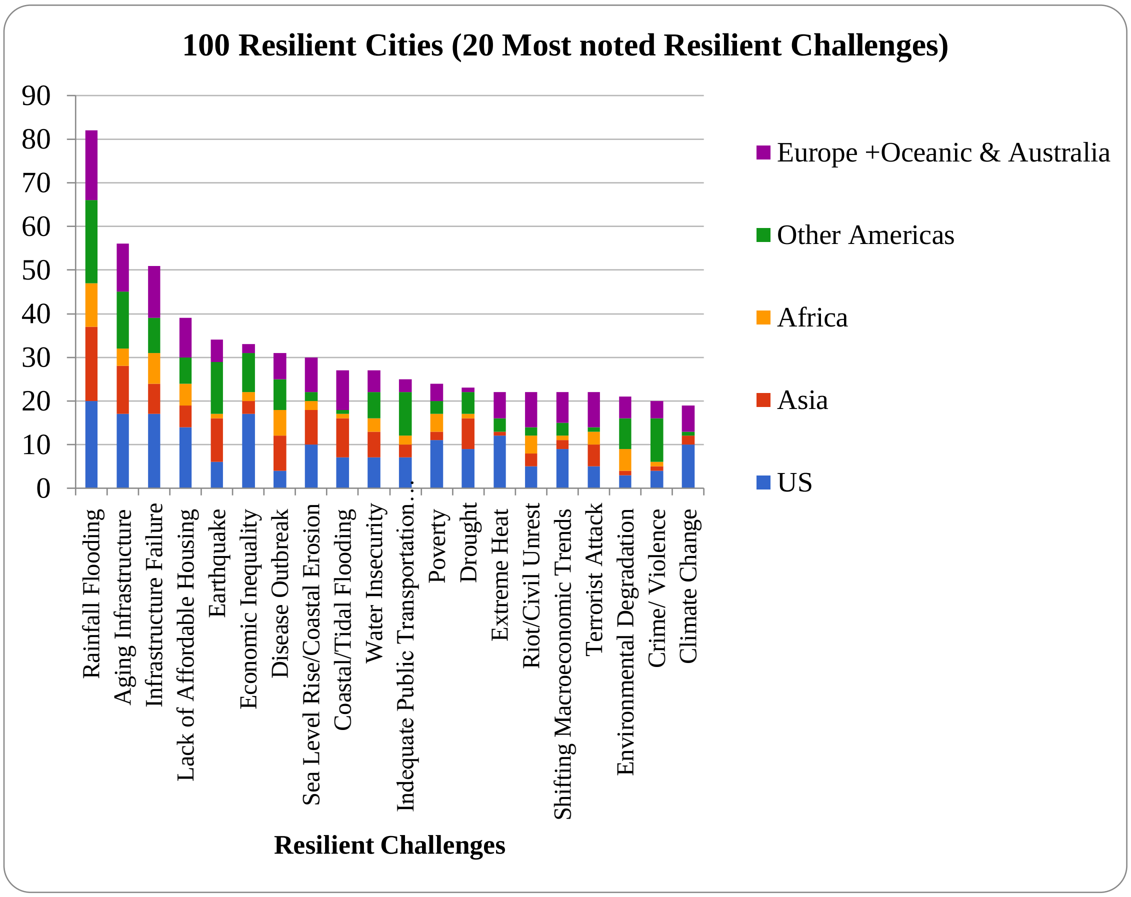
Third, high-income earners are 25% more likely to consider out-migration than low and middle-income earners. The result was significant at the 10 % level. An association of income categories with WTM shows that, as household income increases, so does their WTM (see Table 1.5 above). The household’s income level and source of primary income are found to be correlated. High-income households tend to receive more remittance compared to others. Education, though not statistically significant, is also correlated with household income. The age variable has no explanatory power as far as WTM is concerned.

1.7.1.2 Islanders’ Environmental & Climate Change Perceptions

Households' perceptions of current environmental problems influence their WTM from Banjul. The result shows that, on average, a family is 25% more likely to migrate if they perceive that climate and environmentally-induced factors are primarily responsible for Banjul’s high out-migration rate, ceteris paribus (see Table 1.5). My survey findings reveal that 57% of Banjulians consider environmental and climate-related problems as the most severe resilient challenges facing the city, followed by unemployment (27%), and transportation difficulties (4%).

A review of data from the 100 Resilient Cities Initiative shows that over 100 cities across the world reported similar resilient challenges. In Figure 1.6, I present the top 20 most recorded city resilient challenges facing cities in Africa, Asia, Europe, and the United States (100 Resilient Cities, 2017). For example, Stojanov et al. (2017) studied the perception of Maldivians in the island city of Malé on climate change impacts and environmental challenges. They found that about 37% of Maldivians were worried about environmental problems combined (Stojanov et al., 2017). Over 50% of islanders in the Maldives perceived projected sea-level rise as a severe challenge, and they accepted migration as a potential adaptation option (Stojanov et al., 2017).

Figure 1.6. Top 20 most noted Resilient Challenges among 100 cities globally



Data Source: (100 Resilient Cities, 2017)

Climate change information is a daily household topic in Banjul. Half of the city's population either always or usually hears about climate change. Only 5% of islanders report having never heard about climate change. The majority are severely worried about its impacts. When asked about climate-related loss and damage payments, nearly 70% agree that the developed world should pay, grounding their arguments on moral and ethical grounds. In contrast, approximately 40% (2 billion) of the global adult population have never heard of climate change (Lee, Markowitz, Howe, Ko, & Leiserowitz, 2015).

1.7.1.3 Islanders' Perceptions of a New City Development & Other Issues

Regarding islanders' perception of the need to build a new city in contrast with their WTM, the findings suggest that people with a higher propensity to migrate are highly supportive of developing a new capital city. They are also less hopeful about Banjul's future economic vibrancy and its environmental sustainability relative to those who expressed no interest or intent to migrate.

In specifying who should be responsible for maintaining and protecting Banjul against extreme flooding and rising sea levels, the probit model indicates that, on average, households are 22% more likely to consider migration, if they agree that only government should be responsible for the city's protection, all else constant. In general, islanders who express positive migration intent are more likely to transfer risk and put all responsibility solely on government compared to their opposite counterparts. Similarly, in terms of the developed world paying for climate-related loss and damage, 56% of islanders with migration intent strongly agree compared to 45% among those without migration intent. In a nutshell, islanders with migration intent seem to believe that the city's protection against sea-level rise is not their primary responsibility. However, a few of them would possibly reconsider to stay if the city is protected and fortified with investment from either the government or from international climate adaptation funds.

1.7.2 Discussion on Induced Factors of Migration

1.7.2.1 Environmentally-induced migration

Several pieces of empirical evidence show that climate change impacts and associated environmental deterioration are influencing human migratory patterns globally. Developing countries with less adaptive capacities have high vulnerability and risk levels to this crisis. The current estimate of environmentally displaced persons (EDPs) stands at over 60 million people, mostly internally displaced in developing countries. In The Gambia, evidence from my survey suggests that the majority (over 50%) of over 30,000 out-migrants from Banjul meet the definition of “environmentally-induced population movement.” This estimate is evident grounded on the significant contributions of environmental and climate change factors found to have influenced islanders’ relocation since the 1980s as well as the forced evacuation of some vulnerable households from Banjul North by the Jammeh Administration in the late 2000s. The high risk and vulnerability levels to environmental and climate hazards contributed to their relocation. Across Africa, an estimated 15 million people are considered EDPs, mainly living in the Horn of Africa (Myers, 2005). Similarly, in Asia and Latin America, there are millions of EDPs (Rigaud et al., 2018).

The scholarly debate on whether climate factors or environmental conditions can influence migration remains unsettled. Some scholars explain the complexity involved in not just defining and recognizing EDPs, but also articulate the consequences of their legal recognition and protection (Castles, 2002). The majority of scholars agree on the influence of climate and environmental factors in causing human migration and call for the national and international legal protection of EDPs (Jermendy, 2014; Grassani, 2013; McLeman, 2012; Piguet, 2008; Myers, 2005; Perch-Nielsen, 2004). Denial of their legal recognition violates EDPs’ right to safety and protection as part of their fundamental human rights. Failure to act now could be detrimental to ensuring global peace and stability. Xenophobic immigration policies and the developed countries’ reluctance to protecting people’s fundamental right to migrate should not be the basis of neglecting millions of EDPs across continents.

As highlighted above, migration is not only a reactive response to environmentally-induced calamities. Migration can also be considered a risk reduction strategy for many households in developing countries. The first IPCC report highlights the significance of migration in reducing the household’s vulnerability. Since 2010, the Cancún Adaptation Framework under the UNFCCC recognizes migration as an adaptation option for climate change impacts (Banerjee et al., 2018). The UN General Assembly convened a global conference on migration in Marrakech, Morocco, in

December of 2018. For the first time in modern history, world leaders adopted a Global Compact for safe, orderly, and regular migration. The Compact provides a guiding framework for international migration, as previously stated in the New York Declaration for Refugees and Migrants (UN-GCM, 2018). The conference recognizes the contribution of climate change to inducing human migration but still refrain from using the terms EDPs or ERs/CRs.

1.7.2.2 Economically Induced Factors of Migration

Economists report economic indicators (e.g., unemployment, inequality, poverty, market availability, wealth) as the prime factors of most migration types. At the heart of the migration decision-making process is to attain a net benefit or generate maximum utility (Neo-classical Model). Individuals and households will likely choose to migrate if the cost of protection from an environmental hazard is higher than the benefit received from staying (Perch-Nielsen et al., 2008).

Based on economic principles, the influence of income is essential in influencing the migration decision-making process (McLeman, 2014). According to Smith et al. (2006) study in Florida, migration-wealth/income nexus follows an inverted U curve (Perch-Nielsen et al., 2008). The inverted U curve suggests that middle-income households are more likely to migrate relative to resource-poor and high-income families (Perch-Nielsen, 2004; Martine et al., 2008; Perch-Nielsen et al., 2008; Tacoli, 2009). The reason being that migration can be highly expensive for low incomes, while high-income earners tend to own high capital assets and enough resources to build and rebuild resilience structures when necessary (Burton et al., 1993; Morrow-Jones, 1991 cited in Perch-Nielsen, 2004). In The Gambia, high-income earning households have a relatively high interest in considering out-migration from Banjul than others. Given the income difference between the developed and developing countries, such as The Gambia, those regarded as a high-income group in The Gambia will probably be the middle-income class in America in terms of asset accumulation.

Also, remittance inflow influences migration decisions. The influence can take either direction. Some households use remittances to buy a house, while others can use it to rebuild or strengthen their resilience capacity (e.g., building climate-smart resilient structures) at places they live. Though not statistically significant, remittance inflow contributes a substantial portion of household income in Banjul and The Gambia in general. The correlation between household income and remittance, as a primary source of several households' income, is positive. Revenue from international remittance seems to strengthen a household's ability to relocate from Banjul. It is viewed as a meaningful strategy for avoiding climate risk and enhancing households' resilient and adaptive capacities. In contrast, other studies found that remittance-receiving families in Vietnam, Western Sudan, and Northern Ethiopia were more likely to stay and maintain what others referred to as the "social resilience" of coastal communities (Adelekan,1999: Afolayan and Ezra, 2001; Adger et al., 2002; all cited in R. McLeman & Smit, 2006).

Another economic push factor for migration in developing countries is poverty and unemployment. Increasing urban poverty and high unemployment rates have contributed to rapid international migration rates in Africa (Black et al., 2006). However, the relationship between migration and poverty is not always negative. In many cases, migration is not necessarily an evil byproduct of poverty but often a strategy to eliminate extreme poverty, unemployment, and high inequality in developing countries (Black et al., 2006). In The Gambia, the poverty rate in Banjul is lowest compared to other settlements. Hence, economic poverty could not be the primary determinant to instigate rapid out-migration compared to other factors such as environmental.

1.7.2.3 Sociocultural and Psychologically Induced Factors of Migration

Migration decisions are not only based on environmental and economic factors but also include sociological and psychological determinants. According to Perch-Nielsen, (2004), psychologists study the nexus between migration and emotional attachment of people to places. For sociologists, social capital determinants such as lifestyle, relationships (e.g., marriage), prestige, identity (religion, ethnicity), social networks, information sharing, trust, and cultural differences all influence migration decisions within and across societies (Perch-Nielsen, 2004; Raleigh et al., 2009; McLeman, 2014). Evidence shows that social capital and psychological factors are also considered when making migration decisions (Perch-Nielsen et al., 2008; McLeman, 2014). The "immobility paradox" coined by Fischer and Malmberg (2001) suggests that potential migrants prefer to remain at their homestay, even when known environmental threats are likely to jeopardize their livelihood options (Nawrotzki et al., 2016). In The Gambia, 35% of Banjulians who reject the relocation proposal mainly cited social and psychological reasons for not considering any possible migration at least by 2050 (see Figure 1.5 above). However, the combined social factors described to influence out-migration were found to be statistically insignificant, according to the econometric results (see Table 1.5 above). Therefore, I can conclude that social factors have a lesser effect in influencing migration decisions in Banjul compared to climate and environmentally induced factors. It is pertinent to emphasize that ethnicity, as discussed above, could trigger population movement from Banjul if ethnic rivalry and tribal tensions intensify due to political or other reasons.

1.7.2.4 Demographically Induced Factors of Migration

Demographers, on the other hand, attribute migration mainly due to demographic changes in population growth, density, and pressure on resources. The natural increase in population occurs when the birth rate grows faster than the death rate (UN/POP/EGM-URB, 2008). Over-congestion is an outcome of rising population growth and density. Over-crowded settlements (e.g., Banjul, Lagos in Nigeria, Dakar in Senegal) also suffer from limited housing units. Over-congestion also contributes to poor environmental conditions. According to my study, over-congestion is considered as the primary cause of Banjul's high out-migration rate since the 1980s (Table 1.2 above). However, on average, it has a statistically insignificant bearing on the current household's WTM migration, all else constant (see model 3 in Table 1.5 above).

1.7.2.5 Politically Induced Factors of Migration

Political factors also stimulate households' migration decisions. These include structural constraints such as immigration policies, regulations, controls, and security, especially for international migration (Perch-Nielsen, 2004; McLeman, 2014), shared political alliance (Raleigh et al., 2009), and political rights and freedoms enshrined in a country's constitution (Perch-Nielsen et al., 2008; McLeman, 2014). According to Banjulians, political forces such as safety and security issues have a minimal direct influence on out-migration. Indirectly, political decisions resulting in development failures or lack of institutional responsibilities have immensely contributed to the poor environmental conditions reported to have pushed many Banjulians out.

1.7.2.6 Other Factors of Migration

Other factors affecting migration decisions include distance to possible destinations, access to public infrastructure as well as the household's ability to adapt (Raleigh et al., 2009; McLeman, 2014). Observed migration records from Banjul show that over 95% of out-migrants moved to the closest areas Kanifing Municipality (KM) and West Coast Region (WCR). Similarly, survey evidence shows that among 64% of those with migration intent, 46%, and 40%, respectively, choose the KM and WCR as their preferred destination.

1.7.3 Discussion on Urbanization & Migration Types

1.7.3.1 Urbanization

Urbanization in developing countries, including in Africa, is mainly fueled by a growing natural increase and positive net internal migration. Urbanization, according to Beauchemin & Bocquier, (2004), is the accumulation of people, commerce, buildings, and capital within a geographical location. Most urban residents on the African continent are relatively poor, vulnerable, and lack what Adger et al., (2002) calls 'social resilience' to cope with urban hassles (Adger et al., 2002 cited in Banerjee, Black, & Kniveton, 2014; Potts, 2013; Khan, 2010; Beauchemin & Bocquier, 2004). According to UN-

Habitat, nearly 62% of African urban households are living in overcrowded slums, where they lack access to essential public services, facilities, and infrastructure (Turok, 2016). For example, in Lagos, Nigeria, 72% of households lived in one-room housing units (Opoko & Oluwatayo, 2014). Like in Banjul, the average household size in Lagos is ~4 persons (Opoko & Oluwatayo, 2014). In Banjul, Lagos, and many other African cities, households are becoming further individualized and more of a nuclear family type system. Rapid urbanization has not just contributed to over-congestion but has also disintegrated the African traditional extended family structures, which is partially influenced by the expansion of westernization or modernization concepts. Unfortunately, such sociocultural modifications and over-congested living conditions are resulting in growing family conflict and separations, without amicable resolutions for reunion and reconciliation. Evidence from my survey finds that, in the second-order of ranking key migration drivers, 13% of Banjulians rate family conflict and misunderstanding as the most significant factor of out-migration. Such conflict has further reduced household size in Banjul, as similarly observed in Lagos. Likewise, in Africa, family conflict was ranked as the 5th reason for out-migration in Pakistan (Hasan & Raza, 2009). Consequently, on one hand, informal housing and homelessness emerge to rear their ugly faces in many developing country cities. On the other hand, reduced household size due to conflict translates into increased housing unit development elsewhere, as a response strategy. In such cases, households are driven to locations with facilities, services, and activities that will usher them into better living conditions (Turok, 2016; Bilsborrow, 1998). Therefore, the development of new housing estates combined with urban development expansion projects in West Coast Region of The Gambia have motivated the number of people out-migrating from Banjul.

1.7.3.2 Internal Migration Types

In Africa, internal migration accounts for the most significant migratory trend (Black et al., 2006; Potts, 2013). Internal migration types can be either voluntary or forced and mainly included urban-to-urban, urban-to-rural, rural-to-rural, rural-to-urban, and circular migration. However, the prospects of each migration type can also be constrained by a lack of financial resources, distance to destination, lack of information, social controls, and national, regional, and international immigration regulations (Lucas, 2015).

Across Africa, studies found several pieces of evidence of growing interurban (urban-urban) migration, especially in Nigeria, Zambia, South Africa, and The Gambia (Obeng-Odoom, 2015; GBoS, 2013a; Bilsborrow, 1998). Interurban movements are observed to be predominantly higher among female migrants in 26 out of 46 African countries, according to the UN-PoP report (UN/POP/EGM-URB, 2008). Female dominance is highly associated with women marrying partners from across regions. My study shows that some family members, often parents, would later migrate to stay with their daughters married outside of Banjul. As of 2013, 86,861 Gambians were classified as interurban migrants, among which 32% (27,857) migrated from Banjul. Among the 27,857 city out-migrants, 73% moved and resettled in the KM, 25% ended up in the WCR, and only 2% migrated to the other four regions in up-country (GBoS, 2013a).

Second, rural-urban migration has contributed to urban congestion, high unemployment, and poverty rates in many developing countries in Africa. Urbanization driven by rural-urban drift is a byproduct of colonialism. Urban centers (e.g., Banjul) in Sub-Saharan Africa were former administrative centers of the colonial powers (Beauchemin & Bocquier, 2004). Influenced by economic theories such as Francois Perroux's Growth Pole theory and Lewis' 'dual economy' theory, urbanization in developing countries spread like wildfire, due to rural-urban/ labor migration for exploring economic opportunities, especially in Africa (W. Liu, Dunford, Song, & Chen, 2016; D. Liu, 2015; Opoko & Oluwatayo, 2014; Komarovskiy & Bondaruk, 2013). In The Gambia, 140,761 Gambians were rural-urban migrants as of 2013, the majority of these migrants were females (GBoS, 2013a). Recently, 44% of Gambians reported that rural-urban areas have increased in recent decades (Afrobarometer, 2018). Beauchemin & Bocquier (2004) observed similar results in other African countries. A significant number of rural migrants see no future in agriculture, hence continue moving to urban centers to accumulate some capital in preparation for international migration. As explicitly described by Spittler (1971), the “sons of peasants no longer see a future in agriculture.” Also, returns on better educational opportunities, entrepreneurial resources, and technological innovation in urban than rural have further influenced rural-urban migration (Hasan and Raza, 2009; UN/POP/EGM-URB, 2008). In The Gambia, over 90% of rural migrants reside in KM & WCR (GBoS, 2013a). Only 1.5% of rural migrants (2,166 people) were attracted to stay in Banjul since 1983 (GBoS, 2013a).

In contrast to rural-urban migration, several pieces of evidence show an increasing trend in urban-rural migration or what Berry (1976) called counter-urbanization (Bilsborrow, 1998) in Africa. Counter-urbanization has also been observed in Northern Ireland (Stockdale & Catney, 2014) as well as in the US (Reichert, Cromartie, & Arthun, 2014). On the African continent, net in-migration to urban areas has drastically reduced from 40% in the 60s and 70s to 25% in the 80s (Potts, 2013). Beauchemin & Bocquier (2004) quantified enough evidence to argue that the traditional direction of West African migration flow is reversing with increasing growth. This is true for Nigeria, Cameroon, Coˆte d’Ivoire, Ghana, Senegal, and The Gambia, to mention but a few (Beauchemin & Bocquier, 2004). Evidence shows that urban-rural migration is the most common among males in Burundi, Kenya, Mali, and Nigeria (UN/POP/EGM-URB, 2008). It's not a new phenomenon, in Abidjan, from 1988 to 1992, nearly 12, 000 people were lost per year from urban to rural areas. For example, according to Beauchemin & Bocquier (2004), primary migrants born in urban areas of Coˆte d’Ivoire form 25% of urban emigrants. Besides, rural-urban migrants often visit their homelands and transfer what Levitt (1998) calls ‘social remittances’ (e.g., ideas) for expanding innovation and socio-economic development in rural areas (cited in Banerjee et al., 2014). Some rural migrants eventually return to their villages for retirement and for reclaiming their inheritance or for taking good care of their old ones (Adewale, 2017; Beauchemin & Bocquier, 2004). Furthermore, the impact of Structural Adjustment Programs (SAPs) introduced in Africa by the Bretton Woods Institutions (WB & IMF) in the 80s have significantly contributed to urban out-migration in many African countries from Zambia, Uganda, Tanzania to Zimbabwe, according to Potts, 1995 (cited in Beauchemin & Bocquier, 2004; Bilsborrow, 1998). Such impacts of SAPs are anecdotally evident, especially among laid-off civil servants in The Gambia. Moreover, urban out-migration has been influenced by high rent payment associated with low income earning capacities combined with high livelihood vulnerability in cities (e.g., joblessness or job insecurity) (Adewale, 2017; Potts, 2013). Hence, rural and peri-urban areas provide a sanctuary for current urban dwellers, as the cost of living at those destinations is significantly lower (Beauchemin & Bocquier, 2004). Most of the above factors observed elsewhere have contributed to city out-migration from Banjul to other urban and peri-urban centers and even to rural areas as well. Across The Gambia, urban-rural migration has increased by nearly 47% from 2003 to 2013 (24,298 to 35,124) (GBoS, 2013a). Although, since 1983, only 2.3% (717 people) of nearly 31,069 city migrants from Banjul moved to the rural Gambia (GBoS, 2013a). Therefore, there is little evidence that Banjulians have or will mostly migrate to rural areas. Notwithstanding, urban poverty, and development challenges will gradually force some Banjulians to consider rural sanctuary.

The counter-arguments against urban-rural migration in some studies indicated that climate change impacts severely affecting rural areas could impede or slow any projected growth in urban-rural migration. This is because several rural livelihood sources dependent on rain-fed agriculture will be under current and projected climate change threats (Annez, Buckley, & Kalarickal, 2010; IOM, 2009; Parnell & Walawege, 2011, all cited in Nielsen & D'haen, 2015). Instead, they argue that rural out-migration will continue to grow in developing countries with rising climate-related risks (McLeman & Hunter, 2010) and that rural migrants will become permanent urban residents (McGranahan et al., 2009, in Nielsen & D'haen, 2015; Khan, 2010). Besides, evil practices such as sorcery, existential vulnerability, and poor quality of living make urban-rural or return migration unattractive in Burkina Faso (Nielsen & D'haen, 2015). Evidently, in Kenya, Uganda, and Tanzania, net in-migration to urban areas is exponentially growing (Potts, 2009), mainly due to violent conflict and climate-induced migration caused by severe droughts.

Finally, many urban emigrants can be classified as circular migrants who seasonally commute between rural and urban areas (Potts, 2009; Beauchemin &

Bocquier, 2004). Circular migration reflects inadequate economic opportunities in urban areas (Potts, 2009). Some circular migrants are now increasing staying in rural or pre-urban regions due to the high cost of living in cities. Hence, rural and peri-urban areas have a positive migratory gain (e.g., in Coˆte d'Ivoire) (Beauchemin & Bocquier, 2004). Across national sovereign boundaries, circular migration can be influenced by labor market demands (Ozkul & Obeng-odoom, 2013).

1.8 Recommendation

Given the findings of this chapter, I recommend the following for informing climate change adaptation policies in protecting Banjul, its people, the economy, and the environment in general. First, in agreement with other studies cited above, this study finds migration as a devised adaptation strategy for dealing with environmental challenges and projected climate change risks. Both households and the government should lay down plans and strategies to consider household migration and managed retreat (i.e., relocation of the city) for long-term sustainability reasons. Therefore, the government should incorporate migration as an adaptation strategy into its Climate Change Policy (2016) for reducing risk to sea-level rise in Banjul and other low-lying coastal settlements. This strategic option is missing in the recently published national climate change policy.

Second, given the cultural and historical significance of Banjul city, compounded with the fact that at least 35% of islanders declare no migration intent, the study recommends an assessment of government's investment in hard/soft engineering solutions to protect Banjul at least by 2050. Therefore, cost-benefit analysis studies should be carried out to inform policymakers on critical issues at stake. I recommend future research to conduct cost-benefit analyses to figure out (a) the net benefit of households' out-migration from Banjul (are outmigrants better-off elsewhere?) (b) the net social and economic value of investing in hard/soft engineering solutions for protection against sea-level rise, and (c) the net benefit of developing a second capital city for intragenerational and intergenerational benefits.

Third, as a short-term policy intervention, I recommend that Banjul City Council rebuild and strengthen its current infrastructure (e.g., stormwater and sewer systems), given that an overwhelming majority of its residents are concerned about the city's resilient challenges. These will include rehabilitating and expanding its grey infrastructure systems for enhanced sewer and stormwater management and investing in other soft accommodation strategies such as leveraging green infrastructure or nature-based solutions for mitigating flood risks and impacts.

Fourth, considering that nearly 50% of islanders support building a new city, I suggest that the government commence a national consultation on the matter and mobilize local and international resources to support the process. Fifth, in conformity with one of the principles of The Gambia National Climate Change Policy (2016) (i.e., the polluter pays) (Urquhart, 2016), this chapter submits the voices of islanders in Banjul that it should be a moral obligation for the developed nations to pay for loss and damage attributed to climate change impacts in developing countries, including The Gambia. Moreover, it's my opinion that flood-prone areas be avoided when identifying and rebuilding a new housing unit in Banjul. Finally, as observed in many other places, charities, non-governmental organizations, and religious groups should continue to participate in environmental restoration efforts and provide both economic and psychological support to vulnerable city residents.

1.9 Conclusion

Given my analysis, the study concludes that even without a planned government retreat strategy for islanders in Banjul, 55% of residents are more likely to devise voluntary migration as a coping strategy for dealing with the current environmental challenges and projected climate change impacts by 2050. However, I am mindful of the fact that this intention to migrate could be reversible if the city of Banjul, the central government, or the international community invest public resources in protecting the island against rising sea-levels and its associated impacts. Therefore, burden sharing, appropriate government policies, resilient development efforts, financial availability, evacuation opportunities, social relations and networks, and hard/soft engineering protection measures will significantly reduce the possibility of climate-induced migration from Banjul at least by 2050 (Raleigh et al., 2009; McLeman, 2014; Türk et al., 2015).

Secondly, both internal and international migration has been a critical household strategy for environmental and climate risk-reduction and resilience building in The Gambia and across Sub Saharan African countries, primarily through remittance inflow. If no aggressive measures are taken, I learned from several other studies that more environmental migrants and refugees would emerge from many developing countries (e.g., India, Bangladesh, Indonesia, China, Somalia, Nigeria, The Gambia, etc.) and small island nations (e.g., The Maldives, Kiribati, Tuvalu). They would prefer to move to short-distance destinations (internal migration). However, some would desire to cross international borders but might be constrained by the high cost of mobility as well as xenophobic immigration policies enforced by host countries with stringent regulations for border control and visa restrictions. Consequently, forced migration because of climate and other reasons will expose poor people in fragile states and other developing countries to homelessness, socio-economic impoverishment, marginalization, exploitation, and disempowerment within and across sovereign boundaries (Afsar, 2003; Black et al., 2006; Perch-Nielsen et al., 2008; Piguet, 2008; Raleigh et al., 2009; Potts, 2013; McLeman, 2014; Türk et al., 2015). In a nutshell, I conclude by stating that restricting people's right to migrate voluntarily means limiting their agency, freedom, and ability to prosper and self-actualize. Migration is and should be treated as a fundamental human right, period!

Finally, for further details on the theoretical nexus between climate change and human migration vis-à-vis the trends and issues affecting Banjul, read Appendix A. below. In chapter two below, I present the results of a GIS-based site suitability analysis using a multicriteria decision-making procedure for identifying a 'suitable' location for building the next capital city.

Chapter Two

A New Climate-Resilient Capital City: Site Suitability Analysis using Remote Sensing and GIS-based Multicriteria Decision Making (MCDM) Approaches

2.1 Introduction

The Gambia is highly vulnerable to the impacts of climate change. Its capital city, Banjul, has an average elevation of approximately one meter above sea-level. The island is projected to sink if global mean sea level rises (SLR) by one-meter[7] (Jallow, Barrow, & Leatherman, 1996; IPCC, 2007; Brown, Kebede, & Nicholls, 2011; Drammeh, 2012; Hills & Manneh, 2014; Coates & Manneh, 2015; Amuzu, Jallow, Kabo-Bah, & Yaffa, 2018a). Overall, 23% of the total population in The Gambia are living in areas where elevation is below 5 meters. As I introduced in chapter one, what should be done to adapt to sea-level rise in Banjul? Will the government protect the island? Or should the capital be relocated? If so, where? These questions remain the fundamental research inquires of my dissertation.

Considering Banjul's high level of exposure and vulnerability to climate change hazards, a recently concluded European Union-funded research project recommends the identification of a strategic location for building the next capital city of The Gambia (Coates & Manneh, 2015). Making such decisions of national interest can be profoundly political. Instead of purely relying on the choice of a politician (i.e., in most cases the president), scientific research can help inform policymakers in their decision-making processes. Therefore, the main objective of this chapter is to conduct a site suitability

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[7] *Brown et al. (2011) predicted: "sea-level rise of 0.13m in 2025, 0.35m in 2050, 0.72m in 2075 and 1.23m in 2100 for The Gambia" (Drammeh, 2013 p. 41).*

analysis for the development of a new capital city. Which region has the "most suitable" site for constructing a new climate-resilient capital city? Suitability is a subjective term. I used a geographic information system (GIS) based multicriteria decision-making (MCDM) procedure for conducting the analysis. This methodology minimizes subjectivity in suitability analysis. The procedure considers multiple variables such as demographic, social, economic, ecosystems, and environmental, including climate and hydrological factors in the decision analysis.

Chapter two is organized into seven sections. Section one introduces the study area and highlights urban challenges and opportunities for proper city planning in a developing country context. Section two provides the data sources, input layers, and the applied study methodologies. Section three presents a preliminary discussion on each of the input layers included in the MCDM analysis. Section four contains the findings of the public opinion survey administrated. Section five presents the results of the decision-making ranking matrix. I used the SWOT analysis framework, which stands for strengths, weaknesses, opportunities, and threats, to discuss the results in section six. Section seven concludes the study and offers a few recommendations. Finally, I appendix a detailed literature review on the methodologies used for this study and summarizes its application in similar studies (see Appendix B.).

2.2 Study Background

2.2.1 Urbanization and City Planning

The urbanization is rapidly increasing globally. According to the United Nations (2018), 55% of the world's population (7.8 Billion) live in urban areas, a proportion expected to reach 68% by 2050. In Africa, 43% of people live in urban areas (United Nations, 2018). The urban population in The Gambia is higher than the global and continental averages. Today, over 60% of Gambians are residing in urban areas (Knoema, 2019). Increasing urbanization in The Gambia has created a series of development challenges. These include but are not limited to congestion, growing demand for the use of limited public resources, facilities, and infrastructure, as well as increasing stress on ecological habitats such as the marine and the forest ecosystems. Rapid urbanization is also associated with growing unemployment, sprawling urban poverty level, and increasing environmental pollution of air and water bodies leading to a deteriorating health condition for the population.

City planning is, therefore, a critical pillar for addressing urban challenges. It is also essential for attaining the global sustainable development agenda. The complicated dynamic process of city development requires analytical modeling and strategic thinking, planning, and acting. The process should directly involve all stakeholders with diverse perspectives and patterns of behavior (Arnous, 2013).

City development plans can be modeled with the availability of modeling tools and analytical scientific methods to support the implementation process. Spatial planning and decision support techniques have been widely used to make city planning and decision making more transparent, especially with the development of advanced geospatial technologies (Collins et al. 2001; Malczewski 2004; cited in Arnous, 2013). An example of such a methodological application is the use of remote sensing and GIS-based multicriteria decision making (MCDM) procedures. MCDM approaches are applied for site suitability analysis for a defined land-use purpose (Al-shalabi, Mansor, Ahmed, & Shiriff, 2006; Chandio et al., 2013; M. G. Collins, Steiner, & Rushman, 2001). GIS-based MCDM methods have been applied in numerous subject areas, including urban planning, ecological management, recreation/tourism development, forestry, hazard mapping, real estate development, geological science, climate change mitigation, hydrology, and water resources, and the manufacturing industry to mention but a few(Al-Hanbali, Alsaaideh, & Kondoh, 2011; Chandio et al., 2013).

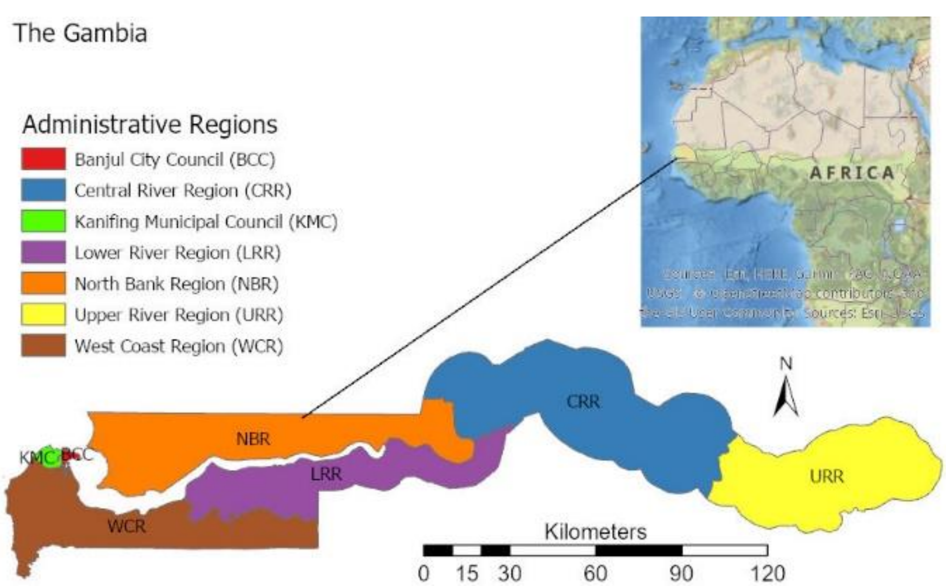
2.2.2 Study Area

The Gambia has a total area of 11,295 km² of which 10,295 km² is classified as land. The country is located at a latitude and longitude of 13°28'N and 16°34'W, respectively. The total population is approximately 2.1 million people, according to the World Bank estimates in 2019. With a Sahelian tropical climate, The Gambia receives an average annual rainfall of 860mm. Daily temperature averages at 28.2° C, while monthly humidity stands at 80% during the rainy season (Drammeh, 2013; UNDP, 2013).

The country's exposure and vulnerability to climate risk factors, such as the impacts of rising sea-levels are exacerbated by its high poverty levels, lack of resilient infrastructure, insufficient financial resources, weak institutional capacity, and lack of social safety nets (Jallow et al., 1996; Drammeh, 2013; UNDP, 2013; IPCC, 2014; Coates and Manneh, 2015; Amuzu, Jallow, Kabo-Bah, & Yaffa, 2018b). As) a highly indebted developing country, unemployment, and poverty rates are over 35% and 45%, respectively. The gross domestic product (GDP) stands at 1.6 billion (current US$, 2017) and grows at 3.5 % annually. Access to quality education, safe drinking water, and primary healthcare remains highly inadequate across the country (GBoS, 2010; WB DataBank, 2018; World Population Review, 2018).

This study accounted for the overall environmental and socio-economic conditions of The Gambia and offers a detailed regional comparison of land suitability for the construction of a new capital city. The analysis considers the variability of indicators from across the seven administrative regions of the country (see study area, Map 2.1).

Map 2.1. Administrative Region of The Gambia



2.3 Methodology

2.3.1 Multicriteria Decision Making (MCDM) procedure

This study employed a geospatial analysis method for site suitability analysis, using remote sensing and GIS-based multicriteria decision making (MCDM) procedures. GIS-based MCDM methods assess, evaluate, and integrate a variety of geographical data and value judgments (i.e., beneficiaries and decisionmakers' preferences) to make an informed decision (Malczewski 2006b, 730, cited in Feizizadeh & Blaschke, 2013). The most commonly used decision analysis techniques in MCDM studies include the analytical hierarchy process (AHP), objective-oriented comparison (OOC), sensitive analysis, and public opinion surveys. For more references on MCDM, AHP, and GIS methods and applications, refer to the literature review section in Appendix B.

In this GIS-based MCDM analysis, each data type generates a data sub-model or a map layer used in the study as a sub-criteria for assessing the overall site suitability (see schematic model, Figure 2.1). In the MCDM matrix below, a score is assigned to each sub-criteria using a Likert scale of 1 to 5 (1 being highly unsuitable and 5 being extremely suitable). I assigned a zero value to a sub-criterion considered as inapplicable (i.e., for the baseline site, Banjul). The scoring process uses the indicator values to assign ranks based on the relative contribution of each sub-criteria/indicator to the ultimate study goal. (Jankowski & Richard, 1994; Malczewski, 2004; Collins et al., 2001; Bennui, Rattanamanee, Puetpaiboon, Phukpattaranont, & Chetpattananondh, 2007; Hossain et al., 2007; Feizizadeh & Blaschke, 2013; Abdullahi et al., 2014). This process eventually creates an MCDM matrix (see Table 2.9, result section). To determine the overall suitability, I aggregated the scores for each candidate site using the MCDM matrix in excel. The location or region with the highest score is considered the most suitable place for building the next capital city of The Gambia.

GIS-based MCDM procedures have helped to resolve alternative site selection conflict, evaluate, and harmonize tradeoffs (Nas, Cay, Iscan, & Berktay, 2010; Charabi & Gastli, 2011; Jeong, García-Moruno, & Hernández-Blanco, 2013). For example, one of the input parameters used in this analysis is the 'degree of access' for the majority of the population to the new city. A highly accessible site to the majority can reduce the transaction cost and save time for service seekers and employees commuting to the new city. Accessibility can be gauged based on the availability of roads, bridges, railways, waterways, etc. One may think that the closer the city to the majority, the better. But, being closer to the majority could also mean putting the city in low lying erodible area with a higher risk of climate-induced flooding (e.g., sea-level rise and extreme precipitation events).

A GIS-based classification method (i.e., natural breaks) has been used for reclassifying the input raster layers (e.g., DEM) into various suitability classes (Basnet et al., 2001; Baseer et al., 2017;). The natural breaks method divides feature classes based on the “natural groupings inherent in the data” (ESRI, 2020). The final suitability map is an aggregated overlay of weighted cells representing all reclassified input map layers (Babalola & Busu, 2011; Bunruamkaew & Murayama, 2011Bagaram et al., 2016; Baseer et al., 2017). The weighted overlay tool in ArcGIS Pro has been used for the analysis. The land suitability is mathematically defined by Bagaram et al., (2016) as:

$$S = \sum_{i} W_i X_i \prod_{j} C_j$$

Where:

S: suitability composite score,

W_i: weight assigned to the factor i,

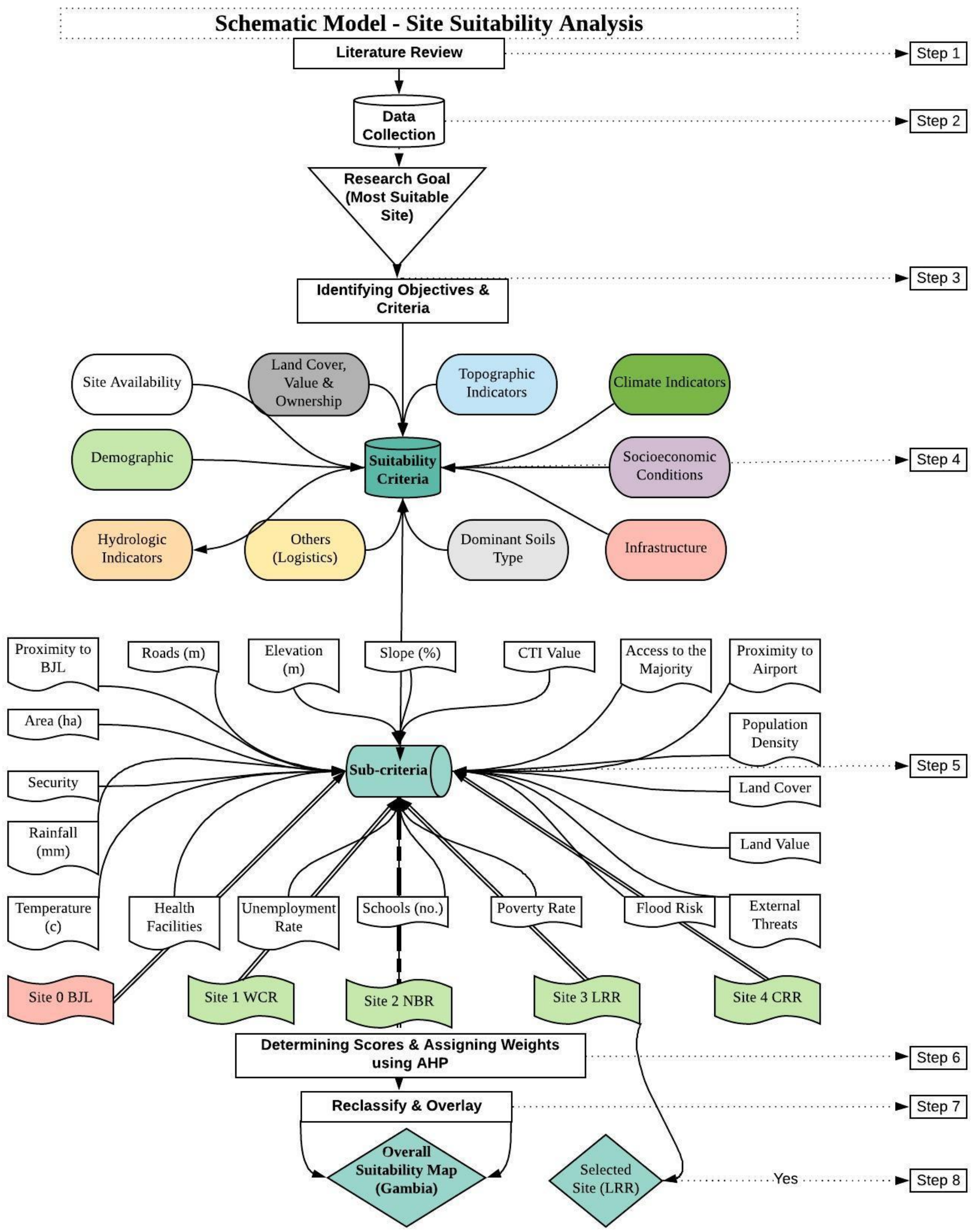
X_i: score of factor i,

Π: is a multiplicative sum of the constraints

C_j: constraint j score (0 or 1)

Given the above equation, for a pixel of land area, if the constraint factor is zero (meaning not suitable), the composite suitability score of that area becomes zero, resulting in the exclusion of the site from the analysis (see Map 2.2).

Figure 2.1. Schematic Model- Site Suitability Analysis using MCDM



The schematic model in Figure 2.1 can be simply explained in the following eight steps;

Step 1. An initial literature review was conducted to understand the MCDM technique and determine suitability criteria and sub-criteria used in similar studies

Step 2. A data layer was collected for each indicator/sub-criteria from several data sources (e.g., USGS, World Bank, GBOS, etc.)

Step 3. Suitability goal was determined, policy objectives set, and suitability criteria/subcriteria selected and agreed upon by public opinion

Step 4. Suitability criteria were grouped into the major categories

Step 5. Each suitability criterium was sub-divided into sub-criteria or single map layers

Step 6. Each sub-criterium was assigned a score and a weight based on their relative importance to attaining the suitability goal and objectives, respectively, using the MCDM matrix and analytical hierarchy process (AHP). The scores were independently assigned based on the data attributes (e.g., mean DEM by site), while the weight assignment relied heavily on public opinion gathered from the survey

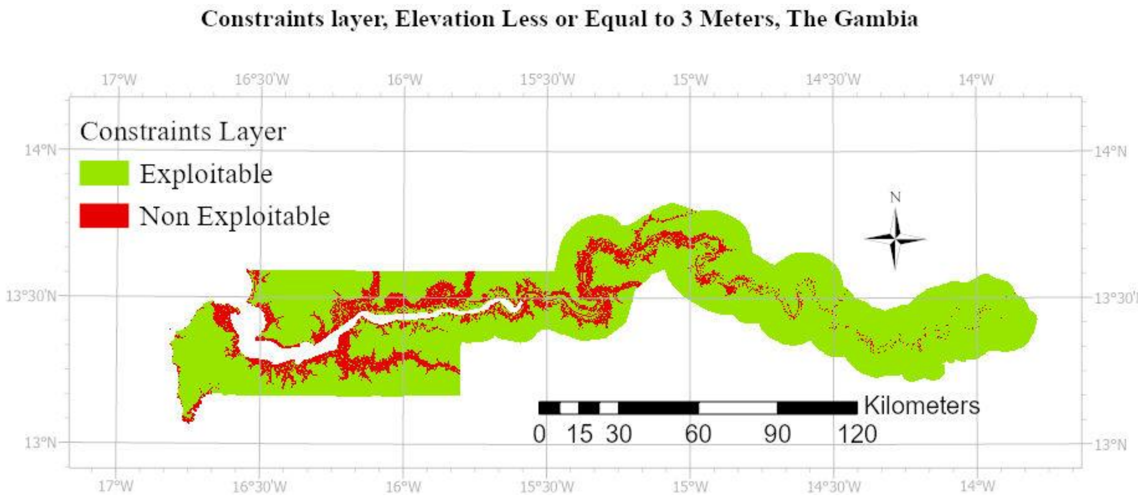
Step 7. All GIS-based input map layers were later reclassified into four classes using ArcGIS Pro (i.e., not at all suitable, poorly suitable, moderately suitable, and highly suitable). The weighted overlay tool was used to overlay all reclassified input map layers to create a final suitability map below.

Step 8. Scores of all sub-criteria were aggregated to determine the site with the highest suitability mark using excel.

2.3.2 Initial Site Selection & Exclusion Criteria

Site identification considers multiple objectives in measuring the suitability of an area for specific land use (Al-shalabi et al., 2006). The starting point for site screening and selection was to define constraint criteria and eliminate all areas within the constraint limit from being selected. The constraint area is also referred to as the exclusion zone (EZ) (Bennui et al., 2007). As shown in Map 2.2 below, all areas with less or equal to three meters of elevation have been classified as non-exploitable sites.

Map 2.2. Constraint Layer:-Elevation less than or equal to 3 meters, The Gambia



I also present the land area of places with less than one, two, and three meters above the global mean sea-level (see Map 2.3). I conservatively estimated the total economic value of losing these areas using the market price of a pixel land, as stated below. Depending on the reference datum (e.g., tidal datum), the monetary values in Figure 2.2 may still be an underestimation of spatial vulnerability.

Map 2.3. Spatial Vulnerability Extent (DEM <=3m)

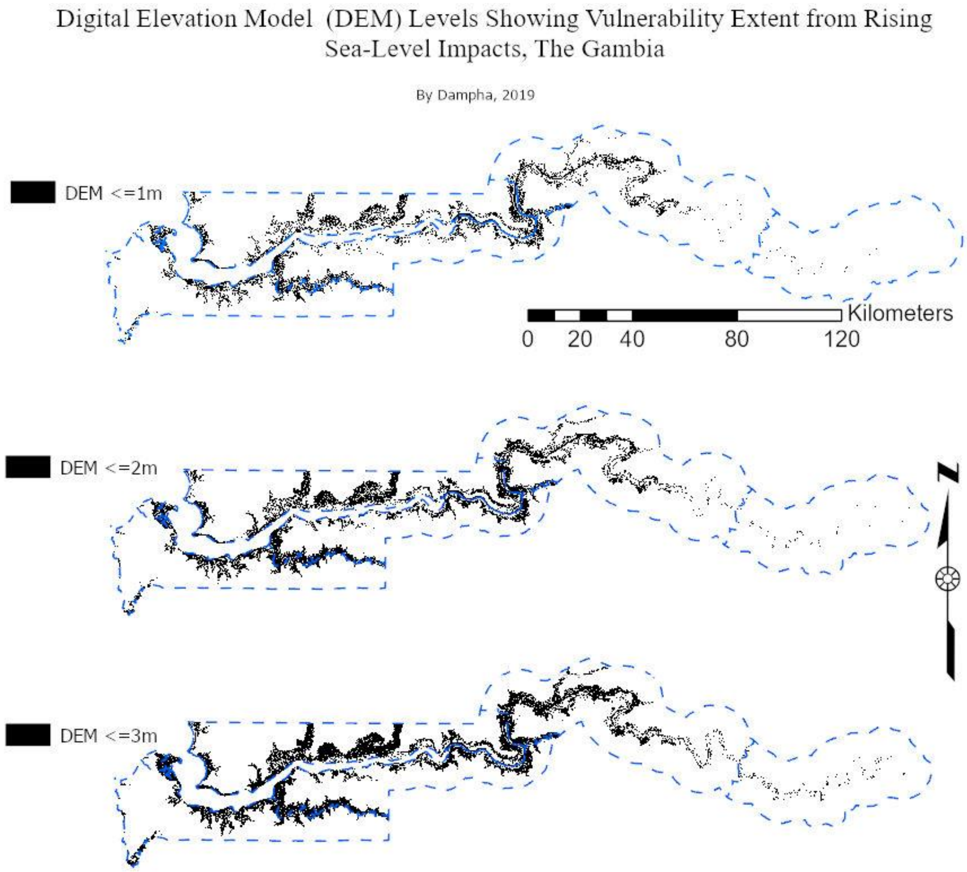
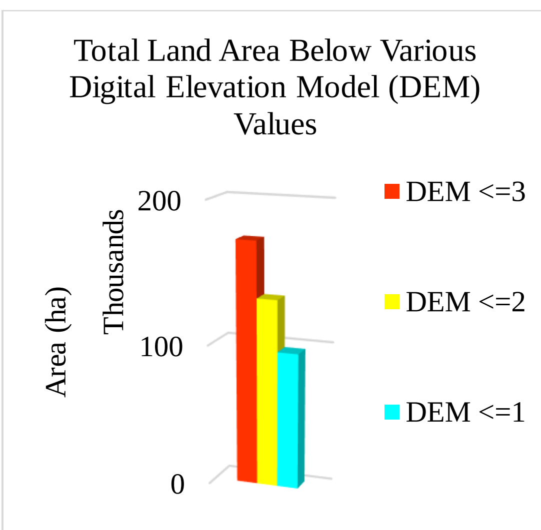
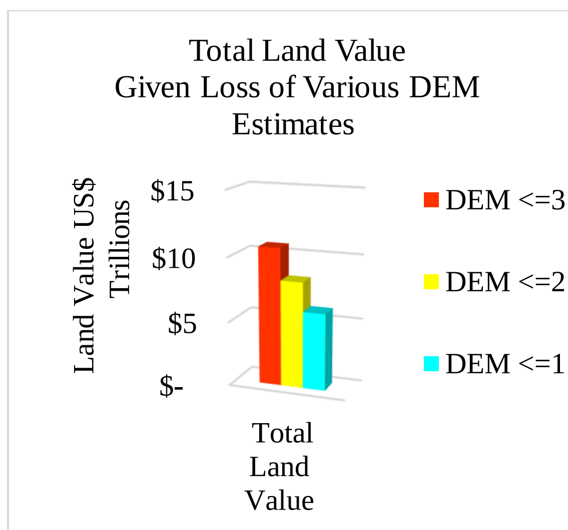


Figure 2.2. National Land Area Below Various DEM Values: Area in ha (Left) & Costs in US$ (Right)

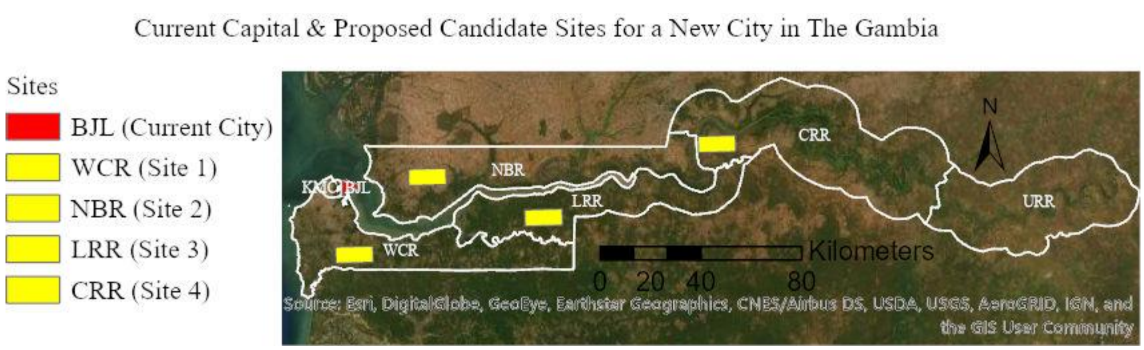




Given that the analysis primarily considers the regional variations of suitability elements, I identified four candidate sites in four administrative regions, namely; West Coast Region (WCR), North Bank Region (NBR), Lower River Region (LRR), and Central River Region (CRR). These regions are numerically represented as proposed candidate sites 1,2,3, and 4, respectively (see Map 2.4). The decision on the spatial positioning of the selected sites was based on remotely sensed visual interpretation of the topographic conditions of the landscape. The current capital city, Banjul, is included in the analysis as a baseline (i.e., represented as site 0). The reasons for not including a proposed location in the Kanifing Municipality (KM) and Upper River Region (URR) are due to additional constraint factors. The Municipality has limited available space to accommodate a new capital city. The area is densely crowded with the highest population density. Building a new city in the KM would translate to displacing a substantial percentage of the population. The overall costs to society will be exorbitantly high with the development of a new capital city in the KM. URR was disqualified due to its lack of proximity to over 70% of the national population.

All proposed candidate sites are equal in size. To offer proper zoning and city planning, I planned that the new city should be at least five times bigger than Banjul, corresponding to 1887 hectares for Banjul (including wetland) and 8945 hectares for the candidate site. This is because the new capital should accommodate all existing settlers instead of contributing to their displacement. Also, enough space is required to build institutions, including public infrastructures, social amenities, recreational sites, and residential plazas for public officials.

Map 2.4. Locations of the Proposed Candidate Sites for a New Capital City Development



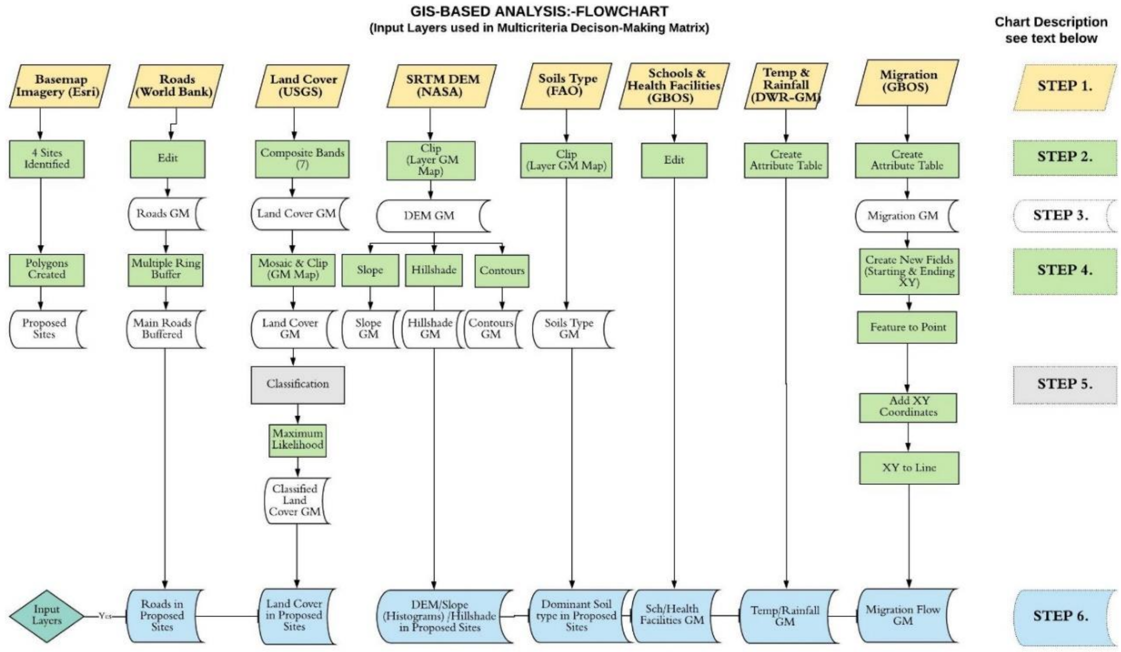
2.3.3 Geographic Information Systems (GIS)

Geographic information systems (GIS) have been used for land-use suitability mapping and modeling for many decades (Malczewski, 2004 and Malczewski, 2006 cited in Chandio et al., 2013; Dawod, 2013). GIS software packages are best for handling a variety of multiple geospatial data layers with different spatial, temporal, radiometric, and spectral resolutions. ArcGIS Pro, Q GIS, ArcView, ArcMap, and similar software packages are widely used with other decision-making techniques for conducting land or site suitability analysis (Chandio et al., 2013; Baseer et al., 2017; Hossain, Chowdhury, Das, & Rahaman, 2007).

I used ArcGIS Pro 2.4.0 (ESRI, 2019) for analyzing both input and output map layers (see Figure 2.3). All thematic map layers used were registered to a Universal Transverse Mercator (UTM) coordinate system, zone 28N, datum WGS, 1984, to allow for proper spatial correspondence.

GIS is a “decision support system and not a decision-making system” (Abdullahi et al., 2014). This limits its decision analysis capabilities for processing multiple criteria with conflicting objectives (Carver 1991, cited in Al-Shalabi et al., 2006). Since GIS do not provide decision-making modules (Al-shalabi et al., 2006), MCDM has been integrated to support the decision making process for site suitability analysis (Sharifi et al., 2009; Dawod, 2013; Demesouka, Vavatsikos, & Anagnostopoulos, 2013; Ebistu & Minale, 2013). GIS, combined with MCDM techniques, provides powerful visualization and mapping capabilities for land-use suitability analysis (Bunruamkaew & Murayama, 2011) (see the methods and the results in chapter 2).

Figure 2.3. GIS-based Flowchart



The Flowchart in Figure 2.3 above can be simply explained in the following six steps;

STEP 1. Includes geospatial and socioeconomic data collection from multiple sources, including the US Geological Survey (USGS), World Bank, and the GBoS

STEP 2. Includes data editing, composite band combination of remotely sensed Landsat images, creating attribute tables, and identifying the candidate sites

STEP 3. Initial map formation, including the creation of an unprocessed Landsat single image

STEP 4. Includes advanced GIS processing, including mosaicing, clipping, buffering, slope calculation, etc.

STEP 5. Land-use land cover (LULC) classification using maximum likelihood classifier to produce the final input LULC map

STEP 6. Final input map layers created for all candidate sites extracted from the country maps using the clip tool, where relevant

2.3.4 Analytical Hierarchy Process (AHP)

The analytical hierarchy process (AHP) is one of the multicriteria decision making (MCDM) decision analysis techniques used in site suitability studies. The AHP technique assigns weights to each data layer with the help of a preference scale, suggested by Saaty (1980) (Wang, Qin, Li, & Chen, 2009; Youssef, Pradhan, & Tarabees, 2011; Mishra, Deep, & Choudhary, 2015; Noorollahi, Yousefi, & Mohammadi, 2016). The preference factor determines the relative importance of each map layer when compared to others (Hossain et al., 2007; Tudes & Yigiter, 2010; Sharmin & Neema, 2013; Qaddah & Abdelwahed, 2015; Gumusay et al., 2016). Likewise, in Bunruamkaew & Murayama (2011) study, the AHP weights were assigned and calculated using Microsoft Excel in this study. The process of assigning weights of relative importance is referred to as "standardization of criteria" (Prakash 2003, cited in Feizizadeh & ZBlaschke, 2013).

The hierarchical structure of AHP comprises a defined study goal, suitability objectives informed by societal preferences, criteria, sub-criteria, weights, constraints, and alternatives for decomposing and addressing complex problems with far-distant implications (Al-shalabi et al., 2006; Akinci et al., 2013; Babalola & Busu, 2011; Azizi, Malekmohammadi, Jafari, Nasiri, & Amini Parsa, 2014). Criteria selection and subsequent weight assignment, using AHP, are described to be the most crucial process involved in land suitability analysis (Baseer et al., 2017). The AHP technique has made heterogeneous geospatial and non-geospatial data integration into GIS-based suitability analysis easily attainable (Wang, Qin, Li, & Chen, 2009; Al-Hanbali et al., 2011; Feizizadeh & Blaschke, 2013; Mishra, Deep, & Choudhary, 2015). Al-shalabi, Mansor, Ahmed, & Shiriff (2006) describe the AHP technique as a "comprehensive, logical and structural framework," which allows policymakers to understand the tradeoffs among objectives and criteria of a complex problem. Others described the process as a "robust structured approach" for suitability analysis (Charabi & Gastli, 2011). I provide a detailed review and a summary table of GIS/MCDM (AHP) applications in different disciplines and places of study (see Tables 1-2-Appendix B).

In this study, the assignment of suitability weights applies a mixed-approach of using stated public preference (from an opinion survey, described below) combined with expert judgment guided by data-driven scientific evidence regarding the various indicators/subcriteria. The stated public preference derived from the survey data, completed by Gambians, provides the analysis with a clear understanding of the relative importance of various sub-criteria and suitability objectives used in this study (see Table 2.1). Assigning the suitability weight factors to the indicators in Table 2.1 below is informed by public preference from my survey results. For example, public opinion shows that land-use conversion to a new city (developed area) must not include forested areas; instead, they prefer barren land. Suitability indicators with tremendous public support were weighted high than those with a divided or less public agreement. The expert judgment component can be viewed as subjective, given that experts are also liable to unintentional biases and have opinions and value propositions. However, both the weighting and scoring exercises were evidence-based and objectively driven. A predetermined set of national development policy objectives specified below informed the process. The scoring was not independently carried-out by me but also with a graduate student[8] who joined the project to fulfill a semester-long final class assignment in a Remote Sensing course.

Table 2.1. Pairwise Comparison Matrix (inspired by Saaty 1980)

Sub-criterion	**Ranks**	**Weights**	**Level of Suitability**
Land Use Land Cover	9	0.08	Extremely importance

[8] *Andrew Van Eps, Master of Geographic Information Science*

Elevation (DEM)	9	0.08	Extremely importance
Accessibility to Major Pop. Centers	8	0.07	Very to extremely strong importance
Reduce Flood and Disaster Risk	8	0.07	Very to extremely strong importance
Reduce Urban Congestion	8	0.07	Very to extremely strong importance
Security (Distance to the Border)	7	0.06	Very strong importance
Land Value (compensation)	7	0.06	Very strong importance
Electricity Network	6	0.05	Strong to very strong importance
Health Care Facilities	6	0.05	Strong to very strong importance
Senior Schools	6	0.05	Strong to very strong importance
Reduce Poverty	5	0.04	Strong importance
Minimize Unemployment	5	0.04	Strong importance
Temperature	5	0.04	Strong importance
Land Ownership	4	0.04	Moderate to strong importance
Proximity to Airport	4	0.04	Moderate to strong importance
Proximity to Banjul	4	0.04	Moderate to strong importance
Slope (landscape)	4	0.04	Moderate to strong importance
Precipitation intensity	3	0.03	Moderate importance
Soil (dominant type)	2	0.02	Equal to moderate importance
Hydrological flow (CTI)	2	0.02	Equal to moderate importance
Proximity to seaport	1	0.01	Equal importance
Total	113	100%	

2.3.5 Objectives-oriented Comparison (OOC)

Objectives-oriented comparison (OOC) is a subset of the AHP technique. It involves the specification of clear suitability objectives before the decision analysis step. The OOC method helps to reduce inconsistencies and enhance consensus building in assigning weights (Basnet et al., 2001). Using the OCC method is quite essential, especially when there are competing priorities with different tradeoffs. The approach also enhances the transparency of the decision-making process. The suitability objectives set for this study were informed by development priorities outlined by various national policies and strategies documents. These include the new National Development Plan (NDP, 2018-2022) (Government of The Gambia, 2017), the National Climate Change Policy (Urquhart, 2016), the Parks and Wildlife Policy (Parks and Wildlife Policy Gambia, 2013), the Forest Sub-sector Policy (Forestry Sub-Sector Policy Gambia, 2010), and the National Adaptation Programs of Action (NAPA Gambia, 2007). I exercised the selection of policy objectives used in this study, and the public was consulted to state how important they considered the relevance of each of the policy objectives proposed and used in the decision-making analysis (see Table 2.2).

Table 2.2. Policy objectives specified for supporting the AHP weighting and scoring processes

Goal	Criterion	Obj. No.	Ranking/Policy Objective
Identify the Most Suitable Site for Building the next capital city	Site Availability	*1.*	*The new capital city should be ~5 times bigger than Banjul; all proposed sites have equal size*
	Topography, Soil & Hydrologic Flow	*2.*	*Avoiding future flood inundation; sites with higher elevation, higher CTI, and lower slope values received higher scores*
	Climate & Weather	*3.*	*Avoiding warmer sites and sites with higher rainfall intensity and severity; regions with higher values received the lower scores*

Socioeconomic	*4.*	*Improving the socio-economic conditions of all Gambians; sites with higher poverty and unemployment rates are given higher scores while sites with more infrastructure (e.g., schools, health facilities) are least favored*
Demographic	*5.*	*Reducing urban congestion; sites with higher population density received lower scores*
Land Ownership	*6.*	*Avoiding massive displacement of current residents; sites likely to be privately owned received lower scores*
Land Cover	*7.*	*Preventing ecological losses; sites with the biggest forest area, wetlands, and water bodies received lower scores, followed by urban areas (due to higher cost involved in compensating current owners)*
Total Land Value	*8.*	*Least cost to the government, society, and the environment; the cheapest site has the highest score*
Disaster Risk	*9.*	*Minimizing anthropogenic and natural risk factors; sites with higher exposure and vulnerability levels received lower scores*
Infrastructure & Logistics	*10.*	*Reducing logistical costs like existing road infrastructure, distance to move from the current capital city, transportation opportunities along the riverway* *Also considers external threats to security from neighboring Senegal; sites with the least logistical cost received higher scores, and sites closer to the border are least favored*

2.3.6 Data Layers & Sources

For the MCDM component of this study, I gathered several geospatial data from the following sources (see Table 2.3).

Table 2.3. Geospatial Data Layers & Sources

Category	Layer	Description	Format	Source	Date
Landscape	Land Use Land Cover	Remotely sensed data from Landsat 8 Operational Land Imager (OLI)). Three images were used	Raster	(United States Geological Survey (USGS), 2019)	Three images captured on December 4, 11, and 18, in 2018
Soils	Soil types	Dominant soil type (using FAO classification CLASS88	Raster	(Soil and Terrain Database (SOTER), 2008)	2008
Topographic	DEM	Digital elevation model (DEM)	Raster	NASA's Shuttle Radar Topography Mission (SRTM) Watkins, 2019	2019
	Slope	Refers to the slope of the land surface			
Hydrologic	CTI	Compound topographic index (CTI)	Raster	USGS (Verdin, 2017).	
Climate	Temperature & Rainfall estimates	Average maximum annual temperature for each region and yearly average rainfall received in each region	Vector	Department of Water Resources	1981-2016

Demographic	Population density & Migration	Population density (area/square kilometer) for each region. Migration data includes region of birth and region of current residence in The Gambia	Vector	Gambia Bureau of Statistics (census data)	2013
Socioeconomic	Per capita income, poverty, and unemployment rates	For each administrative region in The Gambia	Vector	Gambia Bureau of Statistics (GBOS-IHS, 2016)	2010, 2016, and 2018 respectively
Access	Roads	Road networks, highways, and footpaths	Vector	World Bank	2017
Infrastructure	Schools, health facilities	Senior schools only and all healthcare facilities located in each region of the country	Vector	Ministry of Basic and Secondary Education data acquired via GBOS	2019
Other	Country Boundary	Country boundary showing the administrative regions of The Gambia	Vector	(DIVA-GIS, 2019)	-

2.3.7 Public Opinion Survey

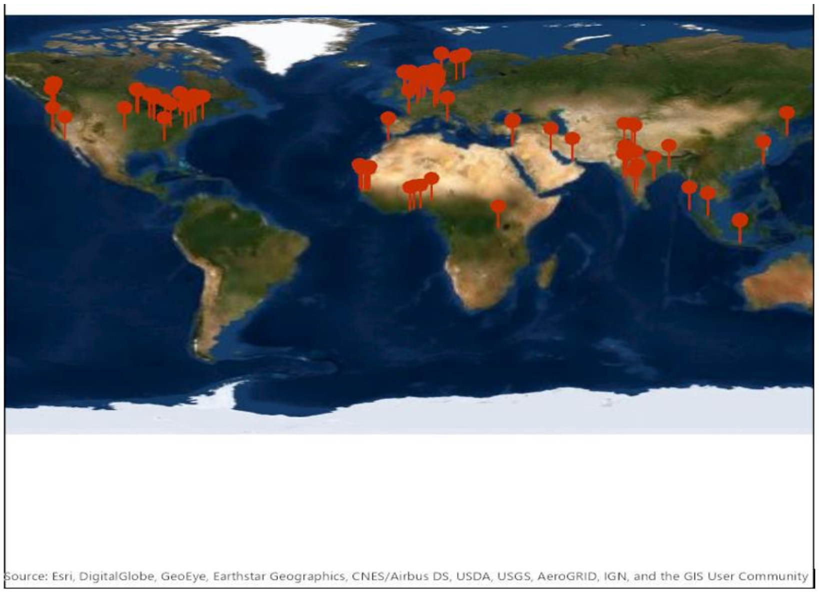
Experts' judgments or public opinions can inform the MCDM analysis. Consulting the public and experts are significant for understanding the value propositions and perceptions of beneficiaries (Bunruamkaew & Murayama, 2011; Bagaram et al., 2016). Some MCDM studies used the Delphi survey or its modified version. Some conducted a literature review, including an analysis of historical data. Other studies consulted experts for providing analytical information on the relative significance of numerous sub-criteria/indicators for attaining the overall suitability objective (Collins et al., 2001; Bunruamkaew & Murayama, 2011).

As part of the methodologies used in this study, I administered a public opinion survey, using both online and one-on-one interview methods. Both survey instruments shared the same sections. Section one focuses on how Gambians agree or disagree with the need to develop a new capital city for the country. They were also asked to select a region of their choice for the new city development. Section two asks how respondents agree or disagree with the proposed national development/suitability objectives stated in Table 2.2 above. The last section collected data on respondents' socioeconomic and demographic characteristics—see the survey instrument in Appendix F.

Data collection started on January 20, 2020, and lasted for six weeks. Target respondents include experts from the public service, private sector employees, civil society members, students, market women in The Gambia as well as Gambians living in the diaspora. Two eligibility checks or constraints were included to control the online survey participation and enhance data accuracy. First, the respondent must be a Gambian resident and national. Second, they must have at least completed high school. The latter condition was applied to make sure that respondents taking the survey have a clear comprehension of the questionnaires. To compensate for omitting Gambians without high school certificates, I narrowed the one-on-one interviews to people without a high school certificate, including those who have never attended school in urban and pre-urban settlements. Four undergraduate students from the University of The Gambia administered the survey. The rural population could not be reached due to the cost implication of transporting interviewers. However, rural opinion was not entirely missing, as 6% (24 people) of the total online responses came from people currently dwelling in the rural Gambia. Overall, the survey is reasonably but not wholly representative of the national population. It favorably represents the views of a predominately young-educated community of Gambians (see the Results section below).

Over 500 responses were received, including 315 online respondents and 200 in-person interviews (~93% completion rate). On the one hand, Gambians completed the online questionnaires from all administrative regions and in the diaspora (see Map 2.5). On the other side, the one-on-one interviews concentrated mainly in urban and pre-urban areas. As stated above, the survey results were instrumental for the decision analysis and especially useful for assigning weights and scores to the sub-criteria based on their relative importance (i.e., percent of public agreement with various objectives/indicators).

Map 2.5. Locations of Survey Respondents



2.3.8 Sensitivity Analysis

Some scholars recommend conducting a sensitivity analysis in GIS-based MCDM studies (Abdullahi et al., 2014). The objective is to "investigate the effect of change in criteria preferences on the alternatives." (Abdullahi et al., 2014). Including a sensitivity analysis in this study has generated sets of subcriteria or policy objectives, which, when re-prioritized, may qualify an unselected candidate site over a selected one (see result section).

2.4 Data Analysis & Preliminary GIS-based Results

2.4.1 Land and Soil Indicators

2.4.1.1 Land-use Land Cover (LULC)

I used Landsat 8 (OLI) satellite data for conducting a land-use land cover (LULC) classification for the entire country. I applied a supervised classification approach using the maximum likelihood (ML) algorithm. The ML classifier calculates the probability that a given pixel belongs to a specific class and assumes that the statistics for each class in each band are normally distributed (Al-Hanbali et al., 2011). ML is the most widely used supervised classification method in remote sensing (Neware, 2019). The Landsat images were classified into seven LULC classes. I provide a detailed description of each class category in Table 2.4. LULC results find that only 6% of the total land area has been discovered to be forested (open and closed forest parks). Figure 2.5 details the proportion of the total LULC type by region in The Gambia. A key point to take note is that, given that the satellite data was captured after the harvesting period (December 2019), a more significant proportion of bare soil sites are possibly agricultural lands.

Table 2.4. LULC Class Description

Class	Description
Grassland/Shrubland	It includes bush and scrubs; some of these areas suffered from ongoing deforestation. These areas have less than 10% tree cover or tree heights less than 11 meters
Bare Soil	It includes ground around buildings, unpaved roads, beach sand, some agricultural land, and barren soil along the River Gambia.
Planted/ cultivated	It includes orchards (e.g., cashew and mango plantations), some planted forest areas, and horticultural gardens.
Wetlands & mangroves	It includes wetlands, mangroves, other forest types situated in wetlands and along The River Gambia.
Settlements/ Developed	It includes houses and developed surfaces such as industries. The class consists of some bare grounds within communities.

Forested	It includes all closed and open forest areas with an estimated tree cover of 50% or more (canopy density)

Figure 2.4. Share of Total Land Area by Land-use Land Cover (LULC) Type (Country-wide)

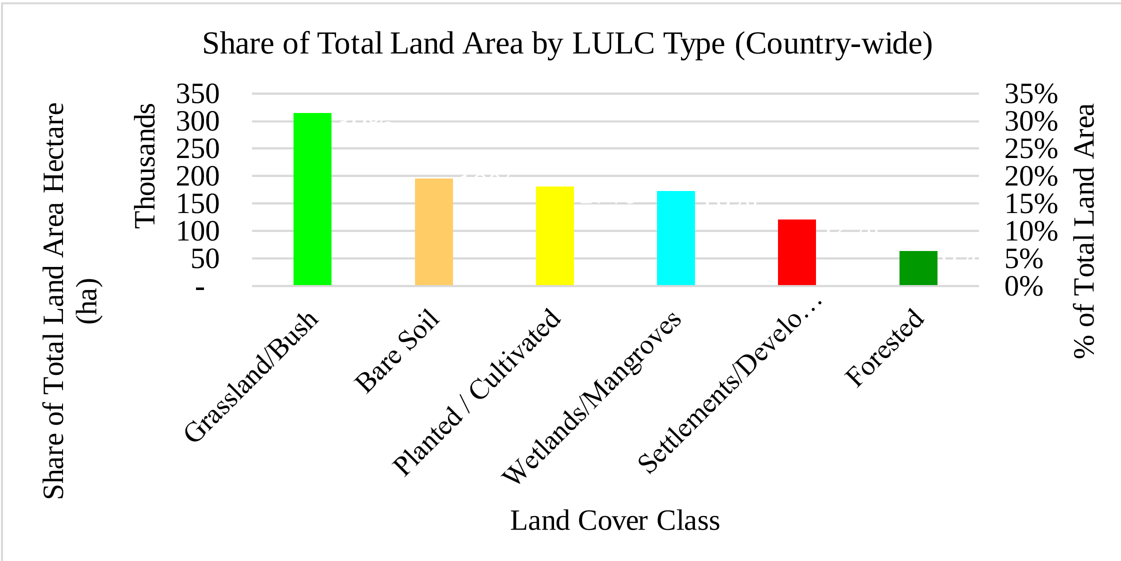
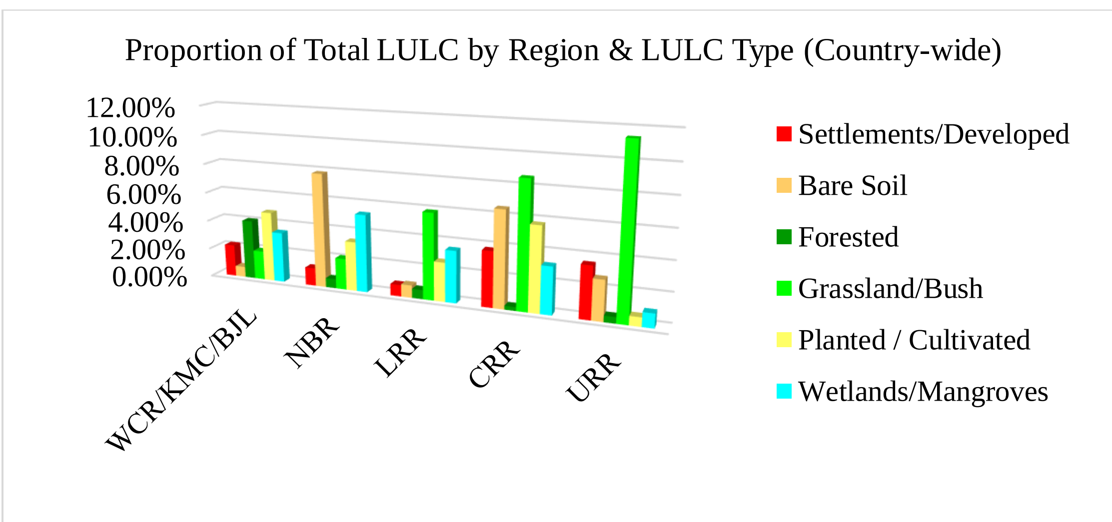
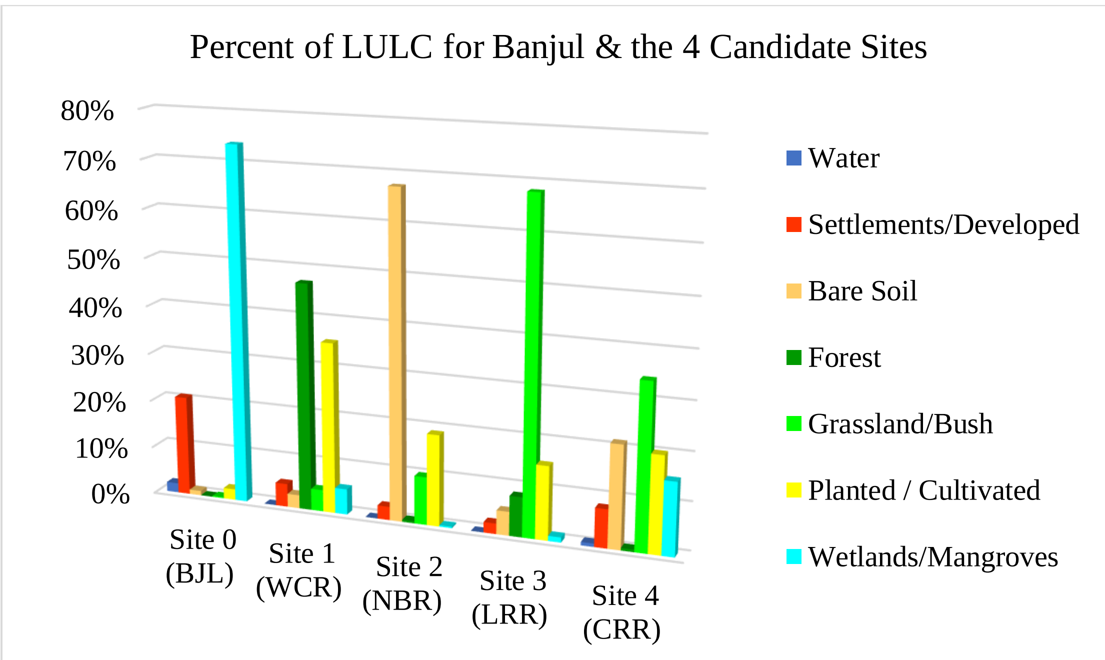


Figure 2.5. The proportion of Total Land-use Land Cover (LULC) by Region (Country-wide)



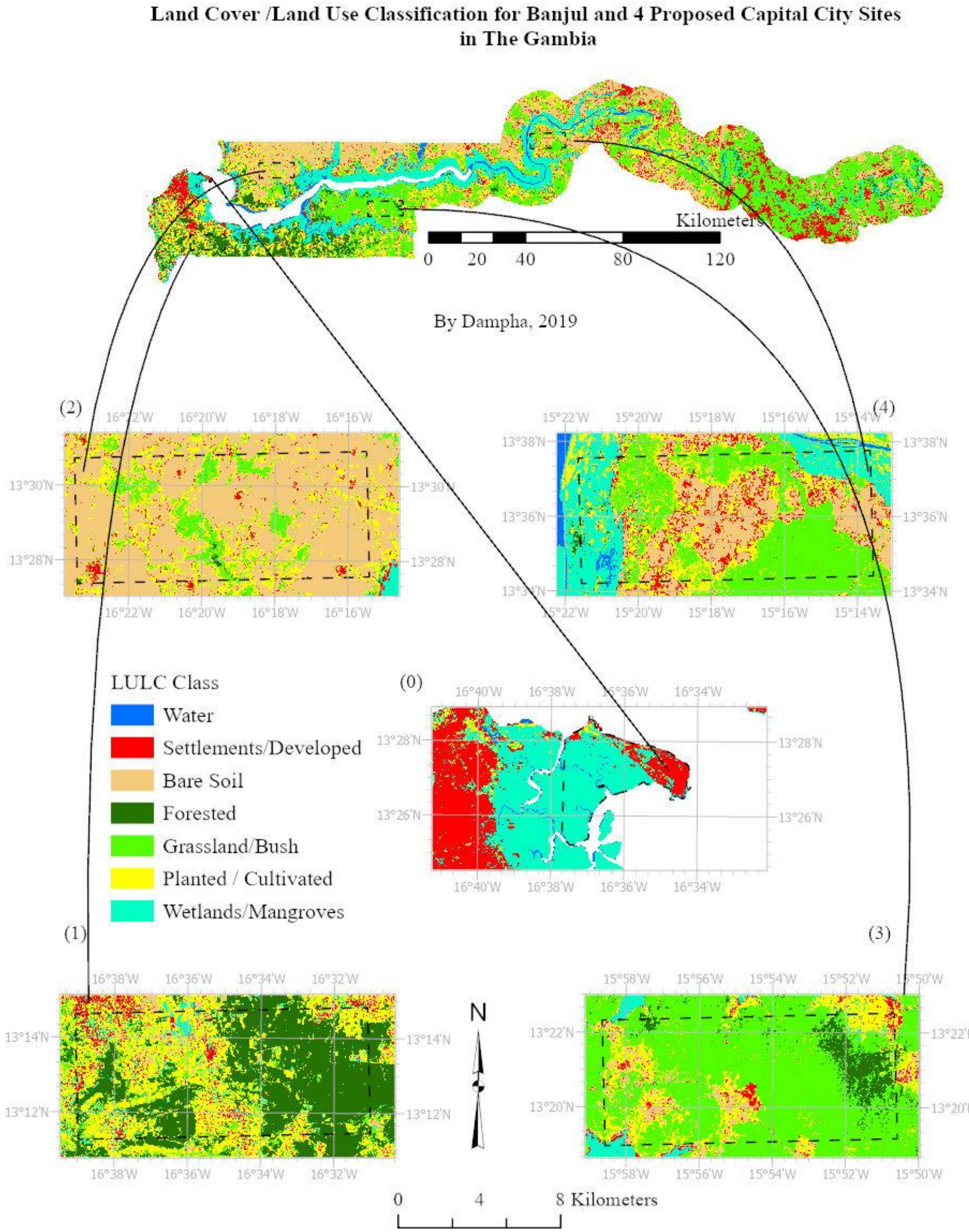
The classified LULC types significantly vary across the four candidate sites in various regions (see Map 2.6). In Banjul (site 0), the map shows that wetlands and mangroves cover nearly 74% (1,377 ha) of the area, while human settlements or developed areas represent approximately 21% (388ha) of the total area. In comparison to the proposed candidate sites, LULC types differ in varying ways. Site 1 in the West Coast Region (WCR) has 47% of open and closed forest areas and 35% of agricultural land. Site 2 in the North Bank Region (NBR) is mostly bare soil (68%) and 19% cultivated area. Site 3 in the Lower River Region (LRR) is mostly grassland (68%). Site 4 in the Central River Region (CRR) has 34% area as grassland (see Figure 2.6).

Figure 2.6. Percent of Land-use Land Cover (LULC) by Proposed Candidate Sites and Banjul

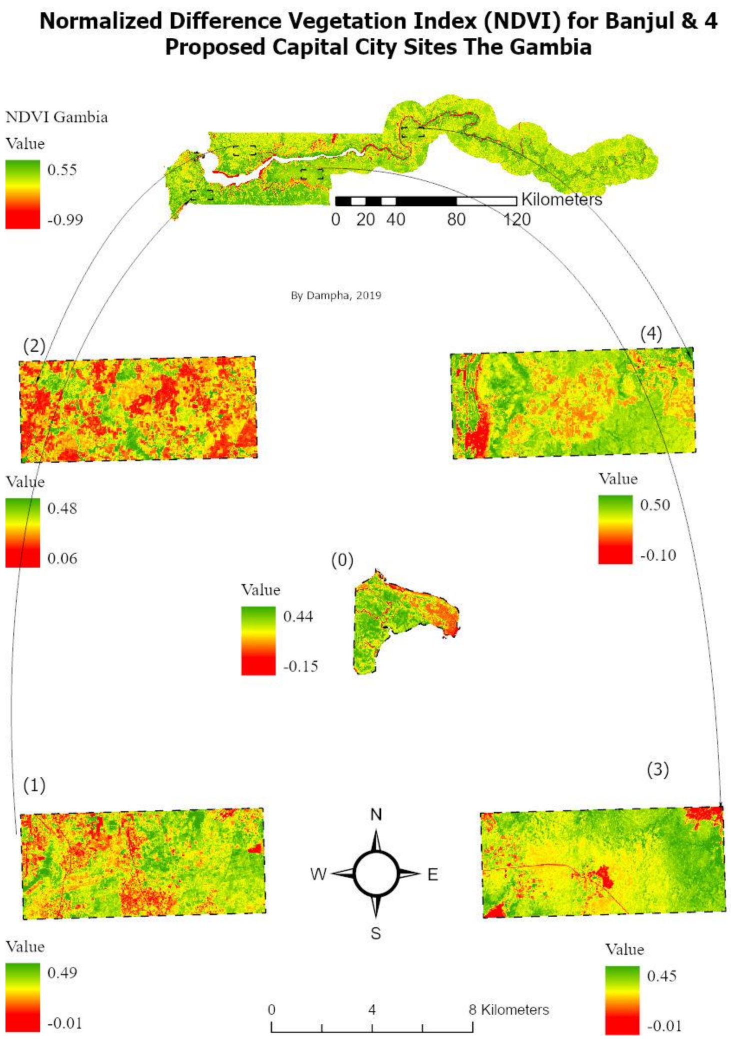


I also used the Normalized Difference Vegetation Index (NDVI) as a way of comparing my LULC classification results. I used the unclassified Landsat image to calculate the NDVI values (see Map 2.7). I further estimated the NDVI for each site using two different value ranges (NDVI value >0.2 and NDVI value >0.3) (see Map 2.8). Higher NDVI values show greener and healthier vegetated areas. Using an NDVI value greater than 0.2, I show similar results between sites 1 (WCR) and 3 (LRR). When I increased the NDVI value to greater than 0.3, the results better identify the site with the healthiest vegetation cover, which turns out to be site 1 (see Figure 2.8 below).

Map 2.6. LULC Classification for Banjul and the Candidate Sites



Map 2.7. NDVI Values



Map 2.8. NDVI >0.3

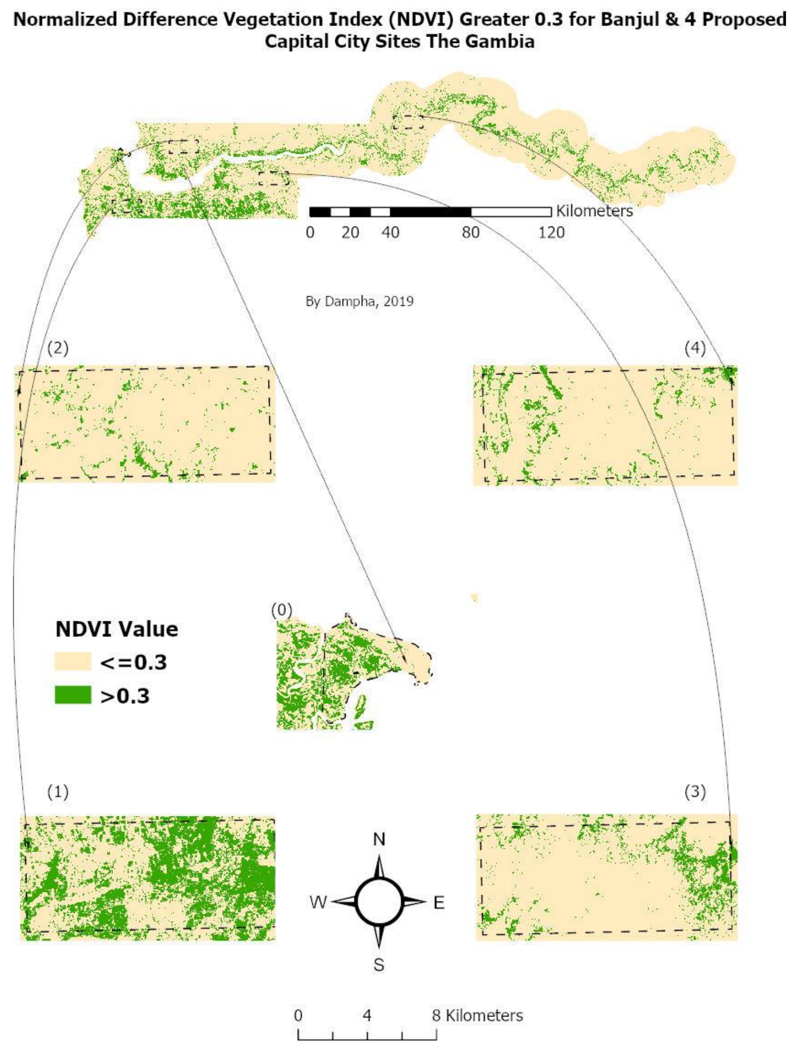
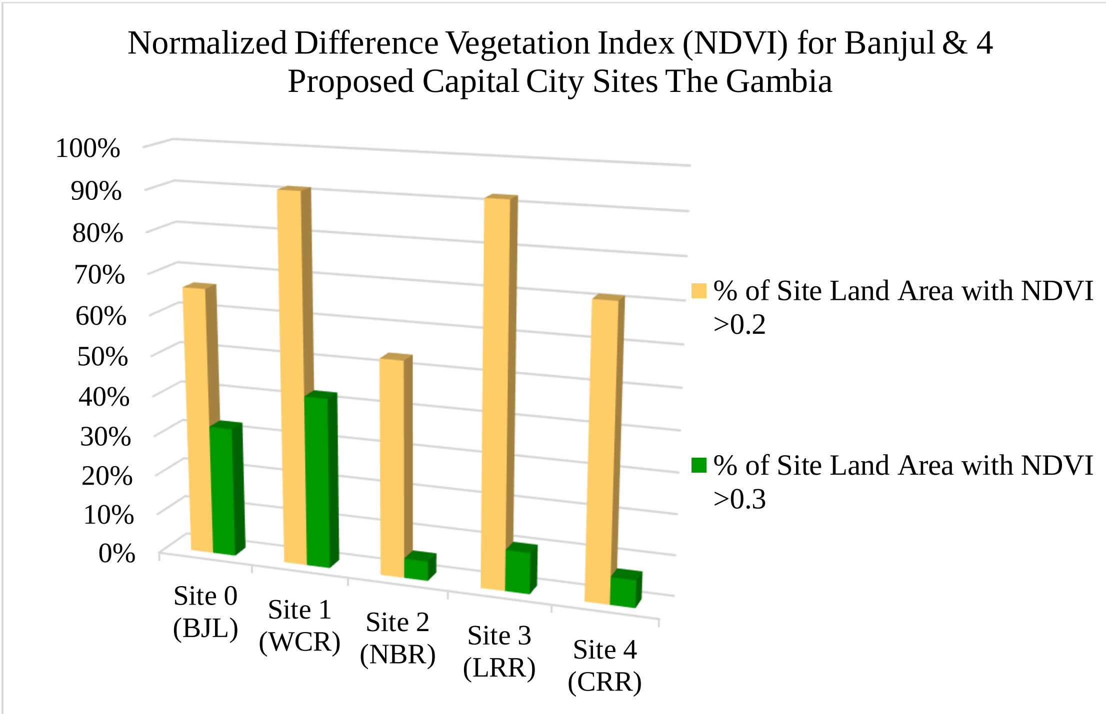


Figure 2.7. NDVI for Banjul & the 4 Proposed Candidate Sites



2.4.1.2 Land Value

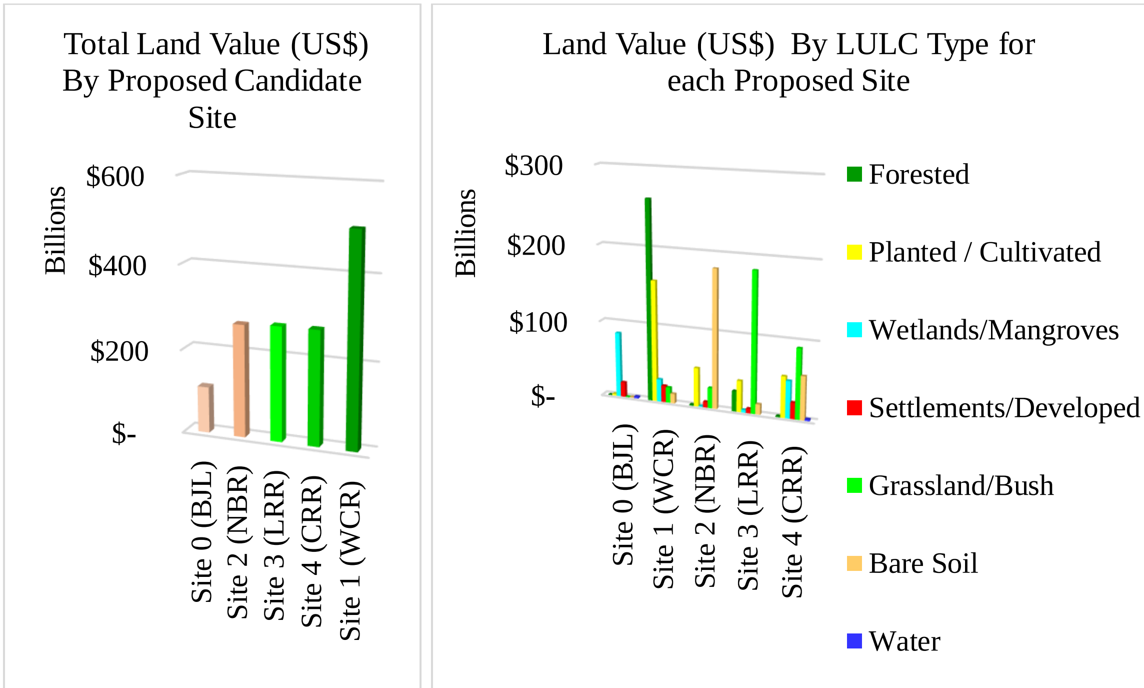
I determined the land value based on the market price per pixel. The price is the average current price for a 30X30m (900sqm) area of land, equivalent to the pixel size of Landsat 8. The price data was mined from DEKA, a company storing and sharing data on land prices in The Gambia (DEKA, 2020). A 900 square meter (i.e., 0.09ha) of land costs approximately US$5000 in the West Coast Region (DEKA, 2020). Using this information, I weighted the potential price differences for the various LULC types. Considering the socio-economic and ecological significance of forests, mangroves, and wetlands to both humans and other species, I reasonably adjusted the standard market price of a pixel land (US$5000) by 20% to account for important ecosystem service values, including those of forest products (e.g., the value of timber). The difference in land value between urban and rural areas was also considered. I used the standard average market price for estimating the land value of all other LULC types in the metropolitan regions (WCR & BJL), except for ecologically significant ones, including mangroves, forests, wetlands, and water bodies. Also, given that rural agricultural land is a sine qua non for ensuring food security and food sovereignty, especially for the rural dwellers, I refused to use the current value of the same area (900sqm) of land in rural areas. Instead, I used 60% of the urban land price per pixel for assessing the market value of candidate sites in rural areas. In a nutshell, a pixel value of land is estimated at US$3000 (D147,000) in sites 2,3, and 4 (rural areas), compared to US$5000 (D343,000) for an equivalent size in sites 0 and 1 (urban areas) (see Table 2.5.)

Table 2.5. Land Value of 900 Square Meters (0.09ha)in US Dollar & Gambian Dalasi for the two main LULC Categorization

Land-Use Land Cover (LULC) Type	**Land Value/pixel in BJL & WCR**		**Land Value/pixel in NBR, LRR, & CRR**	
	US$	GMD	US$	GMD
Forest/Wetland/Mangrove/Water	6,200	303,800	3,600	176,400
All Other LULC Types	5,000	245,000	3,000	147,000

The land value results show site 1 as the most expensive location (approximated at US$ 500 billion) when compensations for land acquisitions are paid, and ecological benefits are accounted for conservatively. On the left-hand side of Figure 2.8, I present the total land value for each candidate site in Figure 2.8. I also provide the land value for each cover type in all five locations (0,1,2,3,4), on the right-hand side of Figure 2.8.

Figure 2.8. Total Land Value/Site (left side) Land Value by LULC Types/ Site (right side)



2.4.1.3 Land Ownership

A dual land tenure system (i.e., statutory and customary) has existed in The Gambia since the colonial eras. According to Bensouda et al., (2013), the "statutory system" governs the freehold and leasehold titles, based on English law, while the "customary system" involves the application of traditional practices of the indigenous communities in managing land-use and transferring ownership rights. The three common land tenure systems in The Gambia include freehold, leasehold, and customary. For more on land governance structures in The Gambia, read Bensouda et al., (2013).

Data on land ownership is not publicly available. However, the State Lands Act (1991) provides some substantial details regarding land ownership rights. The Act empowers the Minister of Lands to designate any regional land as state land. It declared that "all land in the area shall, excluding such land as is held in fee simple, vest in and be administered by the State for the use and common benefit, direct or indirect of the community in which the land is situated" (Bensouda & CO LP, 2013). What this means for building a new capital city is straight-forward. The state has the authority to cede any piece of land for public use. Although, the notion of 'just compensation' of conceding privately-owned land is not explicitly stated. But compensation of surrendered plots of private properties ought to be considered by the state. In The Gambia, land in urban areas (sites 0 and 1) is more likely to be privately-owned compared to rural areas (sites 2, 3, and 4) where communal landownership is predominantly common. Therefore, the government may offer more compensation to privately-owned land than to trustees of communal or family-owned plots.

I factored landownership in the multicriteria decision-making score matrix, using the above details (see Table 2.9 below). Assuming that compensation for communal land will be less expensive compared to privately registered property, sites (2, 3, and 4) in the rural areas receive relatively higher suitability scores.

2.4.1.4 Soil Type

An analysis of this sort requires an understanding of the geomorphological characteristics of the study areas. I analyzed data on the dominant soil class(es) for each proposed site. The data was "derived from the 1:1 million scale Soil and Terrain Database for the region (SENSOTER, ver. 1.0) and the ISRIC-WISE soil profile database, using standardized taxonomy-based pedo-transfer (taxo-transfer) procedures(Batjes, 2008). According to Baties (2008), all profiles in SENSOTER were characterized according to the Revised Legend of FAO (1988) and World Reference Base for Soil Resources (FAO 2006). For more on the soil data acquisition details, read Baties, 2008. I present a brief description of the various dominant soil profiles in The Gambia for easy reference (see Table 2.6). Additional details are found in FAO (1988). The dominant soil classes found in my study areas include; Ferric Acrisols (ACf), Umbric Gleysols (Glu), Eutric Gloysols (GLe), and Dystric Regosols (RGd). Overall, the primary soil type in The Gambia is ACf. ACf also dominates 100% of soil cover in the candidate site 2 (NBR), 95% in site 3 (LRR), and about 10% in site 4 (CRR). The ACf soil type has characterized elements of 'very acid,' 'iron accumulation' and 'connotative of ferruginous mottling' (FAO, 1988).

The second dominant soil class found in the study areas, specifically in site 4 (CRR), is Dystric Regosols (RGd). RGd is described as ill, infertile, dystrophic, and connotative of low base saturation (FAO, 1988). In sites 1 (WCR) and 3 (LRR), there is a mixture of ACf and Eutric Gloysols (GLe) soil types. Nearly 40% of site 1 is GLe. According to FAO (1988), GLe soil class is 'good, eutrophic, fertile, and connotative of high base saturation. This soil type supports the massive cultivated activities discovered in the WCR, as evident by the NDVI values. Finally, in Banjul (Site 0) and some parts of CRR (site 4), the dominant soil type is Umbric Gleysols (GLu). The GLu soil type has the characteristics of a mucky soil mass, connotative of an excess of water. I include a soil map layer showing the dominant soil type in each proposed candidate site (see Map 2.9).

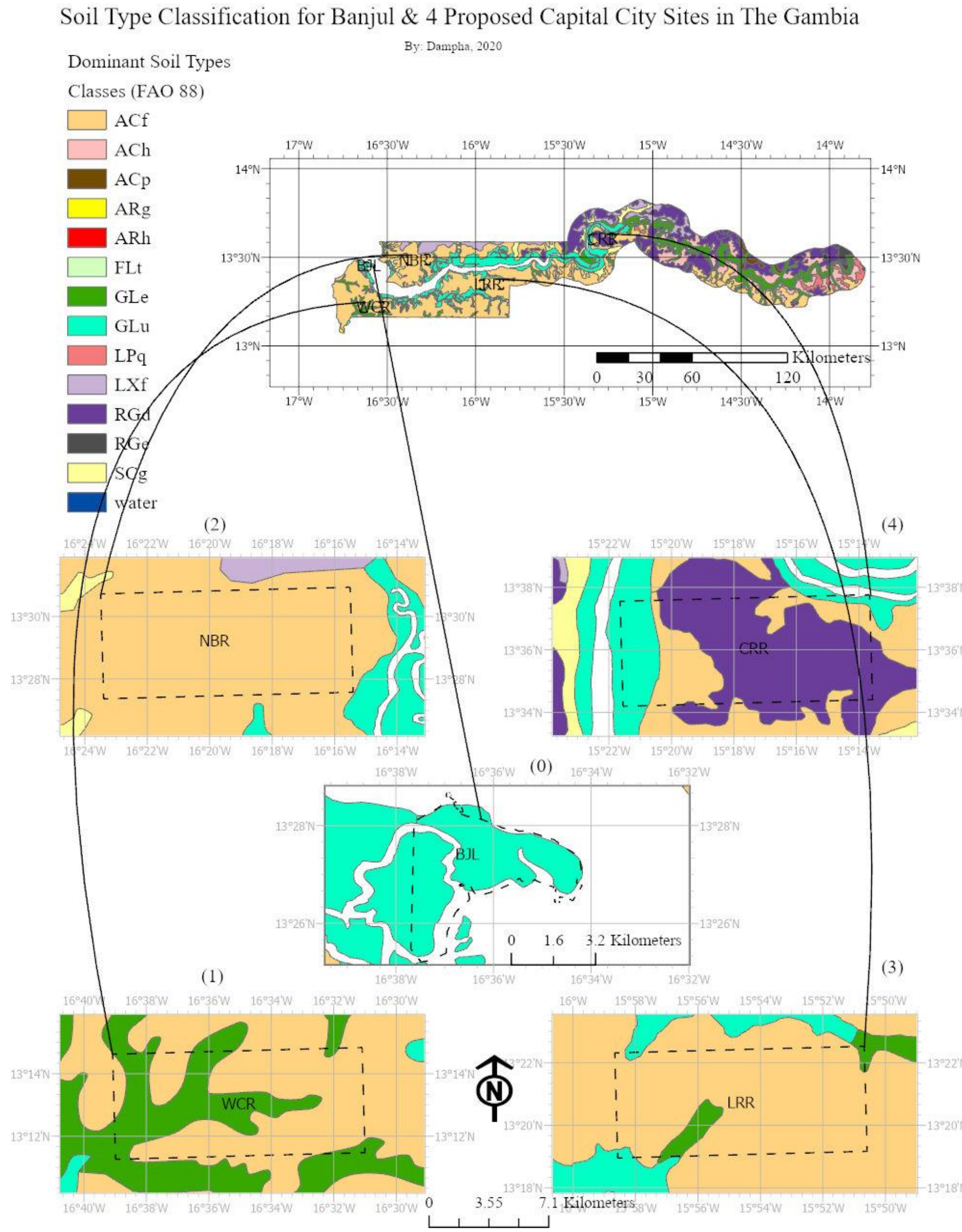
I included the soil information in the multicriteria decision-making score matrix, using the evidence on dominant soil types and their properties (see Table 2.9 below). Sites (1 and 2) largely covered with the ACf soil class receive more scores than sites with other soil classes. For example, the ACf soil has properties that can solidly support infrastructural development than GLu and GLe soil classes.

Table 2.6. Description of Dominant Soil Naming Groups (FAO, 1988, Classification)

FAO Class 88	**Description of Acronyms**	**Elements Used in Naming Major Soil Groupings Level I**	**Elements Used in Naming Major Soil Groupings Level II**
ACf	*Ferric Acrisols*	*Acrisols: very acid; connotative of low base saturation*	*Ferric: iron; connotative of ferruginous mottling or an iron accumulation*
ACh	*Haplic Acrisols*		*Haplic: connotative of soil with a sample normal horizon sequence*
ACp	*Plinthic Acrisols*		*Plinthic: brick; connotative of mottled clay materials which harden irreversibly upon exposure*

ARg	*Gleyic Arenosols*	*Arenosols: sand; connotative of weakly developed coarse-textured soils*	
ARh	*Haplic Andosols*	*Andosols: dark surface horizon; connotative of soils formed from materials rich in volcanic*	
FLt	*Thionic Fluvisols*	*Fluvisols: river; connotative of alluvial deposits*	*Thionic: sulfur; connotative of the presence of sulfidic materials*
GLe	*Eutric Gloysols*		*Eutric: good eutrophic, fertile; connotative of high base saturation*
GLu	*Umbric Gleysols*	*Gleysols: mucky soil mass; connotative of an excess of water*	*Umbric: town; connotative of waste disposal*
LPq			
LXf	*Ferric Lixisols*	*Lixisols: washing; connotative of clay accumulation*	
RGd	*Dystric Regosols*		*Dystric: ill, dystrophic, infertile, low base saturation*
RGe	*Eutric Regosols*	*Regosols: blanket; connotative of a mantle of loose materials overlaying the hard core of the earth*	
SCg	*Gleyic Solonchaks*	*Solonchaks: silty and chak*	*Gleyic: mucky soil mass*

Map 2.9. Dominant Soils Types in The Gambia



2.4.2 Topographic & Hydrologic Indicators

2.4.2.1 Digital Elevation Model (DEM) & Percent Slope

I used data from NASA's Shuttle Radar Topography Mission (SRTM) for the digital elevation model (DEM) (Watkins, 2019). SRTM is a publicly available high-resolution DEM (Shortridge, 2006) and is the most comprehensively available DEM data. The data has been used globally to assess impacts or evaluate threats. These include effects projected from global mean sea level rises, storm surges, fluvial and coastal flooding (Hofton, Dubayah, Blair, & Rabine, 2006; LaLonde, Shortridge, & Messina, 2010; Shortridge, 2006; Shortridge & Messina, 2011).

Like many other studies, I used SRTM-DEM data with 10m contour intervals to show the surface elevation of The Gambia with an 'eye' on the study sites (see Map 2.10). SRTM-DEM has both 3 arcseconds ("SRTM-3") and 1 arcsecond ("SRTM-1") (Kulp & Strauss, 2016). I used 1-arcsecond resolution (3601x3601 pixels) in a latitude/longitude projection, with the spatial reference of (EPSG:4326) (Watkins, 2019). SRTM DEM is referenced to the Earth Gravitational Model (EGM96) geoid.

SRTM is also considered an unclassified "surface" elevation model (Kulp & Strauss, 2016). This means it constantly overestimates the surface (Shortridge & Messina, 2011). Overall, SRTM DEM introduces positive bias (Kulp & Strauss, 2016; LaLonde et al., 2010; Shortridge & Messina, 2011). According to Shortridge & Messina (2011), "the punctual sample root mean square error (RMSE) was 8.6 m, conforming to previous estimates of SRTM error, but many errors in excess of 50 m were identified." Similarly, Kulp & Strauss (2016) added that "SRTM data are known to include large vertical errors in densely urban or densely vegetated areas."

Using the original SRTM-DEM will significantly underestimate the vulnerability of the country, especially when compared to the global mean sea-level measurement. To minimize its positive vertical error, I conservatively subtracted 2 meters from the original SRTM-DEM to assess vulnerability and evaluate the impacts of future inundations. Correcting for vertical errors makes the results consistent with previous vulnerability assessments (Black et al., 2011; Jallow et al., 1996).

I find a mean DEM height of 1.4m in Banjul. In contrast to the proposed candidate sites, mean DEM estimates include 21m for site 1 (WCR), 31m for site 2 (NBR), 27m for site 3 (LRR), and 17m for site 4 (CRR). I also provide histograms showing the mean, median, and standard deviation of slope distribution for all candidate locations (see Figure 2.9).

Map 2.10. Digital Elevation Model(Meters)

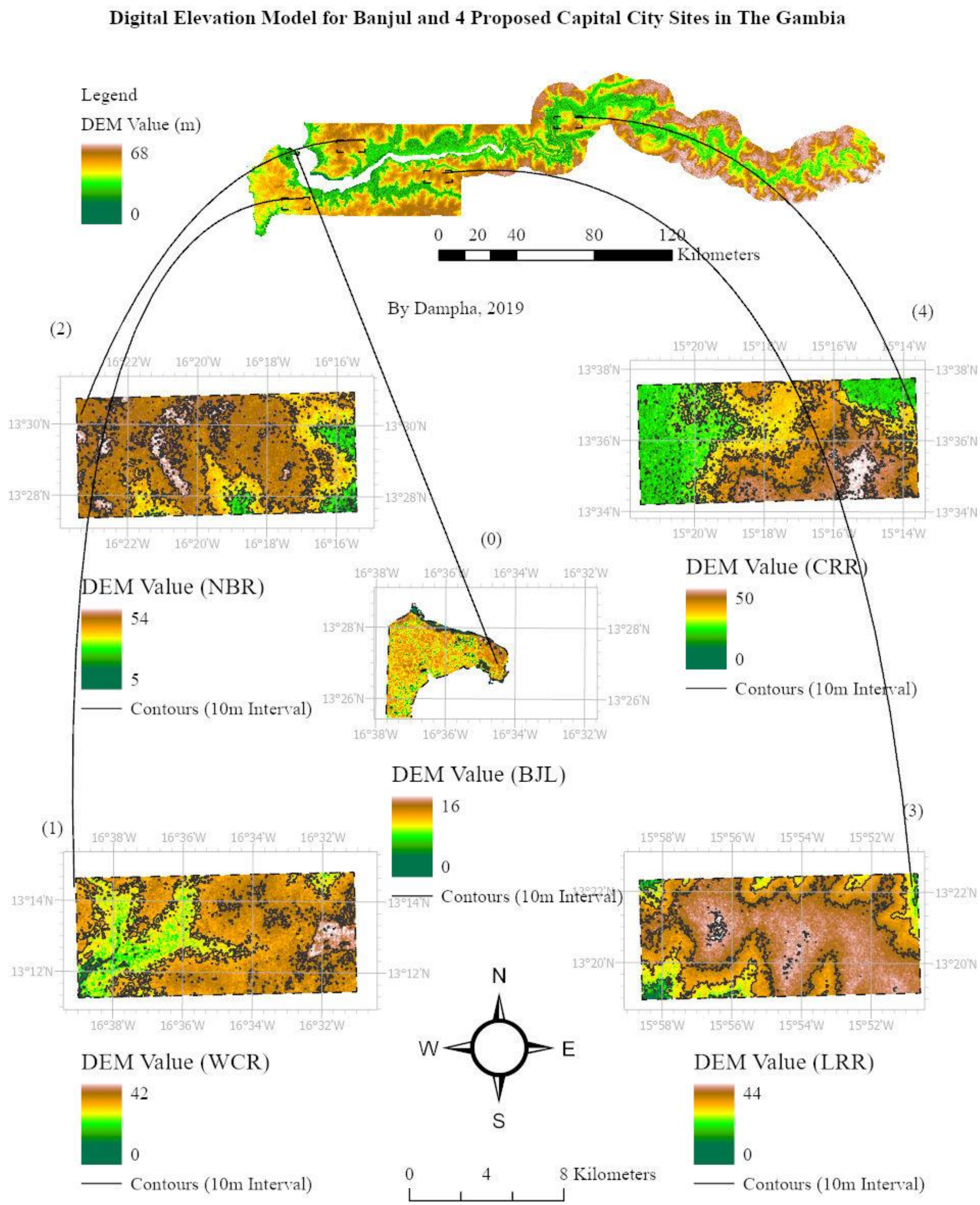
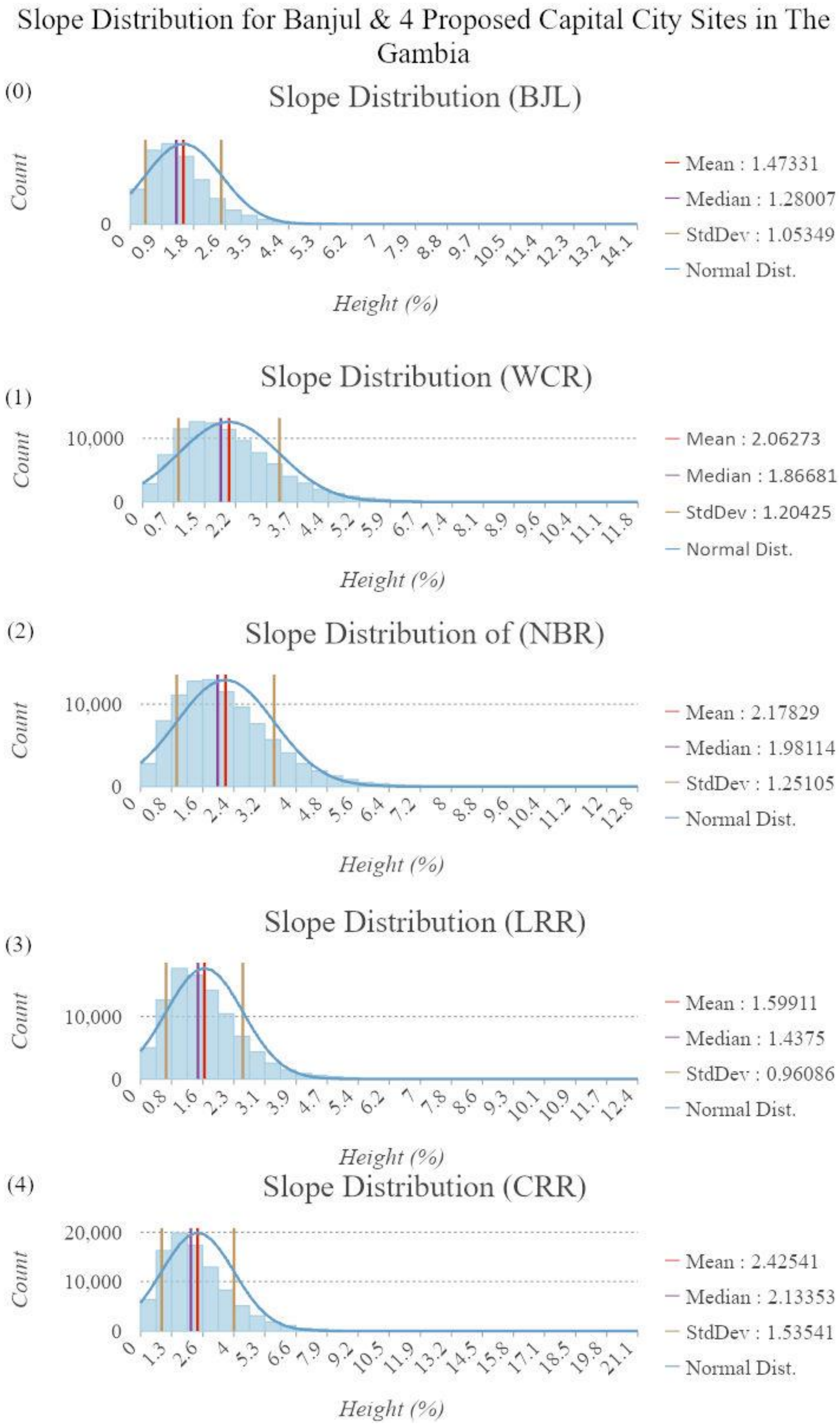


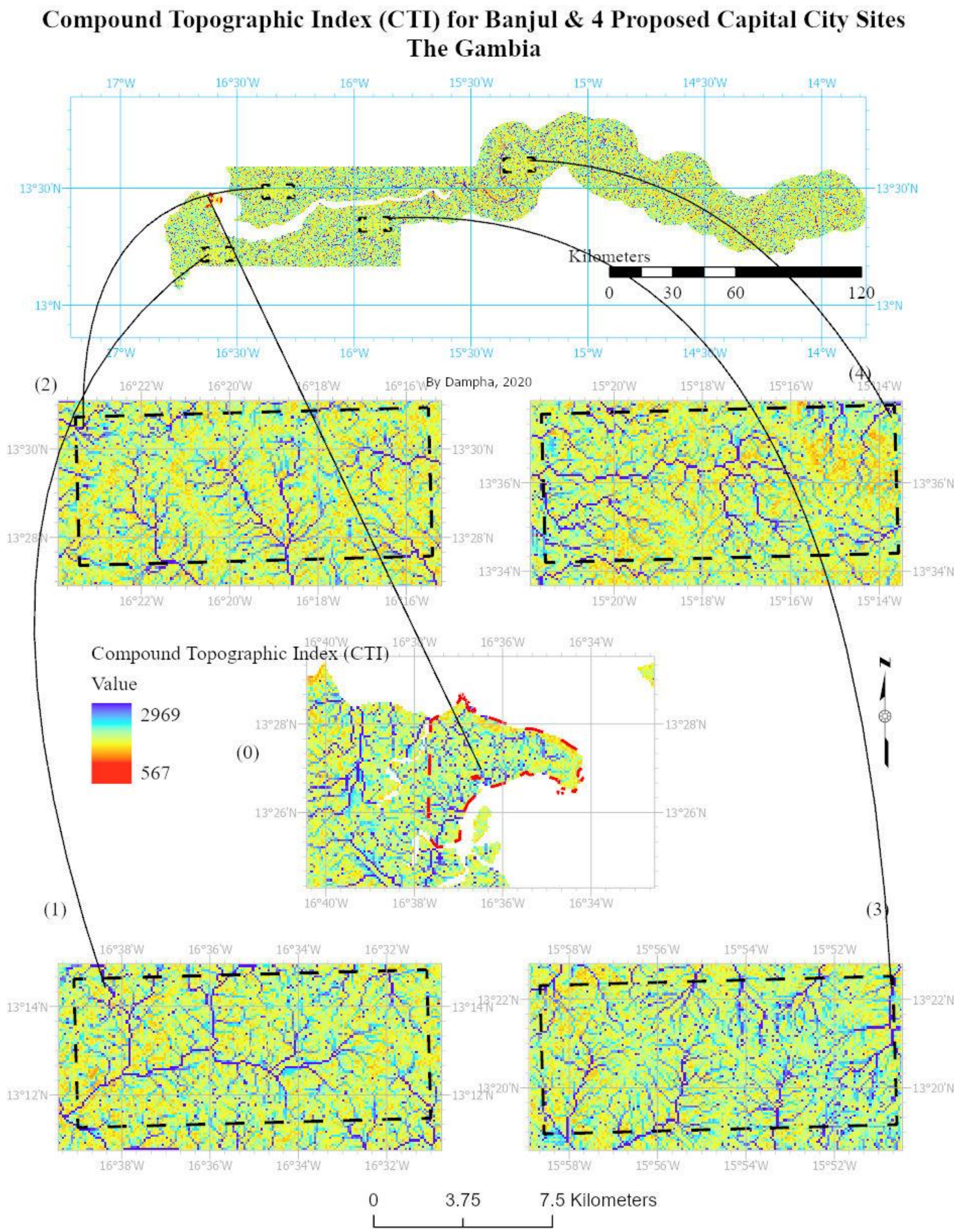
Figure 2.9. Slope Distribution for each Candidate Site



2.4.2.2 Compound Topographic Index (CTI)

A part of the topographic indicators, I also used the compound topographic index (CTI) to provide additional hydrological details. I derived the CTI data for my study area from the USGS. CTI is a steady-state wetness index (also known as Topographic Wetness Index). CTI, according to Yang, Chapman, Gray, & Young (2007), "is a function of both the slope and the upstream contributing area per unit width orthogonal to the flow direction." It is an indicator showing drainage or flow direction of given a landscape. I used CTI in this analysis because of the relative importance of water flow on the natural landscape. This information will help in constructing proper drainage systems or stormwater infrastructure systems in the new city. It can also provide information about the infiltration or percolation conditions of an area. CTI has been proven to be highly correlated with several soil attributes such as horizon depth, silt percentage, organic matter content, and phosphorus (Moore et al. 1993)" (Yang et al., 2007). In the CTI layer, Map 2.11 below, the white lines show flow directions. The higher the CTI value, the bigger the flow accumulation (values are reported in Table 2.9). Amongst the candidate sites, LRR (site 3) has a higher CTI value, hence a suitable location for efficiently facilitating water flow direction and accumulation.

Map 2.11. Compound Topographic Index (CTI)



2.4.3 Weather & Climate Indicators

2.4.3.1 Precipitation & Temperature

Since climate risk and vulnerability are the triggering factors for the proposed city relocation, I incorporated data on weather conditions and climate-related indicators. Climate refers to the mean and variability of relevant weather parameters such as temperature, precipitation, and wind over a specified period (the classical period is 30 years) (Perch-Nielsen, 2004; IPCC, 2007). Weather, on the other hand, is the day-to-day variation in precipitation events and temperature conditions. Long-term climate change events have directly affected weather conditions, especially for countries along the equator, including The Gambia. With a Sahelian tropical climate, The Gambia receives an average annual rainfall of 897mm (see Map 2.12). Daily temperature averages at 28.2° C (see Figure 2.10). Monthly humidity stands at 80% during the rainy season (Drammeh, 2012; UNDP, 2013).

Overall, temperature values and rainfall intensity in The Gambia have been increasing and projected to trend with global warming effects. On average, the eastern parts of the country receive less rainfall, whereas, for temperature, the direct opposite is recorded. Map 2.12 clearly shows climate variability by region. Sites 0 and 1 are mostly favored by temperature conditions (less warm), whereas sites 2, 3, and 4 show increasing maximum temperature values now and in the distant future (see Map 2.12 and Map 2.13). According to the National Climate Communication (2012), "The Gambia will experience an increase in temperatures ranging between 1.1°C and 3.9°C during the period 2030 - 2100" (Second National Climate Communication, 2012).

In contrast to temperature values, precipitation events are relatively higher in sites 0 and 1. For this analysis, increasing precipitation events are unfavorable, given that rainfall intensity can be quite devastating, especially when population density is higher and stormwater infrastructures are inadequate. For more on flood impact and vulnerability in The Gambia, refer to Appendix A.

Map 2.12. Temperature and Rainfall Indicators

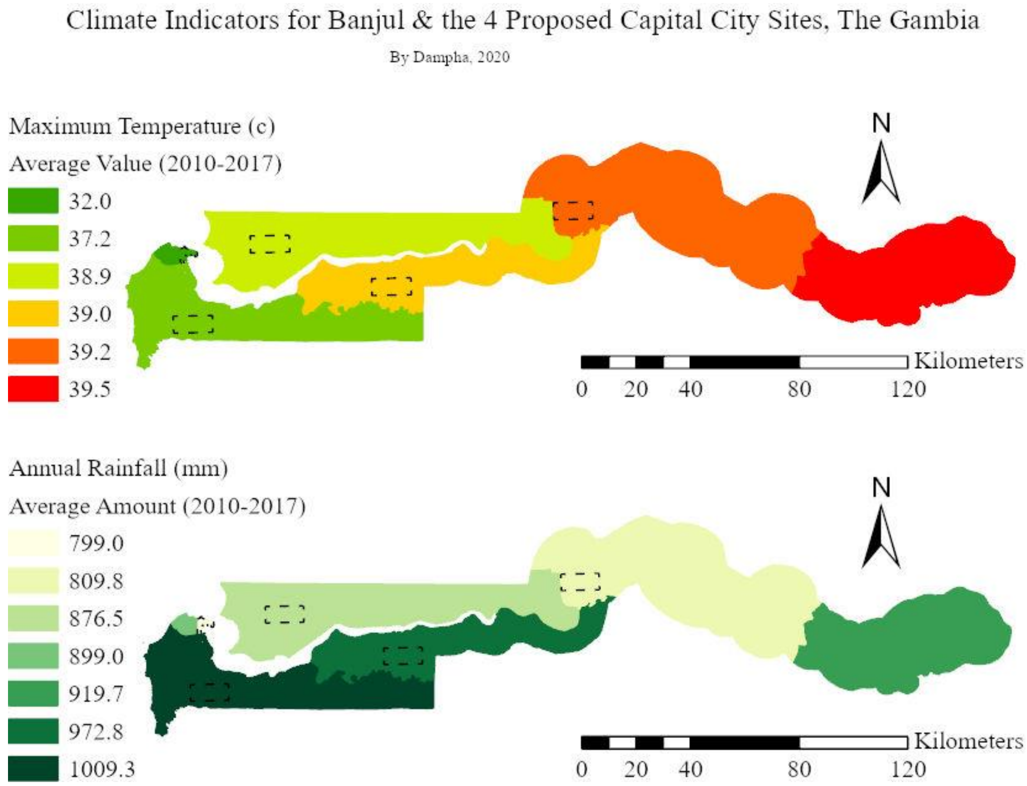
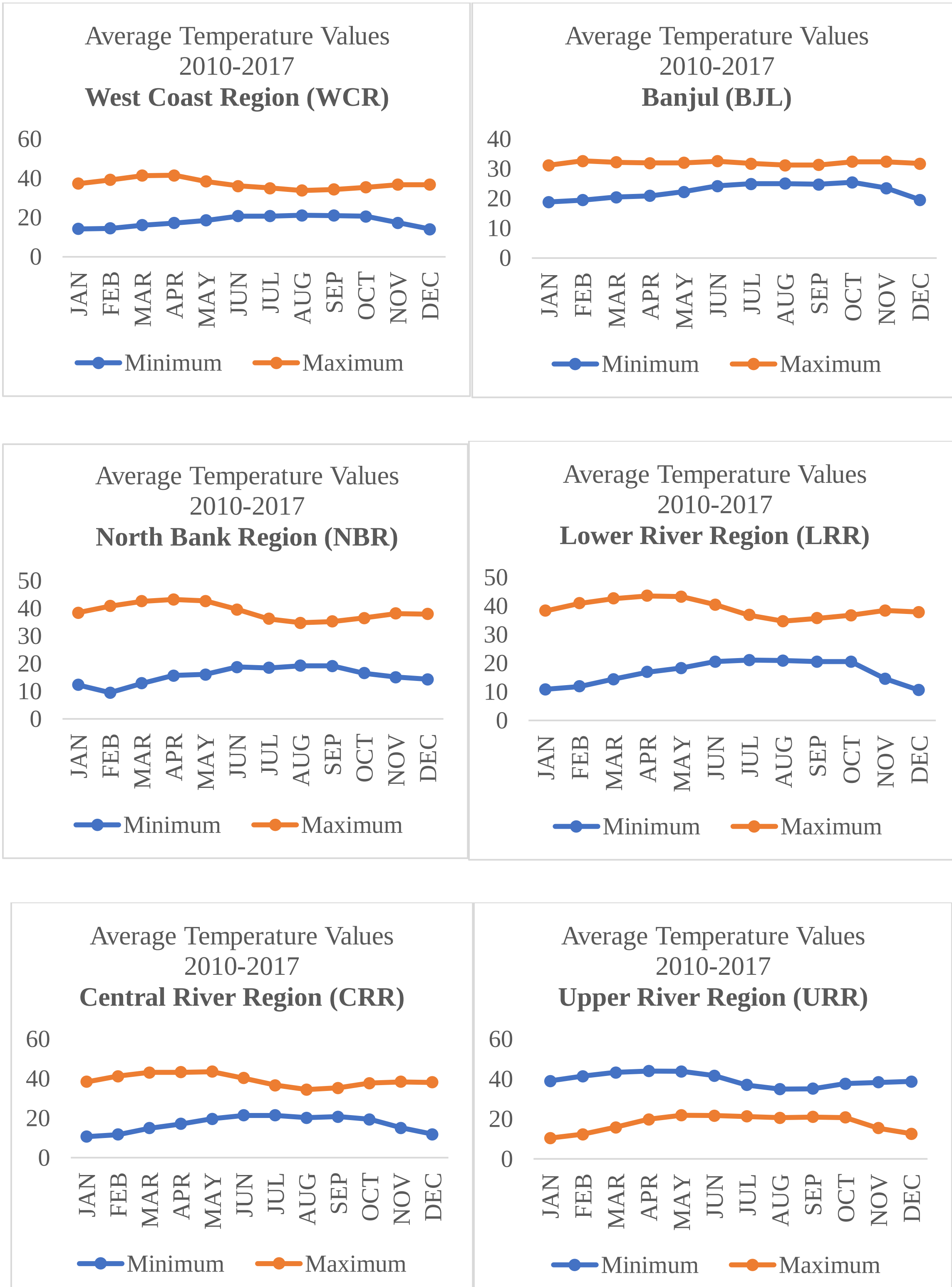
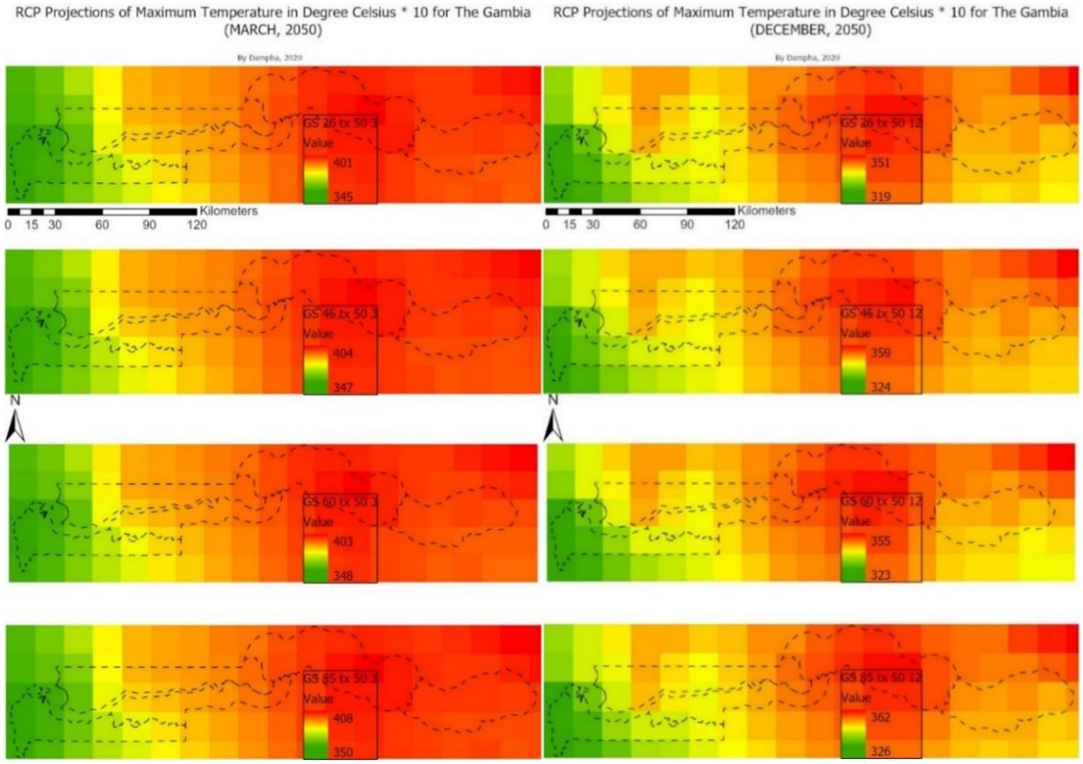
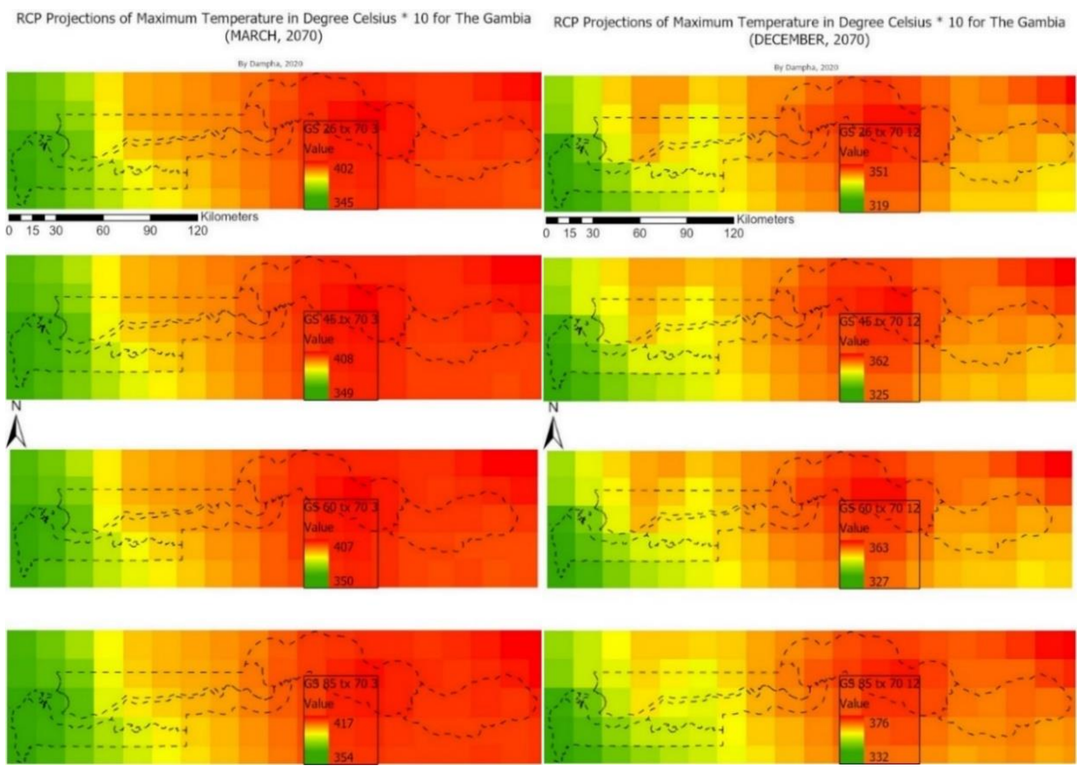


Figure 2.10. Minimum and Maximum Temperatures (Average Values 2010-2017)



Map 2.13.Temperature Projections for The Gambia (2050 and 2070)



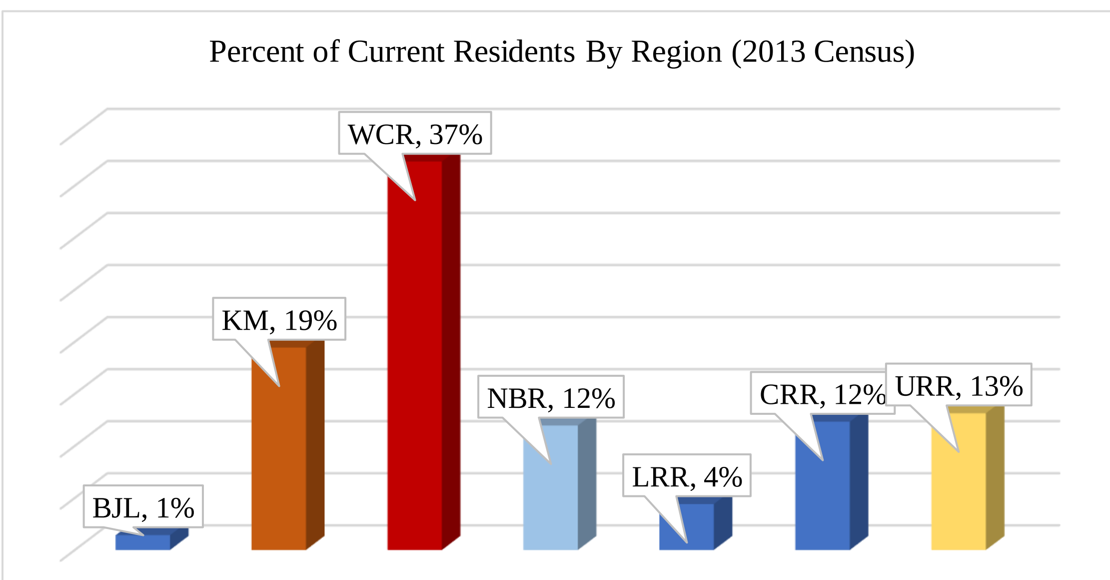


2.4.4 Demographics & Socioeconomic Indicators

2.4.4.1 Population Distribution & Migration

The population of The Gambia stands at over 2.1 million people. Nearly 60% are densely concentrated in the southwestern part, of which 37% reside in the West Coast Region (WCR), and 19% live in the Kanifing Municipality (KM) (see Figure 2.11). The rest of the country, which used to be over 60%, now accommodates only 40% of Gambians. The KM has the highest population density, followed by the WCR. The WCR is the final destination for the majority of internal out-migrants from various regions, except for those from the Upper River Region (URR) (see Map 2.14). For instance, nearly 40% of natives from BJL out-migrated to the WCR. Similarly, close to a quarter of LRR natives are currently WCR settlers. Also, 19% and 15% of natives, respectively, from the KM and North Bank Region (NBR), now resides in the WCR (see Table 2.7). Overall, population density and its pressure on the use of public spaces and infrastructure increasing, especially in the metropolitan regions (i.e., KM and WCR). Due to growing migration rates, candidate site 3 (LRR) has the least population density, whereas sites 2 and 4 have similar density characteristics.

Figure 2.11. Share of Total Population By Region



Also, I provide a matrix showing migration from the region of birth to the area of current residence (see Table 2.7). Besides, I include a migration flow direction map (see Map 2.14). The direction of the red lines in Map 2.14, labeled with counts of migrants (mostly towards the west), highlights the rapid population drift from the eastern and the western part of the country.

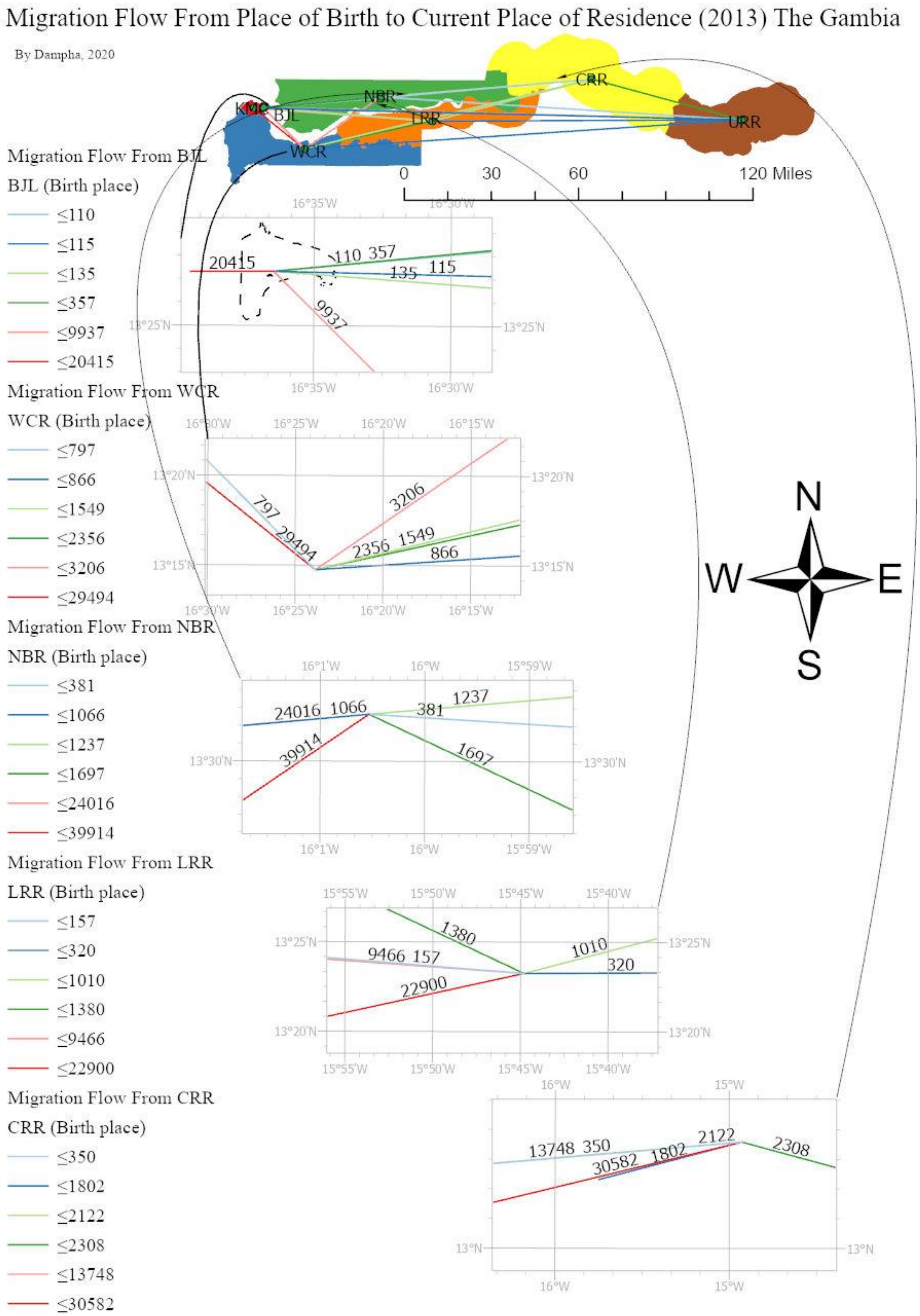
Table 2.7. Migration Matrix: Relating Birth Region to Region of Current Resident (2013 Census)

Region of Current Residence (2013)	Region of Birth							
	BJL	KM	WCR	NBR	LRR	CRR	URR	Gambia[9]
BJL	**21424**	546	797	1066	157	350	285	24625
KM	20415	**223405**	29494	24016	9466	13748	15971	336515
WCR	9937	52545	**474175**	39914	22900	30582	15613	645666
NBR	357	2682	3206	**196714**	1380	2122	425	206886
LRR	135	1011	2356	1697	**68885**	1802	379	76265
CRR	110	917	1549	1237	1010	**205937**	2464	213224
URR	115	623	866	381	320	2308	**222563**	227176
Gambia	52493	281729	512443	265025	104118	256849	257700	1730357

Source: GBoS, 2013 (Table Modified)

[9] *This includes only population born within The Gambian. Non-Gambian born residents are excluded*

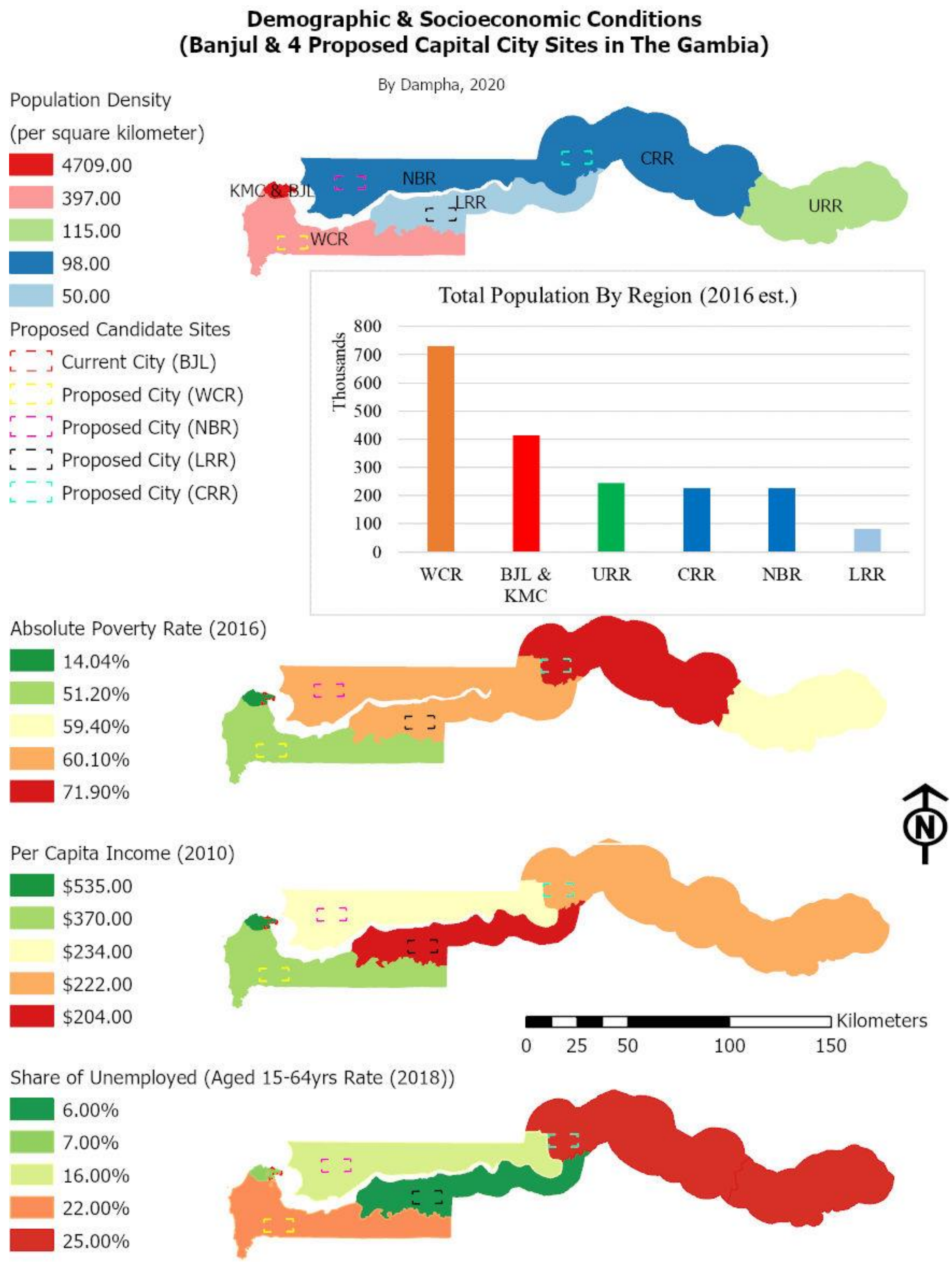
Map 2.14. Migration Flow Direction



2.4.4.2 Poverty & Unemployment

Like biophysical and geomorphological variables, socio-economic indicators ought to be considered in suitability studies. Analysis of the socio-economic conditions shows significant variations in per capita income levels, poverty, and unemployment rates among regions. Map 2.15 visualizes the regional differences for each of these variables, highlighting the proposed candidate sites. In a nutshell, Banjul, KM, and WCR have the least poverty rates and lowest household per capita income earnings. However, WCR has the second-highest number of unemployed residents, topped only by the Upper River Region (URR). Notice that these two regions (WCR and URR), respectively, have the first and third-largest share of the country's populations. In terms of per capita income, LRR (site 3) is the poorest amongst all regions, while CRR (site 4) is the most impoverished area when it comes to headcount poverty rates. Given that it is a policy objective to eradicate poverty and reduce regional inequality, sites located in impoverished areas relatively score higher in the analysis compared to others.

Map 2.15. Socioeconomic & Demographic Characteristics



2.4.5 Infrastructure & Proximity

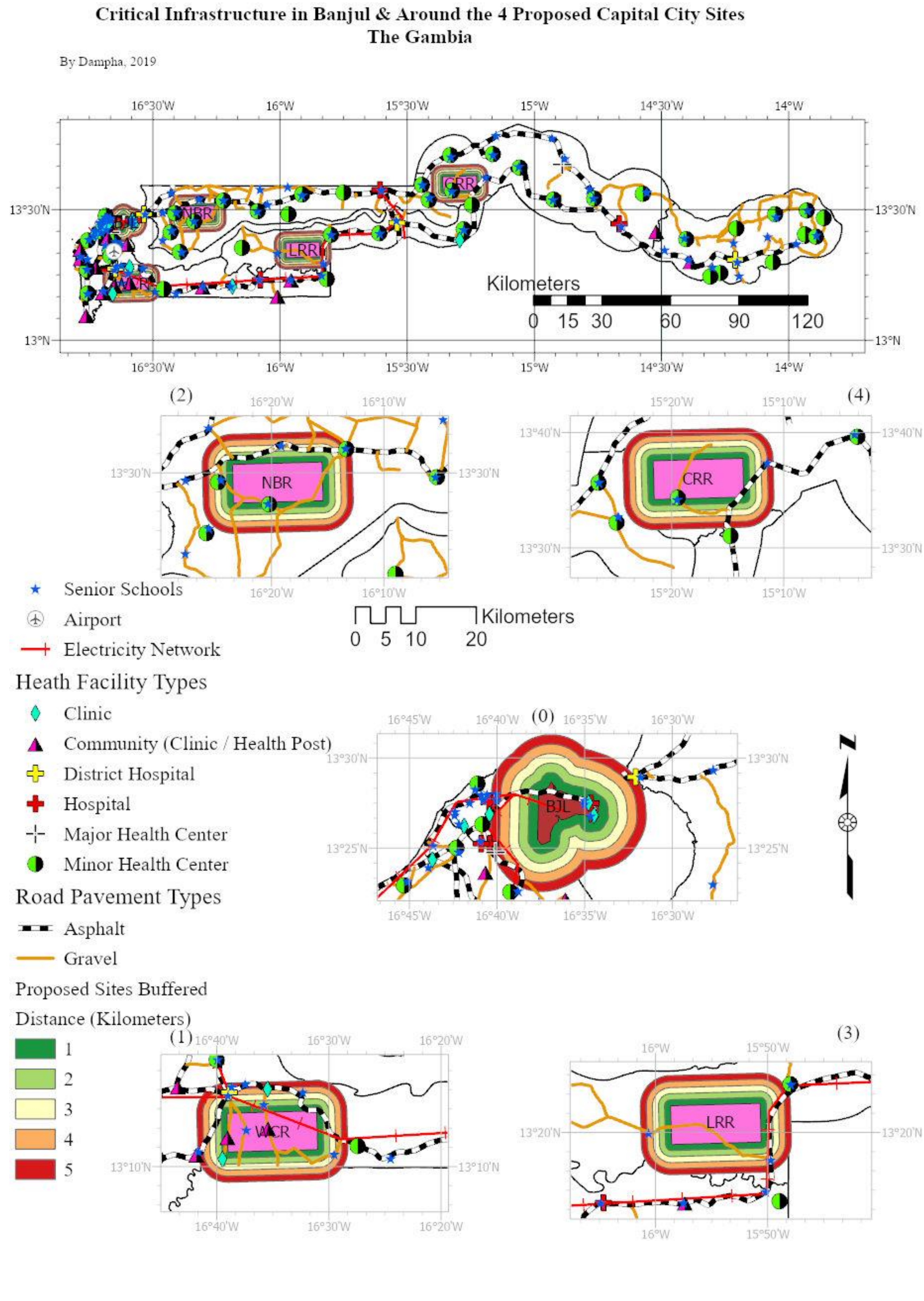
2.4.5.1 Roads, Senior Schools, and Health Facilities

I examined the availability and accessibility of public infrastructure systems. I relied on data from the Ministry of Basic and Secondary Education collected from The Gambia Bureau of Statistics (GBOS), and the World Bank. I limited the analysis of infrastructure systems to roads, senior schools, and healthcare facilities as my proxy for critical infrastructures. The map below shows that most of these structures are heavily concentrated in the western parts of the country, exclusively in the KM and the WCR (see Map 2.16).

On the one hand, infrastructure availability, accessibility, and affordability are critical factors for new city development. Hence, the proposed sites 0 and 1 in the metropolitan area and geographically closer to these facilities received higher scores compared to sites in the rural areas (2, 3, and 4) in the decision-making matrix. On the other hand, I assessed the plausibility of building state-of-the-art infrastructure projects within and around the proposed sites. The new city should provide better public facilities, critical infrastructures, and attractive open spaces. These will include schools, healthcare facilities, roads, bridges, zoos, parks, stadiums, as well as cultural and religious centers. A new city does not only need government institutions. It should facilitate industrial development for boosting private sector development. The private sector-led development will create extra opportunities for economic growth while promoting intra-generational equity.

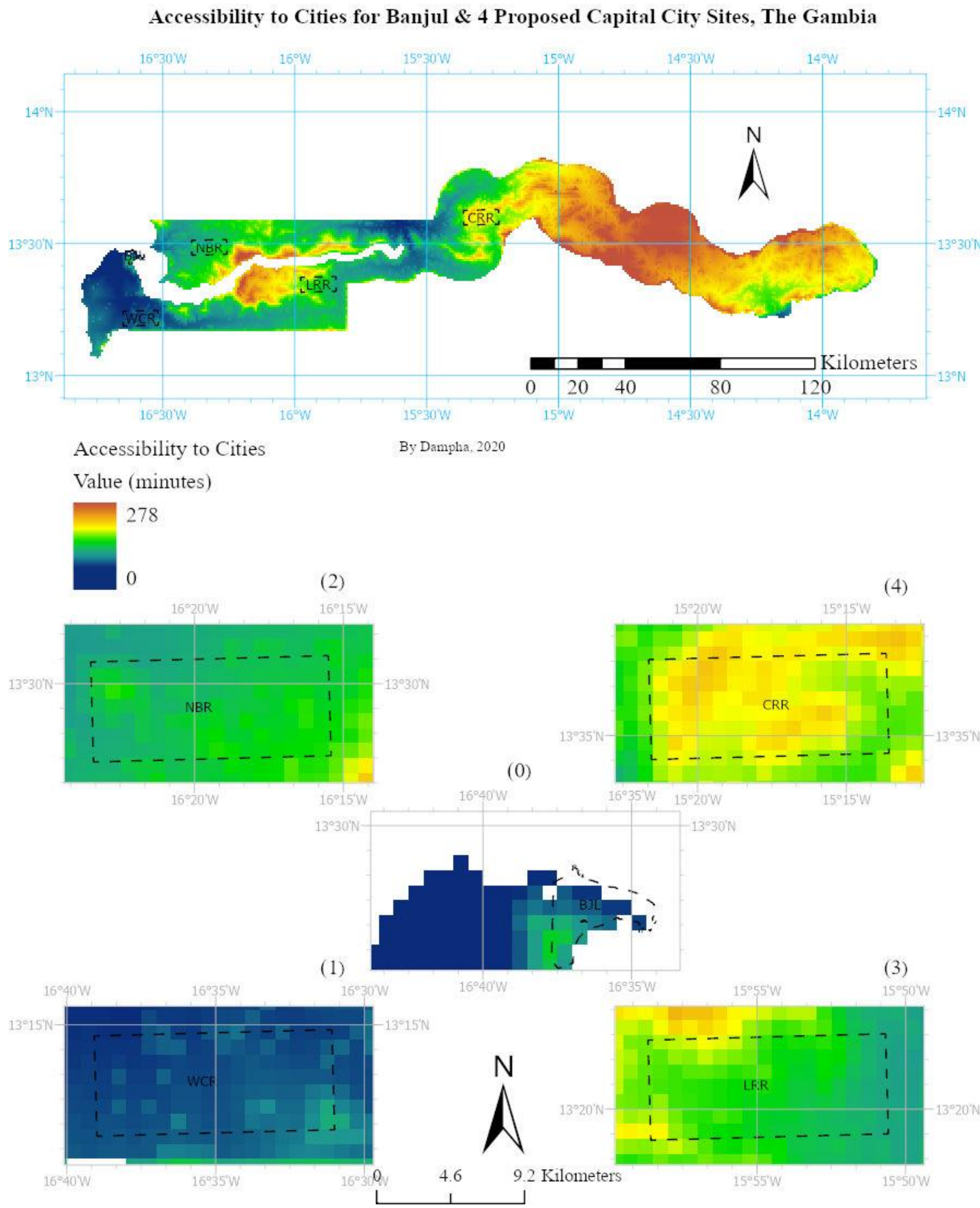
Finally, I evaluated the proximity of all the sites to not only the current city but also to the northern and southern borders for security reasons. Other proximity features include the distance to the River Gambia for transportation, to nature reserves for ecotourism and leisure seeking, and to the existing airport and seaport for travel, trade, and commerce.

Map 2.16. Critical Infrastructure around Candidate Sites across The Gambia



Similarly, Map 2.17, data derived from (Weiss et al., 2018) study, shows the accessibility of people to major towns in the country. The map also detailed candidate sites with the fastest accessibility routes for commuters in minutes.

Map 2.17. Proximity to Major Towns



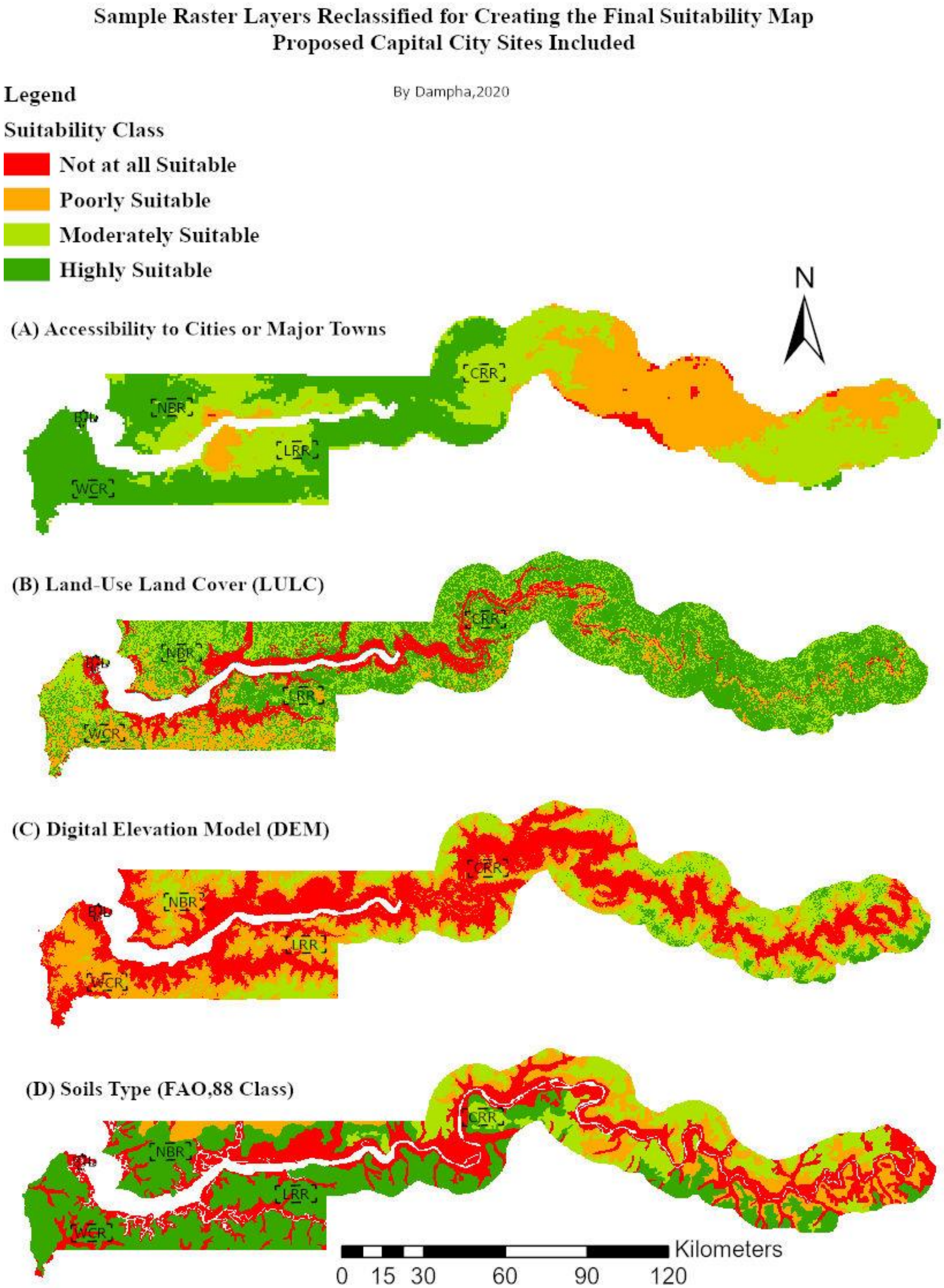
2.5 GIS/MCDM Results

As stated above, GIS and MCDM are complementary analytical tools. Their integration has supported the decision making processes to inform planners, managers, and policymakers (Collins, Steiner, & Rushman, 2001; Malczewski, 1999, cited in Mustafa et al., 2011). GIS assesses factors while MCDM makes decisions and aggregates multiple weights and scores into the analysis for land suitability (Mustafa et al., 2011).

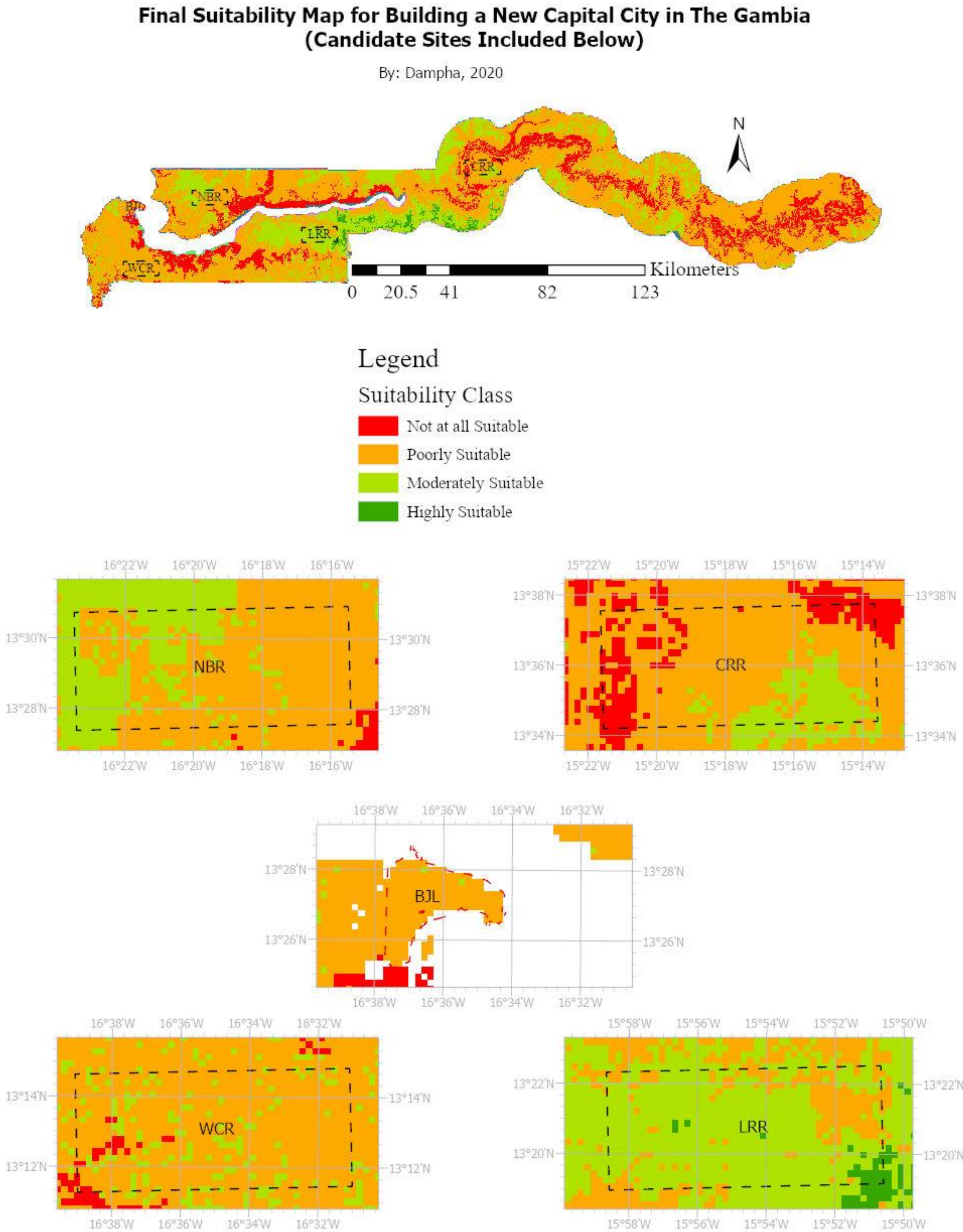
2.5.1 GIS-Based Site Suitability

The final suitability map shows the suitability levels of various regions for a new capital city development in The Gambia. All rasterized input GIS layers have been reclassified to allow a weighted overlay analysis in the ArcGIS Pro software (see sample reclassified input layers in Map 2.18). The final map is an output of the weighted overlay analysis (see Map 2.19).

Map 2.18. Sample Maps Reclassified By Suitability Classes



Map 2.19. Final GIS-Based Suitability Map



2.5.2 Multicriteria Decision-Making Results

The multicriteria decision-making procedure using an excel-based matrix is one of the final steps for this decision analysis. As earlier stated above, in the MCDM matrix below, a score is assigned to each sub-criteria using a Likert scale of 1 to 5 (1 being highly unsuitable and 5 being extremely suitable). I assigned a zero value to a sub-criterion considered inapplicable (i.e., for the baseline site, Banjul). The process uses the indicator values to assign ranks based on the relative contribution of each sub-criteria/indicator to the ultimate study goal. To determine overall site suitability, I aggregated the scores for each candidate site using the MCDM matrix in excel. The location with the highest score is considered the most suitable place for building the next capital city of The Gambia.

The MCDM analysis result identifies the Lower River Region (LRR, site 3) as the most suitable region for building the next capital city (see MCDM Matrix result Table 2.9 - Table 2.11). The LRR region (site 3) doesn't only have better topographic conditions, but the region's central geographic position will maximize fair access to the new capital by both urban and rural Gambians. Given that it's not too far from the densely populated regions, the site has the advantages of de-congesting the urban space, curbing urban deforestation trends, and reducing regional inequality and poverty rates in the country. The region has minimal land compensation costs to the government, at least when compared to site 1 (WCR). The decision is primarily data-driven and informed by a set of priority national development policy objectives (see Table 2.15, above). Changing the policy objectives will introduce a possible change in the suitability result.

The second-best location or region (i.e., site 1 in the West Coast Region) turns out to be the region selected by a majority of Gambians according to the survey result (see survey results below). The reasons for its poor suitability in the GIS-based MCDM analysis are due to factors raised by members of public. For example, according to the survey, Gambians feel very strongly about not using forested areas for city development. Ironically, they didn't know that the WCR has over 65% of the country's closed and open forest parks. The majority of these forestlands are at high risk of degradation and destruction. This contradiction motivates chapter three of my dissertation, where I conducted a land-use land cover change analysis focusing on the WCR region. The objective is to assess the impacts of constructing a new capital city on the remaining forest ecosystem and the essential services it provides for enhancing human wellbeing.

The North Bank Region (NBR, site 2) has emerged had the third-best location as per the variables included in the decision analysis. The site scored well in respect of its topographic conditions and favorable climatic suitability, as well as minimal ecological and environmental damages. The biggest challenge with site 2 (north bank) is accessibility for over 75% of Gambians living on the south bank.

However, should the government anchor its decision solely on public opinion, then site 1 (WCR) may be selected instead of sites 3 (LRR) or site 2 (NBR). Undoubtedly, the WCR scores exceptionally well in terms of people's accessibility to seek services from both the proposed new capital and the existing one. Also, constructing the administrative city in the WCR will reduce the business transaction costs, otherwise expected to be incurred by urban dwellers and government officials if the LRR were to be picked.

The least recommended region is CRR (site 4). Although the region's elevation level is high, the steepness of the landscape implies a relatively higher construction cost compared to the other sites. Besides, site 4 is over 120 kilometers away from the majority of the populace. Current and predicted temperature conditions are also unfavorable.

As earlier stated, some scholars recommend sensitivity analysis in GIS-based MCDM studies (Abdullahi et al., 2014). The objective is to "investigate the effect of change in subcriteria preferences on the alternatives." (Abdullahi et al., 2014). Therefore, depending on what national development policy objectives are re-prioritized by the government and its people, either site 1 or site 3 can be identified for new capital development. Table 2.8 recommends which site to select vis-à-vis the sets of policy objectives prioritized by policymakers emphasizing the importance of sustainability, inclusivity, and prosperity for all Gambians. The government may choose the LRR or the WCR if its national development priority areas are aligned either to the “first sets of policy” objectives or the “second sets of policy” objectives in Table 2.8 below.

Table 2.8. Sets of Policy Priorities Influencing Site Suitability Option

Policymakers should consider these policy Objectives. As the policy priorities change, so do the suitability location.	**Pick the site as per the set of policy objectives prioritized**	
	LRR (Site 3)	**WCR (Site 1)**
First Sets of Policy Objectives		
Mitigating future flood inundations (e.g., potential sea-level rise damage)	✓	
Reducing regional inequality & rural poverty	✓	
Preventing ecological damage and forest cover losses	✓	
Minimizing displacement & compensation cost to the government	✓	
De-congesting the urban area & reducing rural-urban migration	✓	
Protecting the new city for national security reasons (distance from the border)	✓	
Second Sets of Policy Objectives		
Selecting the preferred choice for over 50% of Gambians		✓
Avoiding a warmer site (i.e., relatively favorable weather condition)		✓
Increasing people's access to the new city		✓
Reducing the cost of building many new infrastructures such as schools, hospitals, and etc.		✓
Reducing the logistical/transaction costs (i.e., commuting between the old and new city)		✓

Table 2.9. Multicriteria Decision-Making Matrix for Suitability Ranking

Obj. No.	**Sub-Criteria**	**Suitability Rank ranges between 0–5 (5 equal to very important, 1 equal to less important, and 0 equal to not possible)**				
		Site 0 Current City (BJL)	**Site 1 (WCR)**	**Site 2 (NBR)**	**Site 3 (LRR)**	**Site 4 (CRR)**
2	Elevation (0-68)	0-16	0-42	0-54	0-44	0-50
	Score	***1***	***3***	***4***	***3***	***4***
	Slope (Mean %)	1.47	2.06	2.18	1.6	2.43
	Score	***3***	***1***	***1***	***3***	***1***
	CTI (Values)	1021.21	990.8	974	1012.5	977.62
	Score	***3***	***2***	***2***	***3***	***2***
	Soil Type (FAO88 Classes)	Glu 100%	ACF 55% & Gle 45%	ACF 100%	ACF 95% & Gle 5%	RGd 85%, ACF 10%, Glu 5%
	Score	***1***	***2***	***3***	***3***	***2***
3	Temperature Celsius (Min - Max) (2010-2017)	(21.88- 32.09)	(18.1-37.2)	(15.7- 38.8)	(16.8-39.0)	(17.00-36.1)
	Score	***4***	***3***	***2***	***2***	***1***
4	Poverty Rate (> higher rank)	7.60%	51.20%	59.80%	60.10%	71.90%
	Score	***1***	***4***	***4***	***4***	***5***
	Unemployment Rate (> higher rank)	7%	22%	16%	6%	24%
	Score	***2***	***4***	***3***	***2***	***4***
	Health Care (No. facilities, clinics & hospitals)	11	27	13	7	10

	Score	***3***	***5***	***3***	***2***	***3***

Table 2.10. MCDM Matrix continues

Obj. No.	**Sub-Criteria**	**Site 0 Current City (BJL)**	**Site 1 (WCR)**	**Site 2 (NBR)**	**Site 3 (LRR)**	**Site 4 (CRR)**
	Senior Schools (No.)	14	30	18	6	13
	Score	***4***	***5***	***4***	***2***	***4***
	Electricity Network	Power grid within site	Power grid within site	None	Power grid 1km from the site	None
	Score	***3***	***3***	***2***	***2***	***1***
5	Population Density (> higher rank)	4709	396.6	98.01	50.09	88
	Score	***1***	***2***	***4***	***5***	***4***
6	Communal Ownership (Likely)	Very Unlikely	Unlikely	Very Likely	Very Likely	Very Likely
	Score	1	2	4	4	4
7	Wetland/Forest Area (ha)	807.39	75366	10.72	2.16	421.74
	Score	***2***	***1***	***5***	***5***	***4***
	Water bodies (ha)	444.33	0	0	13.68	611.37
	Score	***1***	***4***	***4***	***3***	***1***
	Current Farmland/Bare Soil (ha)	72.72	7413	5232.06	394.83	2439.63
	Score	***2***	***1***	***5***	***4***	***4***
	Score	***2***	***1***	***5***	***4***	***4***
	Grassland/ Deforested/ Not Cultivated (ha)	300.42	2090.8	2047.5	5824.53	4099.77
	Settlements/Developed (ha)	230.85	20030	1605.24	2659.77	1312.47
	Score	***0***	***4***	***3***	***4***	***3***

Table 2.11. MCDM Matrix continues

Obj. No.	Sub-Criteria	Site 0 Current City (BJL)	Site 1 (WCR)	Site 2 (NBR)	Site 3 (LRR)	Site 4 (CRR)
8	Land Value $	$ 110,257,200,000	$ 503,487,180,000	$ 268,051,140,000	$ 272,913,840,000	$273,543,480,000
	Score	***0***	***1***	***4***	***4***	***4***
9	Disaster Risk (total # of people affected in 2018)	129 people	2653 people	4686 people	1532 people	8748 people
10	***Score***	***5***	***3***	***1***	***3***	***1***
	Roads within Site		18.19 km (gravel)	12.11 km (gravel)	9.79 km (gravel)	7.68 km (gravel and asphalt)
	Score	***2***	***4***	***3***	***3***	***2***
	Security (Distance to Senegalese Border)		3km	8km	6km	7km
	Score	***0***	***1***	***2***	***2***	***2***
	Proximity to the Airport (Distance in Km)	13km	10km	30km (Ferry-crossing difficulty)	70km	145
	Score	***4***	***5***	***1***	***3***	***1***
	Proximity to Banjul (Distance in Km)		20km	25km (Ferry-crossing difficulty)	80km	150km
	Score	***0***	***4***	***2***	***3***	***1***
	Proximity to Major Population Centers	One-main Road	Good travel Network (Roads)	No Bridge, Ferry cutting unreliable,	Easy Travel Network (Roads) & River Transport possible)	Road Transport Available but the farthest distance from 70% of pop.
	Score	***4***	***5***	***1***	***4***	***1***
	Total Score	**53**	**74**	**71**	**78**	**63**

2.6 Public Opinion Survey Results

Consulting the beneficiaries of any project is substantial for understanding their value propositions and perceptions (Bunruamkaew & Murayama, 2011; Bagaram et al., 2016). The survey results provide additional information on citizens' perceptions and preferences of suitability criteria, indicators, policy objectives, and site selection choices. Public opinion on site suitability identification is necessary but not sufficient for making a decision. The public often does not consider the integration of all elements required for conducting a multicriteria decision-making analysis. Suitability decision models include accounting for biophysical, geomorphological, ecological, climatic, and socio-economic conditions of one location over its alternatives. Public opinion often misses some critical factors for decision-making due to limited scientific evidence/knowledge. The public doesn’t know some of the essential data elements, and if they do, they might choose differently.

2.6.1 Respondent's Characteristics

The survey respondents are predominately university or college-educated Gambians between the ages of 25 to 44 years old. A quarter is unemployed. 18% works with The Gambia government, 15% are employed with the private sector, and 12% are full-time undergraduate and college students (see Table 2.12).

Table 2.12. Respondents' Characteristics

Variables	**Observation (Freq.)**	**Percent (%)**
SEX		
Male	347	70%
Female	151	30%
Total	498	100%
Age Bracket		
25-34	170	35%
18 - 24	139	28%
35 - 44	111	23%

45 - 64	61	12%
Under 18	6	1%
65 or Older	5	1%
Total	492	100%
Education Level		
University undergraduate level	169	33%
College/Vocational Training	101	20%
Graduate or Professional Degree	69	14%
High School (Grade 10-12)	58	11%
Never Attended School	54	11%
Primary School (Grade 1-6)	25	5%
Middle School (Grade 7-9)	24	5%
PhD	9	2%
Total	509	100%
Employment Status		
Unemployed	122	25%
Gambia Government	85	18%
Private Sector	70	15%
Student	57	12%
Self-employed	57	12%
Employed Abroad	36	8%
NGO/CSO (Paid position)	31	6%
Volunteering for an NGO/CSO	22	5%
Total	480	100%

2.6.2 Opinion on Regional Selection for a New Capital

According to the survey findings, 52% of Gambians identified the West Coast Region (WCR, my candidate site 1) as their preferred site for building the next capital city of The Gambia. The second and third favored regions are, respectively, the Kanifing Municipality (KM) and Lower River Region (LRR). Among all respondents who chose the WCR, 33% originally came from the region, while 48% reported the area as their current residence (see Table 2.13).

Table 2.13. Respondents' Choice of Region for a New Capital City Vs. Regions of Claimed Origin & Current Residence

Name of Region	Choice of New City Location (Freq.)	Percent (%)	Origin/ Birthplace (Freq.)	Percent (%)	Current Residence (Freq.)	Percent (%)
WCR	245	52%	164	33%	229	48%
KM	95	20%	80	16%	150	31%
LRR	62	13%	82	17%	8	2%
NBR	29	6%	66	13%	9	2%
URR	21	5%	31	6%	5	1%
CRR	17	4%	38	8%	4	1%
BJL	N/A	N/A	27	5%	14	3%
Abroad	N/A	N/A	5	1%	62	13%
Total	469	100.00	493	100	481	100

2.6.3 Opinion on Land Cover Type to be Converted to a New Capital City

Among the various land-use land cover (LULC) types included in the questionnaire, 33% of 481 respondents selected areas with bare soil to be used for a new capital city development. 30% feel that the new city should be situated in currently developed land areas, while a quarter prefers converting grassland sites for proper zoning and development. The survey result strongly reveals that Gambians do not want to sacrifice or destroy the remaining 'forest' cover (based on how they understand the definition of a forest) even when a new capital city is at stake. Similarly, reserving agricultural land areas for enhancing food security and sovereignty is stressed from their responses (see Table 2.14).

Table 2.14. Public Opinion on Land Cover Type to be Converted to a New Capital City

Land-Use Land Cover Type	**First Choice**		**Second Choice**	
	Observation (Freq.)	**Percent (%)**	**Observation (Freq.)**	**Percent (%)**
Bare Soil	160	33%	181	38%
Already Developed Settlement areas	142	30%	93	19%
Grassland/Shrubland	121	25%	147	31%
Agricultural Land	34	7%	31	6%
Forest land	24	5%	29	6%
Total	481	100%	481	100%

2.6.4 Opinion on Suitability Indicators & Policy Objectives

The main takeaway of the survey is the urgency for The Gambia government to identify a location for the establishment of a new capital city. An overwhelming majority, 81%, of nearly 500 Gambians 'strongly agree' to the statement on the need to construct a new capital city by 2050. The survey provides some policy directions for the government to consider when deciding on the location of the new capital. Policy objectives that receive much public support include the need to avoid building the proposed city in a floodplain area (low elevated regions) and a forested site for ecological protection. They also agree that the farther the distance from the proposed city to the border with Senegal, the better for national security reasons. Ultimately, public reaction to the survey questions shows that a new city development should be aimed to reduce poverty, minimize regional inequality, avoid massive population displacement, and reduce the transactional cost to society and development cost to the government. However, the public agreement seems to decrease when asked to prioritize building the capital in a region only because it has the following characteristics: high poverty rate, relatively hot weather condition, high unemployment rate, the mere existence of current infrastructure, and if the land is communally or privately owned– refer to Table 2.15 for more details.

Table 2.15. Opinion on Suitability Indicators & Policy Objectives

Question (no.)	Survey Statement	Observation (Freq.)	Rank (no.)	Strongly Agree %	Somewhat Agree %	Neither agree nor disagree %	Somewhat Disagree %	Strongly Disagree %
1	***The Gambia needs to develop a new capital city within the next 50 years.***	***498***	***NA***	***81%***	***11%***	***3%***	***3%***	***3%***
2	When building a new capital city, the government should avoid building it in a location prone to future flood inundation (i.e., low elevation areas)	504	1	91%	7%	1%	1%	0%
3	Reducing poverty should be one of the top policy agenda to consider when deciding on where to locate the next capital city.	489	2	84%	10%	4%	1%	1%
4	Preventing ecological damage; sites with larger wetlands should be avoided when deciding on a suitable location for a new capital city compared to other sites with less or no wetlands.	477	3	81%	14%	3%	1%	0%
5	Preventing environmental damage; sites with larger forest areas should be avoided when deciding on a suitable location for a new capital city compared to sites with less forest.	476	4	81%	14%	3%	1%	0%

6	Reducing urban congestion should be one of the top policy agenda to consider when deciding on a new city location	491	5	78%	18%	3%	1%	1%
7	Minimizing disaster risks; sites with lower exposure and vulnerability levels should be considered more compared to sites with higher exposure and vulnerability levels.	479	5	77%	15%	6%	1%	0
8	Reducing unemployment should be one of the top policy agenda to consider when deciding on a new city location	300	6	72%	17%	6%	3%	2%
9	Reducing logistical costs to society (e.g., access to the new city), sites with lower logistical costs should be considered more than sites with higher logistical costs.	478	7	70%	21%	5%	2%	2%
10	The next capital city of The Gambia to be five times bigger than Banjul.	500	7	70%	20%	6%	2%	1%
11	Reducing external threats; (e.g., distance from Senegal); sites with greater distance from the border should be considered more than sites closer to the border.	477	8	69%	14%	9%	5%	3%
12	Reducing regional inequality should be one of the top policy agenda to consider when deciding on a new city location.	491	9	66%	21%	7%	4%	2%
13	Sites with greater water bodies should be avoided when deciding on a suitable location for a new capital city compared to sites with less or no water bodies.	475	10	65%	19%	9%	4%	3%

14	Avoiding massive displacement of current residents; sites, where fewer people will be displaced, should be considered more than sites that will result in more displacement of current residents.	477	11	64%	23%	6%	4%	3%
15	Reducing cost to the government; sites with a lower cost to government (e.g., for paying compensation to landowners) should be considered more than sites with a higher cost.	479	12	60%	21%	9%	5%	5%
16	Land ownership type; sites that are communal-owned or undeveloped land areas should be considered more compared to privately-developed and owner-occupied land areas.	288	13	55%	31%	10%	2%	2%
17	Leveraging existing infrastructure; sites with more infrastructure (e.g., roads, schools, health facilities) should be considered more compared to sites with less public infrastructure.	479	14	52%	21%	10%	9%	8%
18	Regions with higher unemployment rates should be considered more compared to regions with low unemployment rates.	489	15	52%	24%	11%	8%	5%
19	Regions with lower temperatures (relatively cooler weather) should be considered more compared to regions with higher temperatures.	490	16	48%	25%	15%	7%	5%
20	Regions with higher poverty rates should be considered more compared to regions with lower poverty rates.	490	17	46%	20%	11%	11%	11%

2.7 Discussion

I used a simple SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis framework to discuss the study results. I simplified the SWOT indicators and addressed each element in relation to the identified candidate sites in Table 2.16.

2.7.1 Strengths

First, there seems to exist not just public support but the political will for building a new administrative capital city in The Gambia. Second, the country's natural and mineral resource endowments can be sustainably exploited for investing in this mega-development project. The use of these resources should factor inter-generational equity considerations. For example, destroying the remaining forestland will result in loss of ecosystems that would have the potential to generate use and non-use ecosystem service values for several generations. Also, the available human capital will provide the expertise needed to support the design and implementation process of this project. These include requisite skillsets in civil engineering, architectural design, and scientific data analysis, to mention but a few. These strengths may yield positive benefits, irrespective of the selected site.

Another strength of the analysis is that it independently appropriated the land in each site without political or community consultation. This approach limits the bias expected from political influence as well as landowner's willingness or unwillingness to offer the area for accomplishing a sustainable national development objective.

2.7.2 Weaknesses

Building a new city is financially intensive– thus, the biggest challenge for pursuing this sustainability path. All else constant, a location with the minimum cost to the government, society, and the biophysical environment should be prioritized as earlier mentioned. Based on the costs associated with the loss of critical natural capital stock and flows of various ecosystem services, site 3 in Lower River Region (LRR) appears to be relatively better compared to site 1 in the West Coast Region (WCR) and site 4 in the

Central River Region (CRR). The total land value for acquiring site 1 (WCR) is estimated at 500 billion US$ compared to US$268 billion for site 3 (LRR). As stated above, the government has the power to cede any piece of public land for national development interest. Therefore, the government may not necessarily pay the actual value of these properties. But the cost accounting is essential for the government to know which site has more cost implications, not just for compensation, but also for the ecological loss of other species and the environmental costs to society in general, as further discussed in chapter three.

2.7.3 Opportunities

The availability of the existing infrastructure is imperative for site identification, given the country's resource constraints. The WCR (site 1) scores relatively high in terms of availability, accessibility, and usability of current public infrastructures than the other sites. This implies a reduced transaction cost for the majority of new city commuters. Access to schools, hospitals, markets, workplaces, and the airport will be faster if the city is situated in the WCR than in the other three regions.

However, site 3 (LRR) offers new opportunities for the government to develop critical and climate-resilient infrastructures for connecting and attracting the people to the new capital city. Based on my findings, both sites 2 in the North Bank Region (NBR) and site 3 in the Lower River Region (LRR) have opportunities and features that could facilitate proper zoning, planning, and developing a modern city.

This study is modeled on the scenario that site 0 (Banjul) will remain as the “commercial capital” city of The Gambia, for the next couple of decades. As a commercial city, Banjul will continue to persist as a hub for national, regional, and international trade and commerce. Thus, additional investment may be required to protect the vulnerable island from sea-level rise inundations. Connecting the commercial capital and the new administrative capital city is essential. Although, the candidate site 1 in WCR is the closest to access Banjul via road transportation, site 3 in the LRR possesses additional opportunities for developing new trading networks and river transportation routes for the movement of goods and people. This development strategy will significantly boost the tourism sector, notably, the eco-tourism sub-sector. The co-benefits may include aggressive efforts to protect, conserve, and restore ecological habitats.

Another opportunity for selecting site 3 is the need to de-congest the growing urban population. Compared to a population density of over 3000 people /km2 in WCR (site 1), LRR (site 3) has only 50 people living in a square kilometer. A quarter of LRR natives residing in the western parts of the country will potentially return if the region is developed to become a climate-resilient city. Besides, the decision will create employment opportunities and curb rural-urban drift and illegal migration of rural youth to Europe.

2.7.4 Threats

Creating a new city will irrefutably contribute to a list of emerging threats, including the destruction of certain LULC types such as grassland. As per the policy objective stated above, land-use change (primarily from grassland to a green city) in the candidate site 3 will cause damage to the biophysical environment. However, for site 1, this new construction will cause more ecological loss to the remaining forest habitats, thus, affecting biodiversity conservation and ecosystem service protection and restoration. The nation's remaining flora and fauna are not only threatened, but many are currently considered endangered. For instance, the World Bank reports that 14 bird species found in The Gambia are threatened as of 2018.

Similarly, site 4 in CRR does not score well on land-use conversion primarily due to the ecological importance of wetlands and water bodies near the location. Land-use conversion from agriculture to a green city in site 2 (NBR) should not be encouraged according to my public opinion survey. Such land-use change in NBR will claim large areas of arable agricultural land, as over 85% of the entire site (89km2) is classified as bare soil or cultivated fields, including few orchards. People in the NBR are active farmers. They mostly feed on their farm produce for sustenance and often export surplus to other regions, including the Kanifing Municipality and the WCR. Hence, the region's contribution to enhancing food security and sovereignty will be undermined profoundly if city development takes effect.

Also, note that the principal reason for building a new capital city is because Banjul has an elevation of 1-meter above mean sea-level, thus highly susceptible to flood risk (Jallow et al., 1996; Amuzu et al., 2018a). Therefore, a site with a reasonable height and a flat landscape will be the most suitable for a new green city placement. In contrast to site 1, site 3 has more suitable geomorphological characteristics for developing a new climate-smart city. The topographic conditions (e.g., height and slope) and dominant soil type for site 3 are relatively better for city development than sites 1.

Finally, and perhaps, more importantly, is the security of the new city. National security is a priority for any sovereign nation. Among all candidate sites, site 3 is the most strategically located for self-defense, as the River Gambia route can be secured and controlled under close military surveillance. Regarding external security threats, Site 3 is almost 6 kilometers from The Gambia's southern border with Senegal, compared to just 3 kilometers for site 1. Equally, the River Gambia route, close to site 3, can be a security outlet in case of internal military insurgencies against the incumbent.

Table 2.16. A Simplified SWOT Analysis

Strengths (S)	**Weaknesses (W)**
Political will Public support Land availability Minerals resources (i.e., sustainable exploitation should be considered) A growing human capital	Lack of financing High political interference in the process Limited scientific knowledge about landscape vulnerability and climate change impacts
Opportunities (O)	**Threats (T)**
Opportunity to build a properly designed green new city Existing infrastructure	Loss of ecosystem services due to deforestation

• International climate financing initiatives • Bilateral and multilateral supports	▪ Flood risk (precipitation & rising sea-levels) ▪ Food security threats ▪ National security threats

2.8 Policy Implications

This new sustainable development approach aims at reducing climate risk and vulnerability, eradicating abject poverty, minimizing regional inequality, and decreasing urban congestion, rural-urban migration, and irregular migration. It also gives emphasis to promoting rural and agricultural development and rendering employment opportunities for the youth. The proposed modern city should promote sustainable development objectives, from the viewpoint of intra-generational and inter-generational equity. The establishment should avoid ecological damage to the remaining flora and fauna of the country. The displacement costs should be minimal. It should take advantage of the presence of existing structures and strengthen the development of new resilient infrastructural projects. The new climate-resilient city should be zoned appropriately and planned well to accommodate a government plaza, residential areas, industrial sites, public infrastructures, and recreational and cultural areas. These facilities will include schools, healthcare facilities, parks, zoos, etc.

2.9 Conclusion

This analysis uses scientific data and seeks public opinion to answer a critical question of where to construct the next capital city of The Gambia.

First, the study gathered the opinion of over 500 Gambians using both online and in-person survey methods. The public overwhelmingly agrees (92%) to the need for a new administrative city for the Republic of The Gambia. On the question of where to situate the city, 52% of the survey respondents choose the West Coast Region WCR (i.e., proposed candidate site 1). However, they disagree with the idea of converting forestlands for the construction to materialize. Ironically, the WCR region is endowed with over 65% of the remaining closed and open forest parks of the country. The tradeoff of city development in the WCR implies forest ecosystem losses, leading to ecological damage and the extinction of other biological diverse species. However, one of the benefits includes the proximity of the city to nearly 60% of the country's population.

Second, using the best available scientific data (remotely sensed satellite imagery) with the same public opinion on suitability indicators and objectives, I applied a GIS-based multicriteria decision-making procedure for a site suitability analysis. This data-driven decision analysis approach aims at identifying the most feasible location, based on the consideration of multi indicators, for building a climate-resilient capital city for The Gambia. Input layers included in this analysis range from land-use land cover, soil type, topographic and hydrological features, weather and climate conditions, demographic and socio-economic characteristics, infrastructure systems to other logistical considerations (i.e., proximity to critical features, e.g., the border, River Gambia, the commercial centers, etc.). Results of this highly complex and methodologically robust approach identify a land area of 8,910 hectares (89 km2) as a reasonable size for developing a new administrative city. The most suitable location, according to the multicriteria decision-making analysis, is situated in Kiang West District, Lower River Region (known in the analysis as candidate site 3).

Picking candidate site 1 or site 3 depends mostly on sets of national policy objectives prioritized. Changing the policy priorities included in the decision matrix will or may, accordingly, change the identified site/region for a new capital city development. It's crucial to stress that both site 1 (WCR) and site 3 (LRR) have cost implications. Site 1 poses more damage costs to the environment and its ecosystem service functions and benefits. In comparison, site 3 in LRR has more transaction costs to the people, especially to the city employees and other frequent service seekers. Overall, a new capital development will significantly benefit national development priorities and contribute to the attainment of global sustainable development goals. Taking account of evidence from this study will facilitate a new development paradigm centered towards eradicating poverty, reducing inequality, unemployment, and curtailing the deadly irregular migration and emigration of Gambians, especially from the poorest regions of the country.

Therefore, I highly recommend that an evident-based scientific decision-making approach, as experimented in this study, be sought to aid the policy decision-making process of such a mega-infrastructural development plan in The Gambia and other places with similar predicaments. In the same vein, I discourage the influence of any form of clientelism in the process.

Finally, I recommend additional research for conducting a detailed quantification of the overall construction costs, including engineering and architectural design costs for developing a new administrative capital city in The Gambia.

Chapter Three

Change Detection (1985-2020): Projections on Land-use Land Cover, Carbon Storage, Sequestration, and Valuation in Southwestern Gambia

3.1 Introduction

The Gambia is rapidly changing– due to increasing population and economic growth (and growth is necessary to reduce poverty). As a small country, there is not much forest or other natural ecosystems. Urban expansion fuelled by population growth, real estate proliferation, and sea-level rise pose existential threats to the remaining natural habitats. This study will analyze land-use change in The Gambia and its impact on ecosystem services such as carbon sequestration.

The Gambia falls under the Sudano-Sahelian agro-ecological zone (Heß, Jaimovich, & Sch, 2018). The country experiences two major seasonal calendars-dry (October-June) and rainy (July-September). The country's population is slightly over 2 million and projected to double by 2050 (Population Pyramid Net, 2019). The doubling of the population will hasten further challenges to its land-use patterns and land cover changes, as the total land size (10,120 sq.km or 1,012,000 ha) remains predominantly fixed or declined, as some areas (e.g., the capital city) are becoming inhabitable due to sea-level rise inundations (Jallow, Barrow, & Leatherman, 1996; Hills & Manneh, 2014; Coates & Manneh, 2015).

The Gambia has a total productive land area of 1.5 million, defined as its ‘biocapacity’ with an ecological footprint of 2 million both measured in global hectares (gha). The ecological footprint measures people’s demand or dependence on nature/natural capital assets and flows (Kubiszewski et al., 2013). A country is declared ‘ecologically deficit’ when its footprint exceeds its biocapacity (Wackernagel, Lin, Evans, Hanscom, & Raven, 2019; Wackernagel et al., 1999). The Gambia became ‘ecologically bankrupt’ in 2002, and as of 2016, the country has an ecological deficit of

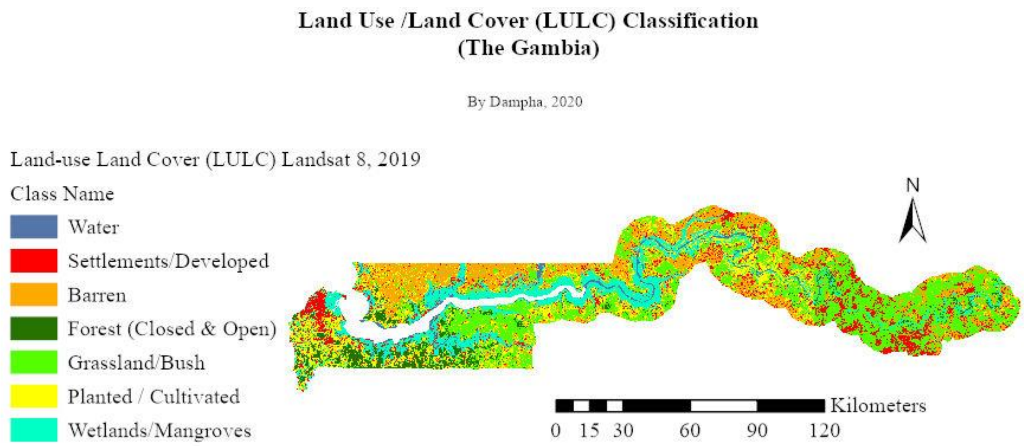
547,341gha. On per capita basis, the average Gambians have an environmental footprint of 1gha relative to a per capita biocapacity of 0.7gha in 2016 (compared to 4gha in 1961) (Global Footprint Network, 2020). With the increasing dependence on natural capital for consumption, income generation, and wealth accumulation, the ecological footprint of an average Gambian will more than double by 2050 (higher for urban dwellers compared to rural settlers). Similarly, as population growth increases, the biocapacity deficit will grow exponentially. Consequently, The Gambia will continue to be not only an economically indebted developing country but also an 'ecological debtor' (i.e., importing biocapacity) from countries with some natural capital reserves, referred to as 'ecological creditors' (Wackernagel et al., 1999; Kubiszewski et al., 2013; Wackernagel et al., 2019; Wackernagel and Rees, 1996).

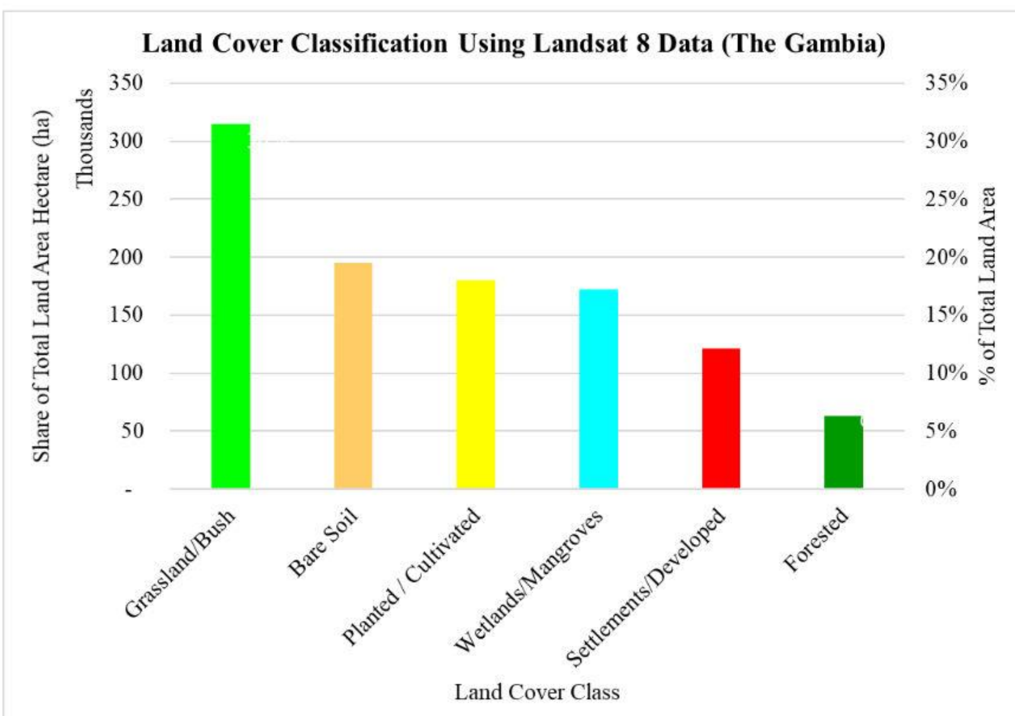
Forests, as natural capital, are global carbon sinks, natural air conditioners, habitats for biodiversity, homes for millions of people, and producers of foods and other essential ecosystem services such as carbon sequestration, flood mitigation, soil retention, and water purification (Houghton & Hackler, 2006; Lewis et al., 2009; Ostrom & Cox, 2010; Harris et al., 2012; Smith et al., 2014; United Nations et al., 2012; Heß et al., 2018; Le Quéré et al., 2018). In most developing countries, forests are the leading suppliers of domestic energy sources. For instance, in The Gambia, forests provide more than 85% of the local energy demand in the form of charcoal production (EU/MNRE, 1992, cited in First National Climate Communication, 2003). Besides, forests regulate surface air temperature and contribute to precipitation via transpiration (Smith et al., 2014; Dampha, Fogelson, Osborne, & Shokohzadeh, 2017).

In The Gambia, approximately 42-48% of the total land area is considered as forests, depending on the definition of a forest (Sillah, 1999; Second National Climate Communication, 2012; Heß et al., 2018). Forest cover categories in The Gambia include state forests, forest parks, protected forests, private forests, and community forests. The Forestry Department manages 96% of these forest categories. For instance, according to Sillah (1999), the Department manages a total of 32,729 hectares (ha) of land, classified as national forest parks, including 4,352 ha in the West Coast Region (my study site).

Using the most recent satellite imagery (captured in December 2019 from Landsat 8), this study conducted a land-use land cover (LULC) analysis of the entire country with a specific focus on the southwestern region. The result finds a percent land area of 42.5% as national forests, including shrub/grasslands, planted, closed, and open forest cover types (see Map 3.1). Of the total closed and open forest covers of The Gambia, 68% are found in the West Coast Region (WCR).

Map 3.1. Land-use Land Cover Map The Gambia

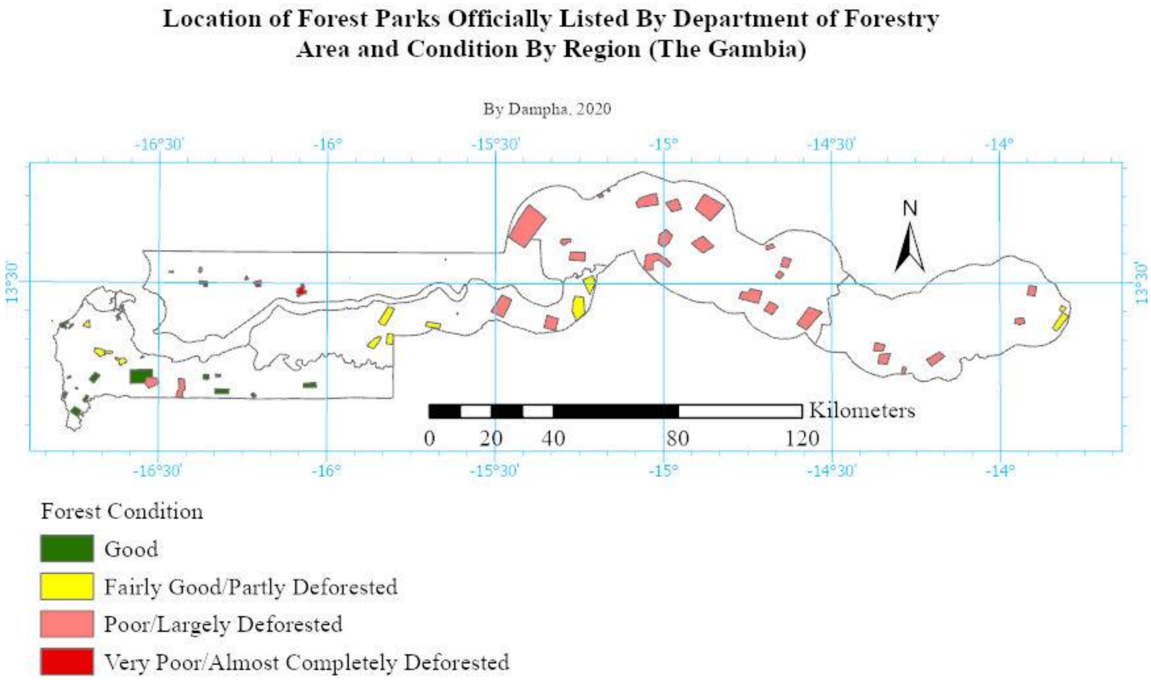


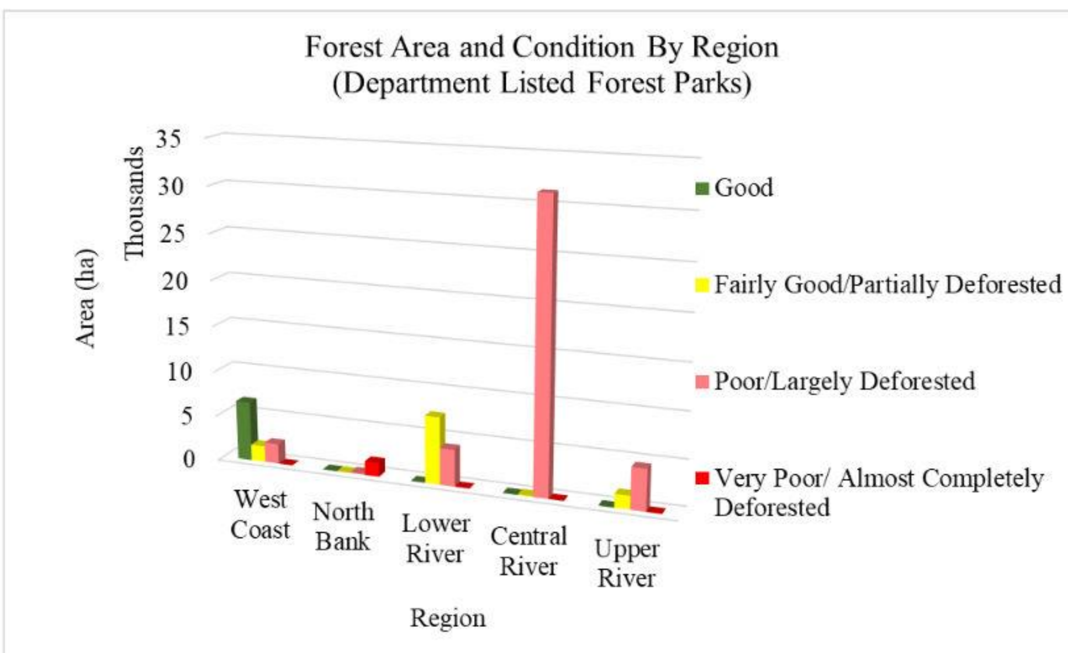


Since 1946, human activities have led to the destruction of nearly 50% of the country's forest cover relative to my estimates using 2019 satellite data (Sillah, 1999). According to First National Climate Communication (2003), the rate of deforestation in The Gambia stands at about 6% per annum. Deforestation is the destruction and conversion of forests into other land-use functions caused by human activities and natural disturbances (Harris et al., 2012; Houghton et al., 2012; Dampha et al., 2017). Others consider an ecosystem to be deforested when human activities reduce tree canopy to less than 10-30% (Van Der Werf et al., 2009). In contrast, forest degradation is measured as partial deforestation, with more than a 10-30% tree canopy remaining (Van Der Werf et al., 2009). Deforestation and land-use change account for about 20% of the total carbon emissions into the atmosphere globally (Gaston, Brown, Lorenzini, & Singh, 1998; Houghton & Hackler, 2006; Gorte, 2007; Van Der Werf et al., 2009).

The Department of Forestry in The Gambia has recently published data on the area of forest parks nationally (GBoS, 2020). Using Google Earth Pro, I digitized the locations of these parks and assessed their habitat condition based on canopy cover density by region (see Map 3.2). I find several open forestlands unnamed and unlisted by the Department. The differences in forested sites are discernible when Map 3.1 above is compared to Map 3.2 below. The majority of the unlisted forestlands are state-owned and community-managed. Map 3.2 brings my attention to the West Coast Region, where significant portions of the forest cover are in ‘good’ habitat conditions. The said region is, however, highly susceptible to human-induced activities causing irreparable environmental damage and non-substitutable loss of critical natural capital. These activities include the rapidly growing land-use conversion from forest to estate and infrastructural development projects (i.e., urbanization) and the increasing bushfires attributed to global climate change impacts.

Map 3.2. Location of National Forest Parks Listed By Forestry Department, The Gambia





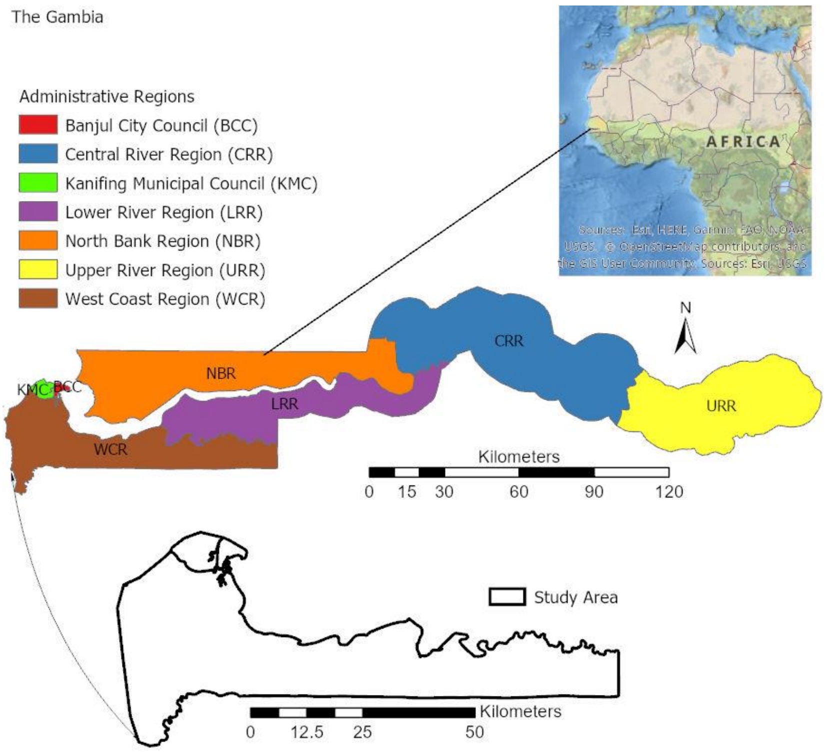
Given the above introduction, this chapter focuses on LULC change detection between 1985 and 2020 in the southwestern area of The Gambia. The research hypothesizes that (a) building a new capital city in the West Coast Region of the country will substantially accelerate the depletion of the remaining forest cover, (b) increasing urbanization is the leading driver of LULC change between 1985 and 2020, and (c) carbon capture and storage capacity have meaningfully declined from 1985 to 2020.

The chapter is divided into five sections. Section one introduces the study area. Section two presents the methodologies used (GIS-based remote sensing) and (InVEST carbon model). Section three shows the results of past, current, and projected LULC changes as part of the first component of the three-scenario-based analysis used in this study. The second component entails carbon stock, storage, and sequestration results generated from the InVEST model vis-à-vis the three-scenarios of the study. Section four discusses research findings in relation to other studies. Section five presents conclusions and study limitations.

3.2 Study Area (Southwestern Gambia)

This geospatial analysis covers three administrative regions of The Gambia: Banjul City Council (BCC), Kanifing Municipality (KM), and the West Coast Region (WCR). These three administration regions constitute the "southwestern region" of The Gambia (see study site Map 3.3). The southwestern region, also commonly known as the urban Gambia, accommodates nearly 60% of the nation's population. The urban population has been increasingly growing due to rural-urban migration, natural population growth, and immigration of nationals from other African and European countries. Over 20% of the country's population migrated, mainly from the rural areas, to the study region since 1983 (GBoS, 2013a). The migration decisions are principally influenced by prospects for urban employment opportunities and better living conditions. In some areas, urban population density is nearly 5000 people per square kilometer (GBoS, 2013a). Increasing urbanization and natural resources dependence have contributed to a large-scale LULC change in the study area. This is affecting the forest ecosystem and all of the direct and indirect services they provide to improve human wellbeing.

Map 3.3. Map of the Study Area

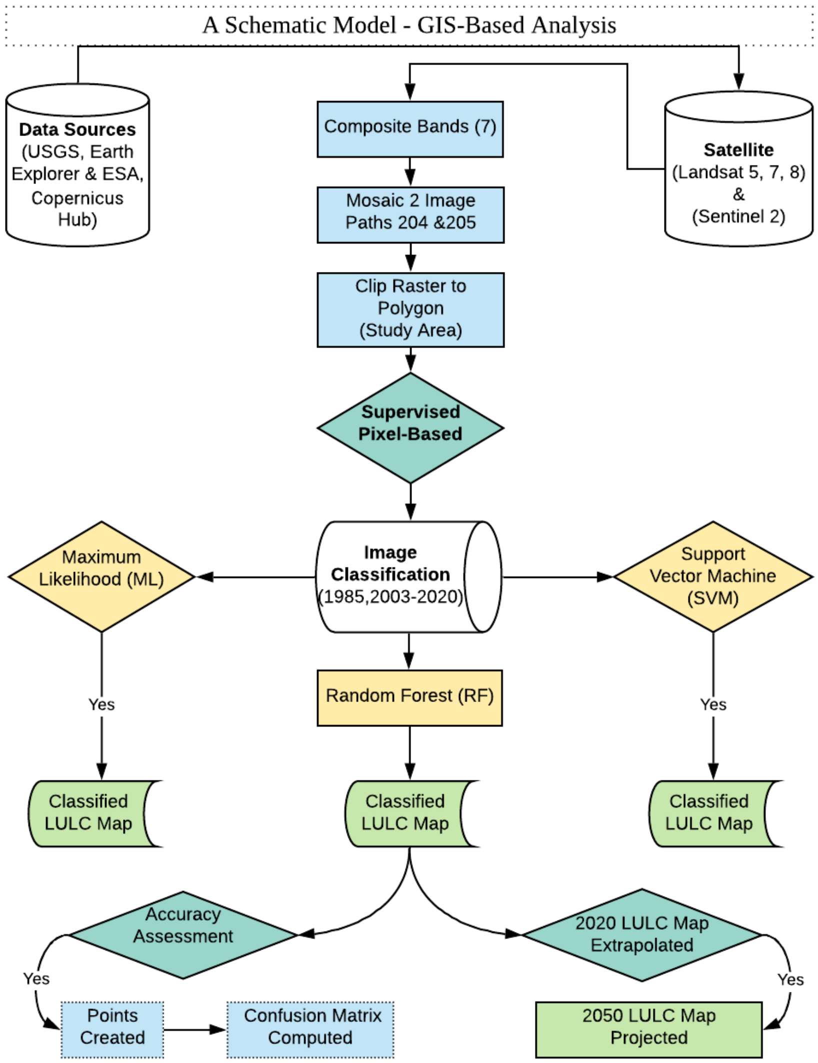


3.3 Methods

3.3.1 GIS-based Analysis

The first component of this study used ArcGIS Pro software (Version 2.5.0, 2019a) with remotely sensed data to assess LULC change. In Figure 3.1, I outline a schematic model of the GIS-based portion of the data analysis. I used a pixel-based supervised classification method and ran three classification algorithms to compare their relative accuracy. The random forest (RF) algorithm produces a relatively better result in comparison to the maximum likelihood (ML) and the support vector machine (SVM) algorithms. The difference is almost visually unnoticeable; thus, I do not present the LULC maps derived from applying the ML and SVM algorithms.

Figure 3.1. A Schematic Model- GIS-Based Analysis



The primary data used in the GIS-based component was remotely sensed imagery of the Landsat satellite, operated by the US Geological Survey (USGS). I also used data from the European Space Agency's Copernicus satellite, Sentinel-2 A, for accuracy assessment purposes. This is because Sentinel 2 has a 10-meter spatial resolution; thus, it is more likely to reflect the ground-truth of the study site than Landsat data with a 30meter resolution. I did not use Sentinel-2 for conducting the LULC change detection because the satellites (both Sentinel-2 A and B) were recently launched in 2017.

I present the details of the various processed Landsat images in Table 3.1. The main criterium for image selection from the USGS database (Earth Explorer) was that the individual satellite image paths must not have more than 16 days temporal difference, either within the same year or between two consecutive years. Atmospheric effects, such as scattering and cloud cover, reduce my chances of selecting closed-date images. In remote sensing, the smaller the temporal differences, the lesser the spectral variations, and the better the overall accuracy of the analysis. It was challenging to find one or two satellite paths needed to cover the entire study area, with closed dates in the same year, due to the temporal resolution of the Landsat satellite (i.e., orbiting the globe in every 16 days). Thus, I eventually used an image from the previous year, falling within 16 days selection criterium. For example, I mosaiced satellite paths 205 and 204 images, respectively, captured in 1985 and 1986 to cover the areal extent of the study site. A similar approach was exercised for 2020 and 2019. In all cases, path 205 image covers 90% of the study area (see areal image extent in Table 3.1).

Table 3.1. Satellite Data Sources for GIS-based Analysis

Landsat Name	**Sensor**	**Sat. Path aerial**	**Sat. Row**	**Spatial Resolution**	**Image Captured Date**	**Color NIR (Areal Extent)**
5	MSS/TM	205	51	30m	Feb. 6, 1985	
5	MSS/TM	204	51	30m	Feb. 18, 1986	
7	ETM+	205	51	30m	Feb. 16, 2003	
7	ETM+	204	51	30m	Feb. 9, 2003	
8	OLI/TIRS	205	51	30m	Feb. 7, 2020	
8	OLI/TIRS	204	51	30m	Feb. 13, 2019	

3.3.2 InVEST-Based Analysis

The second methodological component of this study used the Integrated Valuation of Ecosystem Services and Tradeoff (InVEST) model, developed by the Natural Capital Project (NatCap,2020). Like many InVEST models, the InVEST Carbon Storage and Sequestration model examines how human and natural disturbances contribute to changes in the ecosystem service flows and stocks for the benefit of society and the biophysical environment (NatCap, 2020). Carbon sequestration and storage in the terrestrial ecosystem is possibly the most widely recognized of all ecosystem services (Stern 2007, IPCC 2006, Canadell and Raupach 2008, Capoor and Ambrosi 2008, Hamilton et al. 2008, Pagiola 2008, cited NatCap, 2020). The carbon model uses LULC maps together with estimates of four carbon pools, namely, "aboveground biomass, belowground biomass, soil carbon, and dead organic matter," to determine the total carbon storage of a terrestrial ecosystem (NatCap, 2020). The second element of the model provides an estimate of the total amount of carbon sequestrated between two different periods (NatCap, 2020). The final part uses the social cost of carbon and its annual rate of change as well as a discount rate to compute the economic value of carbon dioxide ($C0_2$) to society (NatCap, 2020). It assumes that the sequestered value of a ton of carbon is equivalent to the costs of avoided social damage of not releasing the same ton of carbon into the atmosphere (Tol 2005, Stern 2007, cited NatCap, 2020). The model has few limitations (discussed below), but so far, it is one of the most commonly used models for ecosystem services valuation studies globally.

The required data, including their sources and descriptions for running the InVEST Carbon model, are presented in Table 3.2. below. The carbon pool values were informed by Saatchi et al. (2011) estimate of the total carbon stock in The Gambia (400,000 metric tons). This value is similar to FAO's (2015) estimate (359,000 metric tons) of carbon content in living forest biomass of the country. The sample CSV file of the InVEST Carbon model informs the distribution of the carbon pool values in Table 3.3.

Table 3.2. Data Source and Description for the Running the InVEST Carbon Model

Name	File Format	Source
LULC Maps	Raster (30by30)	Landsat 5,7, &8 (USGS)
Carbon Pools	CVS (see Table 3.3)	Informed by the model documentation (NatCap, 2020)
Carbon price per metric ton	US$ Integer value (represented as "V" in the equation below)	Stern (2006) & Nordhaus (2007)
Market discount rate in the price of carbon	An integer percent value, (represented as "r" in the equation below)	Stern (2006) & Nordhaus (2007)
Annual rate of change in the price of carbon	An integer percent value, (represented as "c" in the equation below)	Informed by model documentation (NatCap, 2020)

Table 3.3. Carbon Pools Estimates Used

Code	LULC Name	C above	C below	C soil	C dead
0	Water	0.000	0.000	0.000	0.000
1	Developed/Settlements	0.000	0.000	0.112	0.000
2	Bare Soil/ Sand	0.011	0.011	0.112	0.000
3	Forest	0.501	0.311	0.712	0.128
4	Shrubland	0.100	0.070	0.280	0.034
5	Planted/Cultivated	0.022	0.011	0.112	0.000
6	Wetland/Mangrove	0.078	0.034	0.280	0.000

The annual rate of change in the price of carbon was set at -1%, meaning I treated the future societal value of sequestrated carbon to be greater than the amount of carbon sequestrated now. Assuming that future climate change damages to society will be higher as emissions of greenhouse gases continue to increase over time (NatCap, 2020).

The value of the sequestrated carbon over time for a given parcel x is:[10]

$$\text{Value\_seq}_x = V \frac{\text{sequest}_x}{\text{yr\_fut} - \text{yr\_cur}} \sum_{t=0}^{\text{yr\_fut}-\text{yr\_cur}-1} \frac{1}{\left(1+\frac{r}{100}\right)^t \left(1+\frac{c}{100}\right)^t}$$

The debate on the social cost of carbon and the discount rate(s) to use for long-term climate change interventions remains unsettled. For a detailed discussion on this controversial topic, refer to the Stern Review (2009) and several counterarguments from other prominent scholars such as Yohe (2006), Tol (2006), Weitzman (2007), Nordhaus (2007; 2017), Heal (2009) Almansa & Martínez-Paz (2011) and Gollier (2013), Davidson (2014, 2015). Considering the divergent views on the price and the discount rate(s) for climate change-related cost-benefit analysis, I used two different social costs of carbon with their associated discount rates in this study. I present both net present values (NPVs) in the result section for policymakers to determine which economic value estimate to select. The carbon prices and discount rates used in this study were gathered from Stern (2007) and Nordhaus (2007) (see Table 3.12 below). The Stern and Nordhaus' values are, respectively, based on prescriptive (i.e., normative economics) and descriptive (i.e., positive economics) approaches to discounting (Davidson, 2014). Whether one uses either the positive economics view or the normative economics view, the total economic value of carbon to society can vary significantly (see results section below). On the one hand, advocates for the normative economics approach prefer a lower discount rate and a high social cost or price of carbon per ton (see, e.g., Broome, 1992; Cline, 1992; Stern, 2007, cited in Davidson, 2014). On the other hand, the positive economics scholars favor the use of a higher discount rate and a lower social cost of carbon (see, e.g., Birdsall and

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[10] *The InVEST Carbon model equation, copied from model documentation (for more details, see NatCap, 2020).*

Steer, 1993; Lind, 1994; Lyon, 1994; Manne, 1995; Nordhaus, 2007, cited in Hope & Maul, 1996).

3.4 Results

3.4.1 Land-use Land Cover (LULC) Change Detection

This analysis detects a significant change in LULC between 1985 and 2020 in the southwestern region of The Gambia (see Map 3.4). In 1985, 68% of the total land area in the study region comprised of "green spaces" or "forests," including shrub/grassland, planted, open, and closed forest areas. Forest areas declined by 5% in 2003, and 18% in 2020, relative to the 1985 land cover composition (see Table 3.4). These correspond to forest area loss of 5,950 ha from 1985 to 2003 and 22,408 ha from 1985 to 2020 (see Table 3.5). In contrast, the developed/urban areas increased by 15% from 1985 to 2003 and 65% from 1985 to 2020. Overall, since 1985, the study area has lost 22,408 ha of green spaces, including shrub/grassland, planted gardens, and highly forested sites described by the officials as "closed" and "open" forest parks. In this study, mangrove forests are excluded from my definition of green spaces or forests.

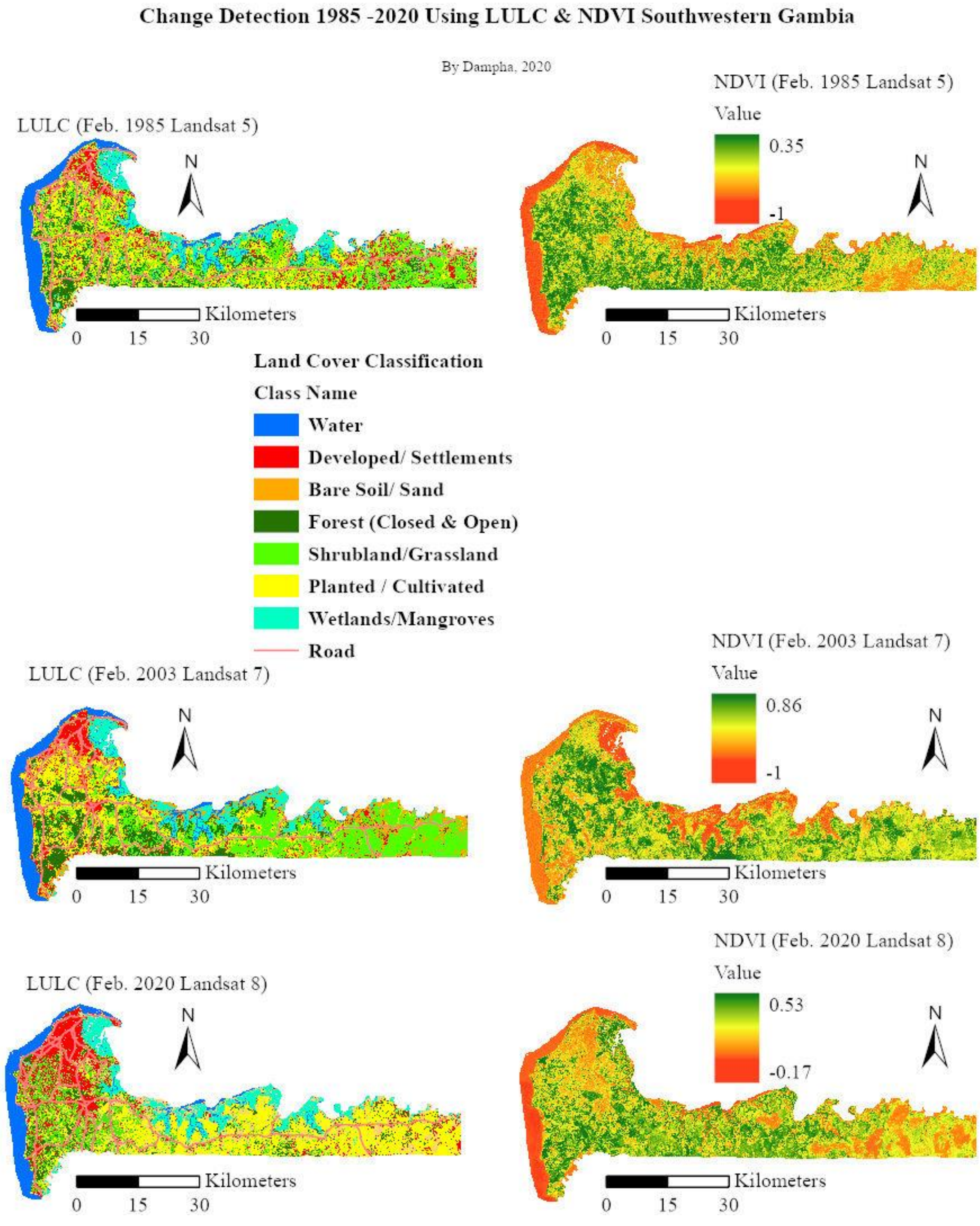
Table 3.4. Percent Change of LULC 1985, 2003, and 2020

LULC Type	1985 (ha)	2003 (ha)	2020 (ha)	% Change (2003-1985)	% Change (2020-2003)	% Change (2020-1985)
Forest/Bush/ Grassland /Planted	122,020	116070	99612	-5%	-14%	-18%
Developed/ Settlements /Bare Soil/Sand	36,675	42127	60,520	15%	44%	65%
Wetland/Mangrove	21,532	22,032	20,095	2%	-9%	-7%
Total	180,227	180,227	180,227			

Table 3.5. Absolute LULC Change 1985, 2003, and 2020

LULC Type	1985 (ha)	2003 (ha)	2020 (ha)	Abs. Diff. 2003-1985 (ha)	Abs. Diff. 2020-2003 (ha)	Abs. Diff. 2020-1985 (ha)
Forest/Grassland /Planted	122,020	116,070	99,613	-5950	-16458	-22408
Developed/ Settlements/Bare Soil/Sand	36,675	42,646	60,630	5450	18395	23845
Wetland/Mangrove	21,532	22,082	22,095	500	-1937	-1437

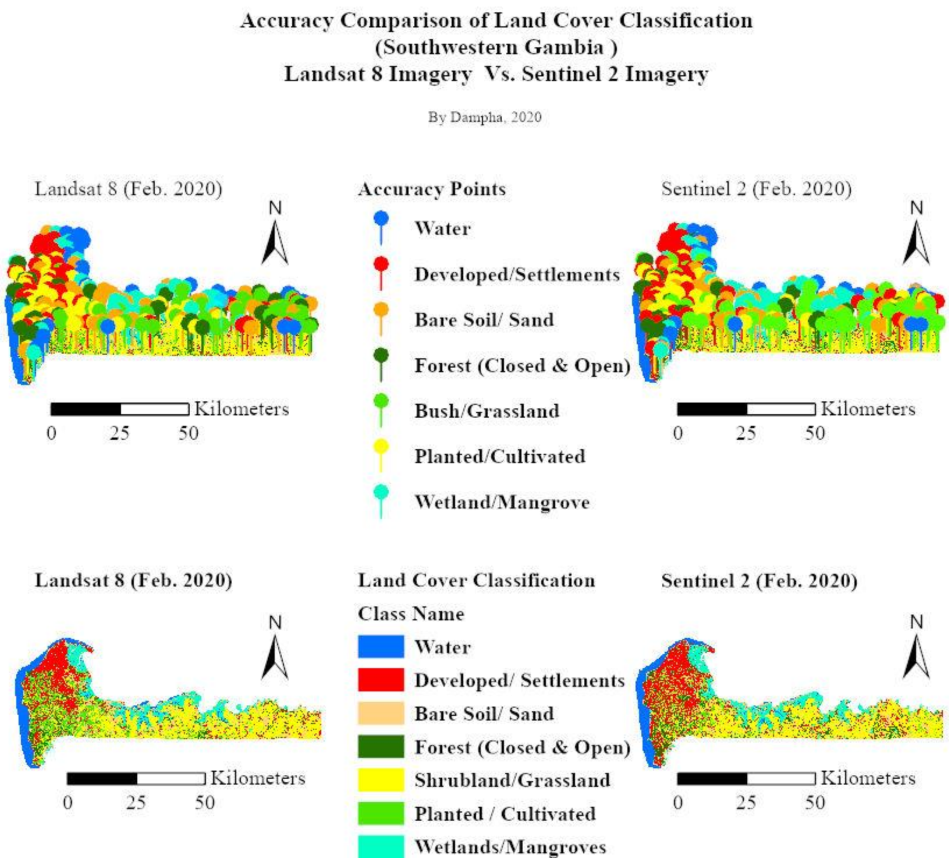
Map 3.4. Change Detection -1985-2020 (Using LULC Types & NDVI)



3.4.1.1 Accuracy Comparison of LULC Maps

The study included an accuracy comparison of data captured in February 2020 by two different satellites (Landsat 8 and Sentinel-2). I used the LULC classified map, derived from Sentinel-2, as the reference map. The reference map is assumed to be more accurate (10m spatial resolution) than the one made from the Landsat 8 imagery (see Map 3.5). This is an "accuracy comparison," not an "accuracy assessment." In performing an accuracy assessment, the reference map should have been predetermined and independent of the producer's analysis. I could not do an accuracy assessment in this study because no previously classified map is traceable and reliable for that purpose. Notwithstanding, using Sentinel-2 imagery for accuracy comparison is better than none and useful enough as per the study objectives.

Map 3.5. Accuracy Comparison of 2020 LULC Maps



I used the accuracy assessment tools in ArcGIS Pro to conduct an assessment comparison. The analysis created 301 accuracy points, distributed across the study area, using an equalized stratified random sampling strategy in the ArcGIS Pro software (see

Map 3.5). The confusion matrix generated from the process is presented in Table 3.6 below. The assessment yields an overall map accuracy of 73%. The overall map accuracy indicates the proportion of classified sites correctly mapped with reference to the presumably “ground-truth” in this case, the reference map created from using Sentinel-2 imagery, with finer spatial resolution compared to Landsat 8. Other output accuracy indices include the Producer's Accuracy, the User's Accuracy, and the Kappa Coefficient. The Kappa Coefficient has values ranging from 0 and 1. The higher the number, the better the agreement between the classified map (derived from Landsat 8) and the reference map (derived from Sentinel-2).

The Producer's Accuracy shows the map accuracy from the map maker's perspective, while the User's Accuracy presents the reliability of the map from the end user's point of view. The Producer's Accuracy is the probability that a real feature on the ground (Sentinel-2) is correctly shown on the classified map (Landsat 8). The User's Accuracy indicates the likelihood that a class on the classified map (Landsat 8) is actually present on the ground (Sentinel-2). The Producer's Accuracy is a complement of omission error, while the User's Accuracy is a complement of commission error. You can compute the errors of omission and commission by, respectively, subtracting the Producer's Accuracy and User's Accuracy percent values from 100%. Type I and Type II errors also correspond to omission and commission errors (Humboldt University Geospatial Online Class, 2014).

From the confusion matrix Table 3.6 below, one can read that "bare soil/sand" and "planted/cultivated" classes have the least reliability from the viewpoint of the map user. In contrast, the "developed/settlements" and "brush/grassland" have the lowest accuracy from the map maker's point of view. The "developed/settlements" class is most confused with the "bare soil/sand" class. For example, 10 points (pixels) that actually represent a "developed/settlements" area on the ground were incorrectly classified as "bare soil/sandy." This is not a significant concern as developed/settlement sites are inextricably associated with areas of bare soil or sand. For the purpose of this analysis, I can assume that these classes are reliable indicators of urban settlements. Besides, the table shows that the "brush/grassland" class is mostly confused with "planted/cultivated" and "forest." Among the land cover type, the forest class (closed and open) has the highest Producer's Accuracy (91%). Therefore, I am confident about the reliability of this map in terms of its ability to distinguish urban settlements from areas with green spaces.

Table 3.6. Confusion Matrix for the recent LULC Classification

Reference Data (Sentinel 2 Feb. 2020)

Rows: **Landsat 8 (Feb. 2020)**

Class Value	**Water**	**Developed/**	**Bare Soil/ Sand**	**Forest**	**Bush/ Grassland**	**Planted/ Cultivated**	**Wetland/ Mangroves**	**Total**	**User's Accuracy**	**Commission**	**Kappa**
Water	**34**	0	3	0	0	0	6	43	**79%**	**21 %**	
Developed/ Settlement	0	**34**	3	0	3	3	0	43	**79%**	**21 %**	
Bare Soil/Sand	0	10	**23**	1	4	1	4	43	**53%**	**47 %**	
Forest(closed /Open)	0	3	0	**30**	6	3	1	43	**70%**	**30 %**	
Bush/ Grassland	0	3	0	0	**37**	1	2	43	**86%**	**14 %**	
Planted/ Cultivated	0	6	0	1	8	**28**	0	43	**65%**	**35 %**	
Wetland/ Mangroves	0	0	7	1	1	0	**34**	43	**79%**	**21 %**	
Total	34	56	36	33	59	36	47	**301**			
Producer's Accuracy	**100 %**	**61 %**	**64 %**	**91 %**	**63 %**	**78%**	**72%**		**<u>73%</u>**		
Omission Error	**0%**	**39 %**	**36%**	**9 %**	**37%**	**22%**	**28%**				
Kappa											**.69**

3.4.1.2 Comparison with State Listed Forest Parks in Southwestern Region

Based on the Forestry Department's categorization of forest types, I find two kinds of forest categories in healthy habitat conditions in the Southwestern region. They are classified as closed and open forest parks, respectively. Of the total land area (182,338 ha) in the study region, officially listed forest parks[11] (i.e., closed forest) account for 2.37%, while unofficial or open forestland represents 3.38%. The open forests are mainly under community and private management schemes (Sillah, 1999). This study used the normalized difference vegetation index (NDVI) values and applied image interpretation techniques used in remote sensing to evaluate the habitat conditions of these forest areas (see Map 3.4). However, given their positioning in the urban landscape associated with the current property regime type, open forests (a common-pool resource), these forestlands are exposed to a moderate and a high risk of human interference in the study region (see Table 3.7). The vulnerability nature is a tragedy of the commons problem (Ostrom & Cox, 2010). If unmanaged and unprotected by both local and national stakeholders, the region will suffer from further deforestation and land-use conversion (Feeny, Berkes, McCay, & Acheson, 1990). Map 3.6 complements Table 3.7 below by showing the spatial positions of both open (community) and closed (state) forest parks in the study site.

Table 3.7. Open Forest Parks -My Proposed Protected Areas (PAs) in the West Coast Region

Location Description	Direction to Site	Forest Condition	Risk of Destruction	Area (ha)
Bassori	East	Good	High, if Unprotected	2719.73
Kiti	West	Good	High, if Unprotected	577.63

[11] The Department of Forestry reports data on only 4352 ha of forest parks in the recent national environmental compendium (GBoS, 2020).

Gunjur	East	Good	High, if Unprotected	233.25
Berrending	South	Good	High, if Unprotected	552.72
Gunjur	West	Good	High, if Unprotected	168.62
Kunjukeng	West	Good	High, if Unprotected	66.18
Nyantan Faraba	East	Good	High, if Unprotected	32.94
Berefet	South	Good	Moderate, if Protected	271.34
Somita	North	Good	Moderate, if Protected	131.22
Kanjabina	North	Good	Moderate, if Protected	676.49
Batending	South	Good	Moderate, if Protected	142.20
Kanfenda-to-Kanilai	West	Good	Moderate, if Protected	589.21
Total Land Area (Proposed PAs)				6161.53
Proposed PAs as a share of the total land area, WCR (Open Forest)				**3.38%**
Official Forest Area as a share of the total land area, WCR (Closed Forest)				**2.37%**

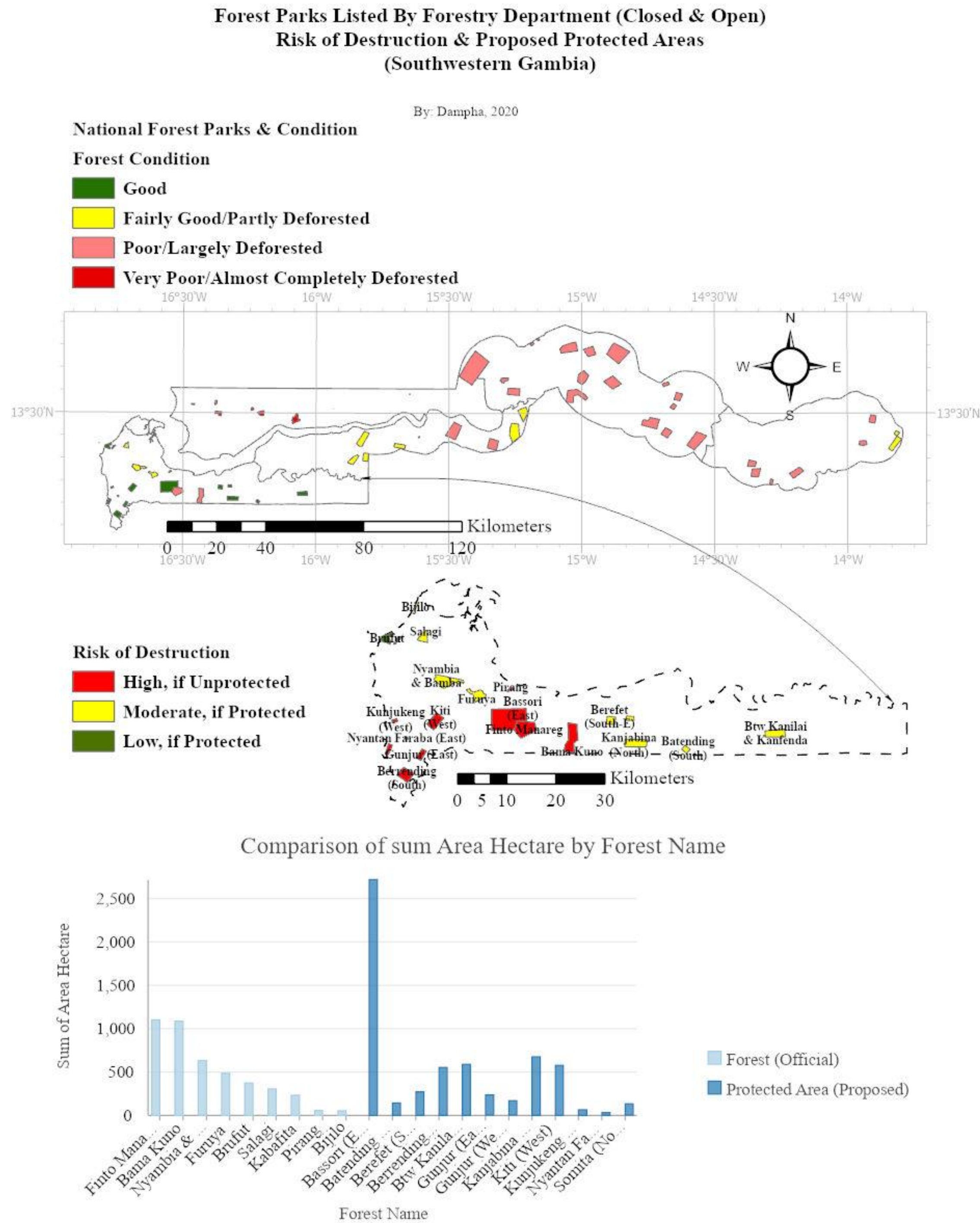
I contrast the area estimates of forest parks from my assessment to that of the official records of closed forest parks in the West Coast Region (see Table 3.8. below). This study finds no evidence of major land-use conversion of these closed forest parks relative to the official estimates from the Forestry Department. Though I have seen a decline in forest area for all the parks except in Bijilo, and Nyambai and Bamba forest parks combined. I can confirm that the difference between this study and the department's estimates of the areal extent of Nyambai and Bamba forest parks combined is very likely a recording error from the latter (i.e., the Forestry Department). Though the measurements of the forest parks look similar, forest cover degradation is highly noticeable, especially in Bama Kuno and Finto Manareg, both located in Kombo East district (see Table 3.8. below). The degradation is evaluated by assessing the 2019 landscape conditions of the parks, as remotely sensed by satellite imagery. The results are also compared with images from Google Earth Pro.

Table 3.8. Forest Parks- Area (ha) & Conditions in My Study Area (Dept. of Forestry Est. Vs. Est. of this Study)

District in West Coast Region	**Name of Forest Park**	**Dept. Forestry Est. (ha)**	**My Study Estimate (ha)**	**Forest Condition**
Kombo North	Bijilo	51.5	52.81	Fairly Good/Partly Deforested
	Salagi	312	303.13	Fairly Good/Partly Deforested
Kombo South	Nyambai & Bamba	591	629.67	Fairly Good/Partly Deforested
Kombo Central	Kabafita	243	232.94	Fairly Good/Partly Deforested
	Furuya	488.8	484.47	Fairly Good/Partly Deforested
	Pirang	60.4	55.86	Fairly Good/Partly Deforested
Kombo East	Finto Manareg	1106.6	1101.94	Poor/largely Deforested
	Katilenge/ Brufut	406.8	371.57	Good
	Bama Kuno	1092	1088.63	Poor/largely Deforested
Total (ha)		4352.1	4321.02	

Source: Department of Forestry (cited in GBoS, 2020) & My Study Estimates

Map 3.6. Forest Cover (Closed & Open): Risk of Destruction & Proposed Protected Areas



3.4.2 Land-use Land Cover Projection (2020-2050)

The future LULC change projections analyzed in this study are based on three different development pathways, namely, a business-as-usual (BAU) scenario, a new capital city (NCC) scenario, and a sustainability (SUST) scenario. The BAU scenario extrapolates future LULC change based on the past trends observed from this GIS-based analysis and considerately accounts for projected population growth and economic prosperity. The NCC scenario predicts LULC changes expected if The Gambia decides to locate its next capital city, as discussed in chapter two above, in the study region (Southwestern Gambia). The SUST scenario includes policy interventions, which, if designed, implemented, and enforced, can drastically minimize the loss of forest cover and enhance carbon sequestration capacity in the study area.

3.4.2.1 Business-as-Usual (BAU) Scenario

Overall, the BAU scenario assumes that the current national deforestation rate of 6% will continue (National Climate Communication, 2003). The scenario makes the following critical assumptions about land-use change and land cover conversion.

First, the BAU scenario accounts for forest cover degradation for direct and indirect local livelihood sustenance uses. The majority (70%) of Gambians depend on agriculture and forest resources for employment and for obtaining their daily survival means. For instance, in The Gambia, forests provide more than 85% of the local energy demand in the form of charcoal production (EU/MNRE, 1992, cited in First National Climate Communication, 2003). In 2014, charcoal production in The Gambia was estimated to be over 60,000 tons (Urquhart, 2016). Also, forest trees are used in traditional medical treatments, and such forest products are extracted and sold in the markets (Sillah, 1999). As the national population continues to grow at an annual rate of about 2.9 to 3% (a trend recorded since 1970), the demand for forestland and forest resources will accelerate (World Bank, 2020).

Second, the BAU scenario considers land-use conversion from forest to developed areas for urban expansion, industrial, and infrastructural development based on trends observed in the region. There have been lots of land grabbing, including forested areas, from the local communities by the government, and through public-private partnership agreements. Another aspect of the land-use conversion of forestland is for agricultural production. As current farmlands become estate areas, local communities are cutting down more forested regions to cultivate crops such as groundnut and other cereal products. Commercial or mechanized farming is predicted to rise with an increase in per capita income and private sector investment in agricultural development. Overall, change in forest cover/green spaces will be driven by the high demand for urban land-use conversion, as the country's population and its per capita income and ecological footprint are projected to increase by two-fold. And its urbanization rate continues to intensify by 2050.

Finally, the BAU scenario also factors in current management strategies and national policy objectives. It assumes that all official closed forest parks (4,321 ha) will be managed and maintained as prescribed by the National Forest Policy objectives (Forestry Sub-Sector Policy Gambia, 2010). The BAU scenario recognizes the current roles of state and non-state actors, including the local communities. It assumes that all current forest stakeholders will participate in the co-management process of national forestlands. For example, The Gambia government, in partnership with the United Nations Environment Program (UNEP), secured funding from the Green Climate Fund (GCF) to implement a six-year ecosystem-based Adaptation (EBA) project. One of the project components is to restore and regenerate 10,400 ha of degraded forest, savanna, and mangroves, representing 1% of the national territory as forests (Nyangado & Pouakouyou, 2017). Though, the region of focus for this analysis is not benefiting from the EBA forest regeneration efforts. However, ongoing collaborative efforts like the EBA project under the BAU is forecasted to protect 3% (5,470 ha) of open forest areas, maintain 3% (5,470 ha) of the planted area, 3% of grassland, sustain 2% (3,646 ha) of closed forest parks, and restore 1% (1,823 ha) of green spaces through the integration of urban green infrastructure initiatives such as street trees in urban planning. The existing non-state interventions in forest regeneration and protection initiatives by international conservation organizations and local environmental groups are expected to continue. Such organizations include the United Nations Environment Program (UNEP), Green-Up Gambia, Household Disaster Resilience Project (HELP-Gambia), and Community Action Platform for Environment and Development (CAPED) (see Figure 3.2 and Figure 3.3).

The Gambia lost nearly 50% of forestland within the last eight decades. According to earlier work, by 1983, 35,550 ha of forest parks and potential community forest areas were degraded in the study region (Sillah, 1999). Since 1985, this study observes a significant reduction of forest areas in the southwestern part of The Gambia (see Table 3.4 above). Forest cover loss tripled between 2003 and 2020 compared to the deforestation detected between 1985 and 2003. Considering that the country's small land area remains almost constant with some parts becoming inhabitable with rising sea-levels, this analysis predicts an 80% decline of forests by 2050 relative to the 2020 level if business-as-usual continues. This reduction corresponds to a forest cover loss of approximately 79,556 ha. As a proportion of the total land area, forests/green spaces will likely decrease from 55% in 2020 to 11% in 2050 (see Table 3.9). By mid-century, urban areas will grow from 34% in 2020 to an estimated 74% of the total land area in the study area.

Table 3.9. Percent of Total Area By LULC (Trends with BAU Protections)

LULC Class	**1985**	**2003**	**2020**	**2035 Projection (BAU)**	**2050 Projection (BAU)**
Forest/Bush/Grassland/Planted	68%	64%	55%	30%	11%
Developed/Settlements/Bare Soil/Sand	20%	23%	34%	58%	74%
Wetland/Mangrove	12%	12%	11%	12%	15%
Total	100 %	100 %	100%	100%	100%

Figure 3.2. Example of an Environmental Group in Action (Green-up Gambia)

Image Credit: Green-Up Gambia, 2019

Figure 3.3. Example of an Environmental Group in Action (HELP-Gambia)

Image Credit: HELP-Gambia, 2018

3.4.2.2 New Capital City (NCC) Scenario

Studies have recommended The Gambia government to build a new capital city (NCC), as the current one is projected to be underwater by 2100, due to rising sea-levels (Jallow, Barrow, & Leatherman, 1996; Hills & Manneh, 2014; Coates & Manneh, 2015). I consider this proposal as a long-term climate change adaptation plan. In chapter 2, we learned that over half of Gambians preferred the next capital city to be situated in the West Coast Region (i.e., within the southwestern region, as referred to in this chapter). Suppose that the government declares a site in the southwest region by 2030; this scenario makes three principal assumptions.

First, it assumes that the government will grab and convert a significant part of forestland to developed areas. In chapter 2, this area is estimated to cover 8,945 ha. I assumed that this area of land, including forested sites, will be ceded by the government using provisions in the current State Lands Act (1991) (see landownership details in chapter two above). Constructing buildings and other infrastructural development projects will be used to justify this land-use change. Recent anecdotal evidence supports this claim. In 2018, the Barrow Administration decimated over 16 ha of the Bijilo Monkey forest park purposely for building an international conference center, funded by the Chinese government (see Figure 3.4).

Second, developing a new capital city in the study region is assumed to increase land-use demand for human settlements, as population size grows, and the land area remains constant as a fixed asset. An increase in demand will trigger a spike in property values, thus motivating landowners to sell the remaining forest areas under their custody to estate developers. This assumption is based on the law of supply and demand, as well as the gravity model of migration. The gravity model predicts spatial interaction between destinations on the pretext of population size and distance between destinations. The model illustrates that movement is directly related to the populations of places and inversely related to the distance between them. Today, 60% of the national population lives in the southwestern region. The region’s current population density is over 3,000 people per square kilometer. By 2050, with the doubling of the national population, over 6,000 people will occupy a square kilometer of land in the study area. Constructing a city in the region will ultimately attract more Gambians and non-Gambians alike.

Finally, I assumed that most ongoing restoration and conservation programs, as specified under the BAU scenario, will be significantly undermined and undervalued with the establishment of a capital city. Will you restore and protect forestland for intra-and intergenerational benefits when people's basic needs are unmet? Many environmentalists and conservation groups will have to answer this ethical question. As evident in most developing countries, people in The Gambia will likely prioritize creating spaces to live and cultivate food to survive than to maintain forests for other ecosystem service benefits such as carbon sequestration and air filtration. Theories such as the hierarchy of needs supported this claim. According to Maslow's hierarchy of needs, people satisfy their immediate physiological and safety needs (e.g., food and shelter) before worrying about other elements of self-actualization and sustainability issues (Poston, 2009). As Udo & Jansson (2009) stated, "as in Maslow's hierarchy of needs, nations that are struggling to survive are less concerned with environmental sustainability than advanced and stable nations."

Given the above assumptions, this analysis finds an estimated 80% (79,690ha) of the current green space areas, excluding closed and open forest parks, will be vulnerable to land-use conversion and land appropriation. Under the NCC scenario, the southwestern region would be left with approximately 5% of the entire land area as forests. The remaining 5% can be guaranteed if only aggressive protection and conservation of the measures are administrated (see Table 3.10). The existing urban space will likely increase from 34% to 80% as a share of the total land area by 2050 under the NCC scenario. Wetland areas will increase because of sea-level rise. However, the mangrove ecosystem will be under emerging threats.

Table 3.10. Percent of Total Area By LULC (Trends with NCC Protections)

LULC Class	**1985**	**2003**	**2020**	**2035 Projection (NCC)**	**2050 Projection (NCC)**
Forest/Bush/Grassland/Planted	68%	64%	55%	28%	5%
Developed/Settlements/Bare Soil/Sand	20%	23%	34%	60%	80%
Wetland/Mangrove	12%	12%	11%	12%	15%
Total	100%	100%	100%	100%	100%

Figure 3.4. Google Earth Pro Image of Monkey/Bijilo Forest Showing Parts Destroyed and Replaced with Conference Centre

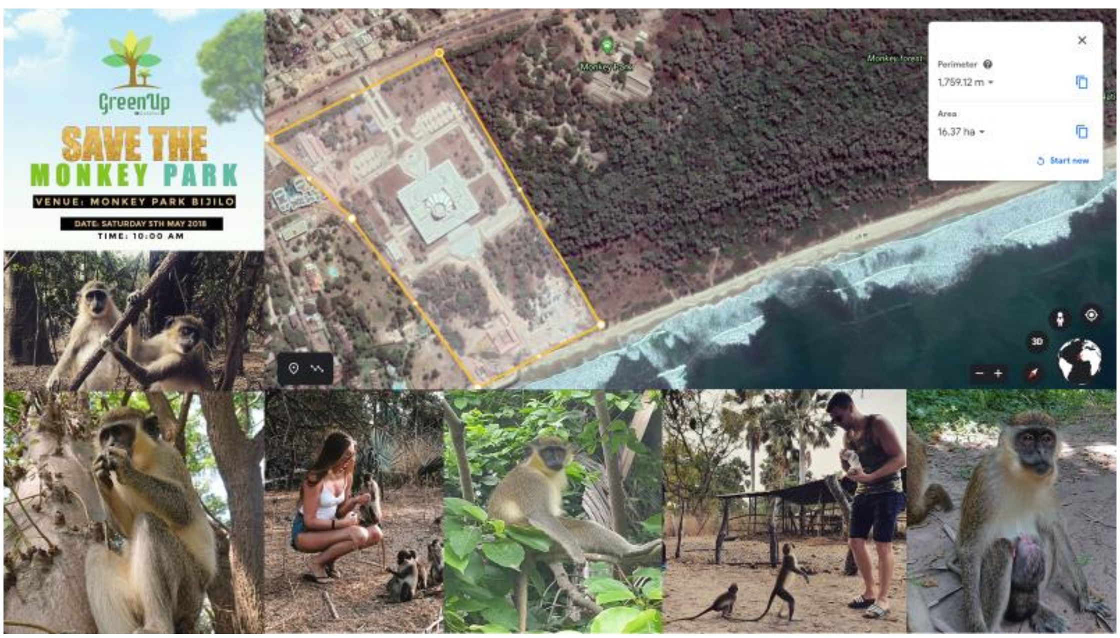


Image Credit for "Save the Monkey Park": Green-Up Gambia, 2018 & Images of People & Monkeys Credit: Gaultier Lefevere & Amandine Roelandt, Facebook Post, 2020**.**

3.4.2.3 Sustainability (SUST) Scenario

Unlike the BAU and the NCC scenarios, the sustainability (SUST) scenario is about what "should be done" differently (policy interventions) to change the status quo. It is not about what could happen if current trends continue (BAU) or what may likely occur if a new city is built (NCC). The goal of the SUST scenario is to initiate protection, conservation, and restoration strategies aimed at maintaining 25% of the total land area as forests in the southwestern region of The Gambia and limit urbanization to only 60% (see Table 3.11). The National Forest policies of 1995 and 2019 both proclaim that a national "forest cover of 30% is sufficient for maintaining an ecological balance necessary for sustainable economic growth" (Forestry Policy Gambia, 2010). Given the trends presented under the BAU and likely under the NCC scenarios (e.g., demographic changes and economic growth), the SUST scenario targets to avoid forest loss below the 25% threshold of the total land area by 2050 in the study region. Whether protecting 25% of forest cover is considered an ecologically sustainable path is subjective, as what constitutes sustainability are broad sets of capitals, some of which are hard to define and measure (P. Kumar & Smith, 2019; Managi & Kumar, 2018; Polasky et al., 2015). For the purpose of this analysis, the 25% target is my sustainability goal. I defined ecological sustainability as the country's ability to properly manage, protect, and sustain 25% of the total land area in the southwestern region for intra-and intergenerational ecosystem service benefits.

The Gambia government's forest policy seeks to preserve, maintain, and develop forest resources covering at least 30% of the total land area, and ensure that 75% of forest lands are managed, protected, and promoted for sustainable flow of forest products to needy urban and rural populations (Forestry Policy Gambia, 2010). Since 1983, the forest policy aims at transferring nearly 200,000 ha of state forestland to community forest management schemes by the year 2005 (Sillah, 1999). These include 32,729 ha of national forest parks, 4,321 ha of forest parks in the southwestern region. However, according to my findings, not only has this specified policy target failed, but more deforestation and environmental degradation have occurred in the study region, especially since the year 2000.

To attain the sustainability goal, I proposed four broad policy areas focusing on the formulation, implementation, and enforcement of various forest preservation, protection, and restoration strategies and programs. Some of the sustainability strategies presented below are in agreement with the policy objectives specified in the new National Development Plan (NDP, 2018-2022) (Government of The Gambia, 2017), National Climate Change Policy (Urquhart, 2016), the Parks and Wildlife Policy (Parks and Wildlife Policy Gambia, 2013), the Forest Sub-sector Policy (Forestry Sub-Sector Policy Gambia, 2010), and the National Adaptation Programs of Action (NAPA Gambia, 2007). For example, The Gambia's National Adaptation Programs of Action (NAPA) identified three priority areas for forest stakeholder intervention. These include sustainably using forest resources for commercial and non-commercial purposes, raising community awareness, and restoring ecosystem health and biodiversity (NAPA Gambia, 2007). As mandated by their various legislative Acts, the Departments of Parks and Wildlife Management, Forestry, Lands, and Agriculture will be principally responsible for the consideration, implementation, management, and sustainability of the proposed policy directions and management strategies under this scenario. I assumed that local communities would be empowered with a shared responsibility to manage and restore community forest parks for solidifying the co-management scheme of forest resources.

The first sustainability strategy focuses on national protected areas (PAs). In the study region, only two official forest parks are gazetted as PAs (Abuko nature and Tanji Bird reserves**)**. The Parks Department policy seeks to increase the national proportion of PAs from 3.3% to 5% since the 90s (Sillah, 1999). This policy target is unmet, and in fact, it is 50% less than the recommended national PAs target (10% of the national territory) set by the United Nations' Convention on Biological Diversity. In contributing to the attainment of the national PAs target, the SUST scenario considers the formulation of legislation to gazette all my proposed list of open forestland (6,161 ha) as PAs in the southwestern region of The Gambia. This is applicable and enforceable under the current laws of The Gambia. I learned in chapter two that the State Lands Act (1991) makes provisions for the Minister of Lands to designate any "regional land" to be "state land" for the benefit of the community in which the land is located (Bensouda & CO LP, 2013). The area of my proposed PAs account for nearly 60% of closed and open forest covers and 3.38% of total land area in the study region (see Table 3.7 above). The conservation of all PAs should consider co-management and polycentric governance approaches, as fundamental pillars of sustainability. Polycentric governance structure involves a complex and systematic arrangement of roles and responsibilities between multiple governance levels (Ostrom & Cox, 2010). For a detailed discussion on the concepts of co-management and polycentricity in forest resource management, read, Ostrom & Cox (2010). The success of these policy objectives depends on the level of community-based participation in forest conservation and restoration efforts. The definition of PAs, according to the laws of The Gambia, should be reviewed and revised to allow local participation in the co-management of their natural resources. The participating communities should yield some benefits from state declared PAs through a monitored and sustainable based practice. I assumed that local community members would remain to be receiving ecosystem service benefits from several forest resources in the PAs, including dry wood for charcoal, wild fruits, and honey productions, amongst others. Also, a sustainable timber harvesting scheme should be incorporated into the co-management plan. Given the contribution of the tourism sector to national GDP, this sustainability approach can further boost the ecotourism sub-industry and attract more arrivals from the growing global ecotourism community. Other ecosystem services benefits of protected forests include recreational opportunities for birdwatching, flood mitigation, water quality improvements, and, more importantly, as supporting habitats for wildlife conservation and overall biodiversity protection.

The second sustainability strategy calls for maintaining forestland through the implementation of market-based conservation and restoration programs. It assumes that the government will strengthen collaboration with international partners to introduce market-based instruments for promoting forest resource management. This is critically essential as the majority of local communities source their livelihoods from forest resources. Payment for ecosystem service programs such as Reducing Emissions from Deforestation and Forest Degradation (REDD+) and conservation easement projects can be used to incentivize local forest owners from selling their land to developers. There are massive areas of community forest (i.e., shrubland) to be used by local landowners to participate in these schemes. With the availability of funding, 10% (~18,233ha) of the total land can be maintained through market-based conservation and restoration programs. These mechanisms will offer both economic and ecosystem service benefits to local actors and global initiatives for promoting carbon sequestration and biodiversity conservation. Local actors should be sensitized to restore the lost forest areas and afforest new sites for receiving financial gains.

The third sustainability strategy relates to reserving land for urban agricultural development. Food security threats are plausible in the study region due to growing population demand and land-use change from agricultural land to urban settlements, as discussed above. The government, through the Department of Lands in partnership with the Ministry of Agriculture, should reserve at least 7-10% (~13,000-18,000ha) of the total land area of the study region for agricultural uses only. Through such legislation, landowners will be innovative in developing horticultural gardens and irrigation systems for planting fruit trees (e.g., orchards) and crops for enhancing the national food basket. Non-state actors should create awareness on the importance of maintaining some agricultural land areas in the study site. The development partners, including the private sector and international development organizations, are presumed to support local communities with resources to advance their agribusiness industries. This strategy will facilitate self-reliance, ensure food sovereignty, generate employment opportunities, reduce urban poverty level, lessen the income gap between the rich and the poor, and minimize the overall national dependence on aid from the global north. It is also in line with my earlier findings on which land cover type that Gambian should prefer to reserve in chapter two.

The final sustainability strategy requires the incorporation of green infrastructure projects in already developed urban and new estate development areas. The SUST scenario assumes that the government will develop a comprehensive plan for incorporating green infrastructure or nature-based solutions for mitigating urban flood risk and strengthening urban climate resilience. The development of impervious surface areas in urban areas increases the risk of inundations from frequent and extreme precipitation events. The southwestern region is already classified as disaster-prone and highly vulnerable to many climate hazards. Urban flood risk is exacerbated by the lack of proper stormwater infrastructure systems. Green infrastructure projects in urban areas serve as nature-based stormwater management systems. They include street trees, green roofs, urban parks, and rain gardens (see Figure 3.5). The benefits of urban green infrastructure initiatives include dipping flood risk, minimizing urban heat island effect, reducing air pollution impacts, improving health and mental wellbeing, strengthening biodiversity, and promoting livability in the urban landscape (Chenoweth et al., 2018). Urban green infrastructure initiatives by local municipalities, private actors, and individual households under the SUST scenario should account for 1-3% (1,823 -6,000 ha) of the total land area in the study region. This sustainability strategy is likely attainable with the formulation and implementation of a comprehensive green infrastructure plan by three local municipalities in the study region.

Whether a new capital city is situated in the study region or not, some aspects of my proposed sustainability strategies remain plausible. However, with the development of a new capital city in the area, the feasibility of reaching the sustainability goal (25%) will be grossly limited, especially without a proper environmental management plan. Some of the sustainability strategies are even more critically important if the government will be taking a policy decision to build the next capital city of the country in the West Coast Region, as inferred by public opinion (see Chapter 2).

Table 3.11. Percent of Total Area By LULC (Trends with SUST Protections)

LULC Class	**1985**	**2003**	**2020**	**2035 Projection (SUST.)**	**2050 Projection (SUST.)**
Forest/Bush/Grassland/Planted	68%	64%	55%	43%	25%
Developed/Settlements/Bare Soil/Sand	20%	23%	34%	45%	60%
Wetland/Mangrove	12%	12%	11%	12%	15%
Total	100%	100%	100%	100%	100%

Figure 3.5. E.g., of Urban Green Infrastructure Initiatives

Image Credit:girg.science.unimelb.edu.au/

3.4.3 Carbon Storage and Sequestration

3.4.3.1 Past & Recent Trend

The total carbon storage of the InVEST Carbon model aggregates carbon stocks in the aboveground biomass, belowground biomass, soil carbon, and deadwood carbon. The majority of the terrestrial-based carbon in The Gambia is stored in my study area (i.e., the southwestern region of the country) (see Map 3.7). In 2020, the total carbon stock in the region is approximately 66,449 megagrams or metric tons compared to 88,262 in 2003 (see Map 3.8). Due to deforestation and land-use conversion, from 2003 to 2020, the area lost 21,824 tons of carbon, equivalent to loss economic value ranging from US$521,526 (min) to nearly $7million (max) (see Table 3.12). The minimum value uses a carbon price of $32/ton and a discount rate of 5%, as proposed by Professor William Nordhaus. The maximum amount uses Professor Nicholas Stern's recommended social cost of carbon, \$326/ton, with a discount rate of 1.4%. The difference in social cost or marginal damage cost to society is explained by the philosophical and ethical differences in valuation and discounting approaches adopted (normative vs. positive economics) (see methods section above).

3.4.3.2 Business-as-Usual (BAU) Scenario

Under the BAU scenario, 24,499 tons of carbon will be released from the study site by 2050, relative to the 2020 level. This carbon emission is associated with an economic loss ranging from US\$472,600 to nearly \$7.6 million (see Table 3.12). I compared carbon stock from 1985, 2003 to 2020, with the 2050 projections of potential sequestered carbon storage sites in the study site under the BAU and the SUST scenarios (see Map 3.8).

3.4.3.3 New Capital City (NCC) Scenario

Under the NCC scenario, a significant amount of carbon will be emitted into the atmosphere from the southwestern region compared to what I can expect under the BAU, and of course, under the SUST scenario. An estimated 45,474 metric tons of carbon is likely to be released by 2050, relative to the 2020 level. In monetary terms, this is equivalent to an economic loss ranging from US\$685,270 to almost \$11 million (see Table 3.12).

3.4.3.4 Sustainability (SUST) Scenario

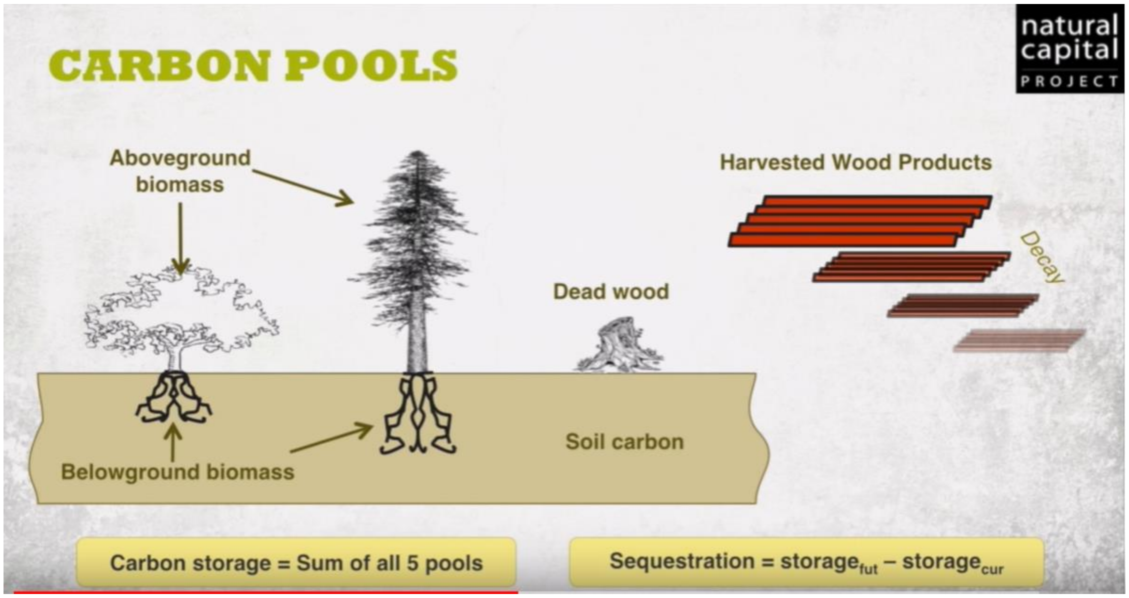
Suppose that the government and other stakeholders can successfully attain the SUST Scenario goal by implementing the policy actions identified above, the study region will only produce net emissions of only 3,371 tons of carbon by 2050 relative to the 2020 level. The economic loss to society ranges from \$65,027 to slightly over \$1million. Based on Stern’s valuation parameters, my SUST scenario would likely save society a monetary value of nearly US\$10 million between 2020 and 2050 (see Table 3.12).

Table 3.12. Total Carbon Stock & Its Economic Value (Study Area)

LULC Year (Under Various Scenario)	Total C Stock in End Year (Mg)	Change in C (Mg) Loss	Net present values (NPV) in 2010 US$	
			Nordhaus (C Price, 2007) US$	**Stern (C Price, 2007) US$**
2003	88,262			
2003-2020	66,449	-21,824	-521,526	-6,899,830
2020- 2050 (BAU)	41,950	-24,499	-472,600	-7,557,036
2020- 2050 (NCC)	**20,975**	**-45,474**	**-685,270**	**-10,957,702**
2020-2050 (SUST)	63,078	-3,371	-65,027	-1,039,803
Hectare C Value (C$/ha) [12]			**NPV/ha**	
2003-2020			$39.48	$521.86
2020- 2050			$29.58	$474.60
Model Parameters				
Price/Metric ton of carbon (V)			$32	$326
Market discount in Price of Carbon (r)			5%	1.40%
Annual rate of change in the price of carbon (c)			-1	-1

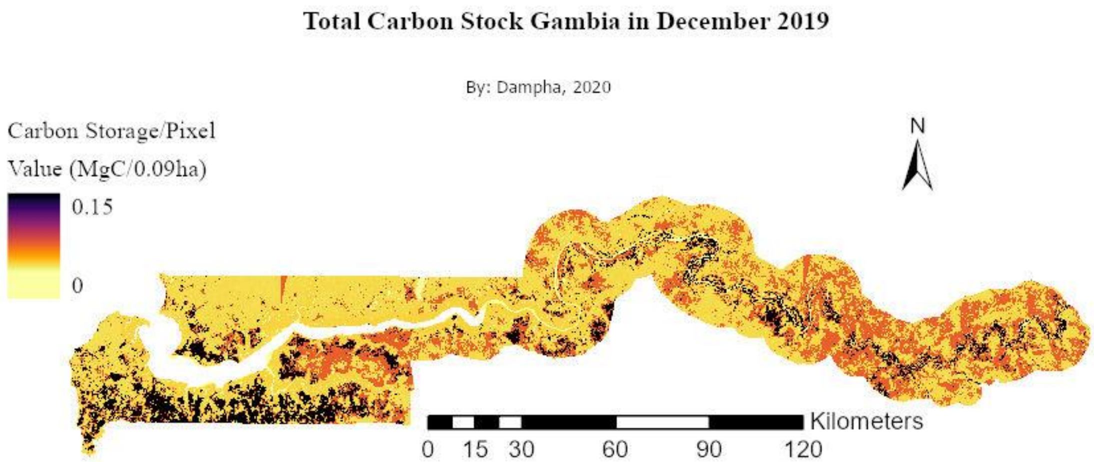
[12] *A hectare equals to 11.12 pixels (Landsat image pixel size is 0.09 or 30*30 or 900sqm)*

Figure 3.6. Illustration of InVEST Carbon Model

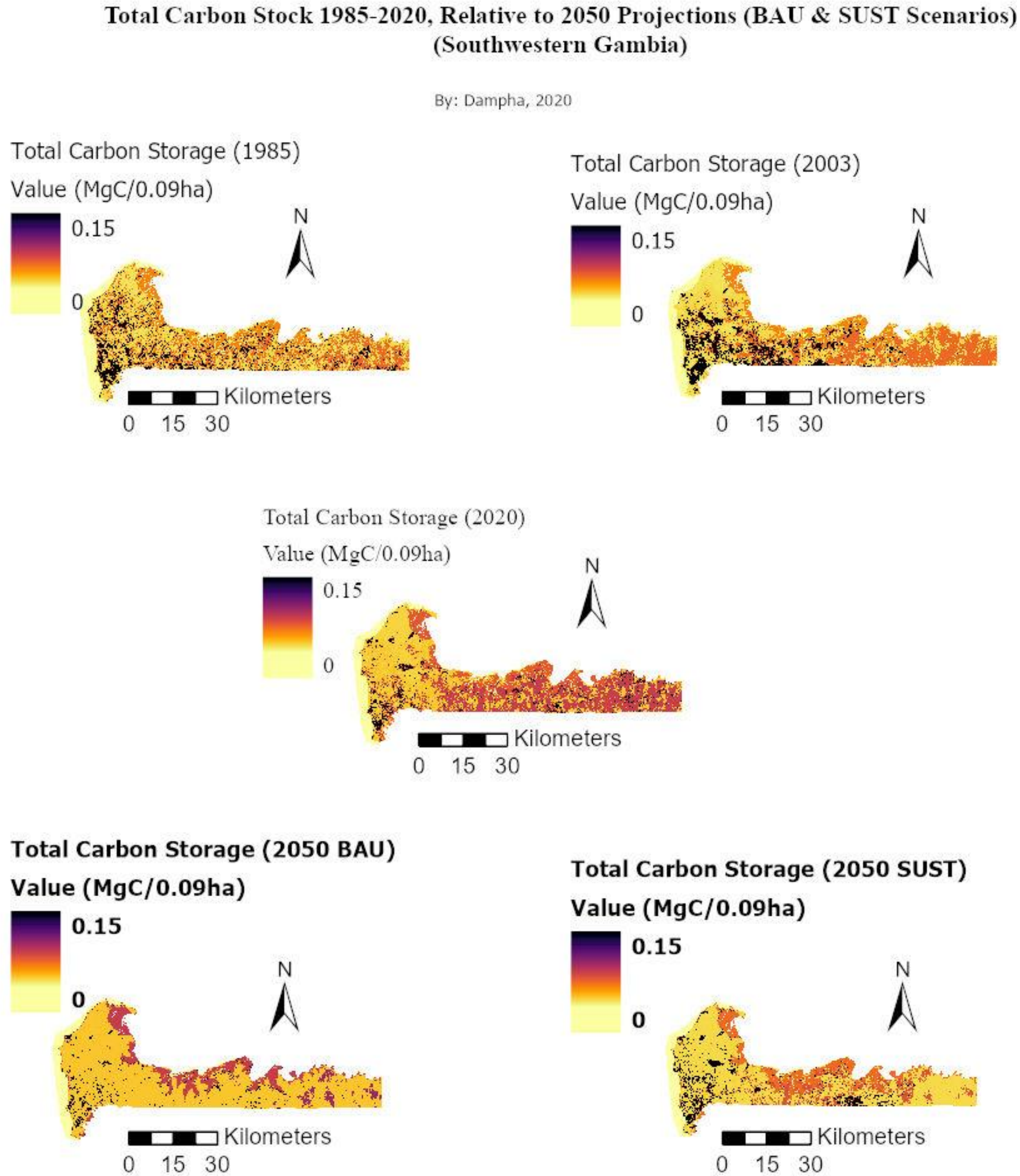


Source: (Wolny, 2015)

Map 3.7. Total Carbon Stock, The Gambia



Map 3.8. Total Carbon Stock 1985-2020 Relative to 2050 Projections (BAU & SUST Scenarios)



3.5 Discussion

3.5.1 Land-use Land Cover Change (Southwestern Gambia)

There is no traceable record of a recent study on forest cover and land-use change for this study area since 1985. This chapter findings reveal a forest cover reduction of 18% between 1985 and 2020 in the southwestern part of the country. The most significant change occurred between 2003 and 2020 compared to the forest cover change detected between 1985 and 2003. Less forest canopy density is evident today compared to the 1985 forest ecosystem conditions.

The primary drivers of forest degradation and land-use change in The Gambia include climate change impacts (e.g., draughts leading to bushfires), urban expansion and population growth, real estate proliferation, high remittance inflows, commercial timber production, local wood extraction (e.g., for domestic energy consumption), and infrastructural development (i.e., building roads, markets). Similar causes of deforestation are reported in other developing countries, including in China, Guatemala, Honduras, and Nicaragua (Houghton et al., 2012; Dampha et al., 2017). The main barriers to mitigating deforestation and land-use change include bribery and corruption, limited institutional capacity to conduct proper monitoring, poor leadership, lack of adequate enforcement of environmental and forestry laws, ineffective co-management strategies, insufficient funding, and lack of clear land ownership rights (NAPA Gambia, 2007; Gambia's 2nd National Communication, 2012; Dampha et al., 2017; Heß et al., 2018). In Appendix C below, I provide a detailed review of national deforestation trends in The Gambian, forest degradation, and forest ecosystem services (e.g., carbon sequestration) in general.

The solutions to protecting and regenerating forest cover and its vital ecosystem services such as carbon sequestration and recreational activities are discussed under each of the three scenarios presented above. The goal of the sustainability (SUST) scenario is for the government and other forest stakeholders to protect and restore 25% of the total land area as forests, including the existing closed and open forest parks, shrubland, and planted areas (e.g., orchards, street trees, etc.). Attaining the targeted sustainability goal will require working with local communities and other stakeholders to introduce, implement, and enforce forest management policies and legislations. Emphasis should be accorded to designating PAs status to all existing open forest parks, providing market-based payment incentives to local forest owners for enhancing restoration and conservation initiatives, preserving some grassland for urban agricultural development, and leveraging on green infrastructure solutions for reducing flood risk and accelerating the infiltration rates of stormwater for recharging the groundwater aquifers. Nature-based (green infrastructure) solutions also contribute to improving air quality and minimizing urban heat island. The most significant challenges to meeting the SUST scenario include; (1) lack of data on land ownership rights and ecosystem values, (2) institutional weaknesses and leadership challenges, (3) the development of a new capital city in the study region, (4) the doubling of the Gambia's population by 2050, (5) the increasing intensification of real estate development and industrial expansion leading reduced biocapacity, and (6) the accelerating economic prosperity of society driving the national ecological footprint.

Both the BAU and the NCC scenarios will result in a significant land-use conversion from forests to urban/developed areas. Under the BAU and the NCC scenarios, the regional forest cover will decrease from 55% of the total land area in 2020 to only 11% and 5%, respectively, by 2050. The BAU assumes that current policy objectives related to parks and forest areas will be met accordingly and, as discussed above. The NCC scenario suggests that only 5% of the study site will remain forested. This area will engulf current state forest parks in the southwestern region according to my predictions. Under the BAU and more so under the NCC scenario, some parts of open and closed forest parks will continue to suffer from forest destruction, irreversible natural capital and biodiversity losses, and land-use change in favor of infrastructural development projects. The recently established conference center is an exemplification of state-led land-use conversions to be anticipated, especially under the NCC scenario in the southwestern region of The Gambia.

3.5.2 Carbon Storage, Sequestration, and Valuation

In The Gambia, forests contain 359,000 metric tons of carbon in living forest biomass (FAO, 2015). Saatchi et al. (2011) study estimated a national forest carbon stock of 400,000 tons, using a 25% forest cover definition. The total forest carbon stock estimate from this study is 421,344 tons, including all forest cover types in The Gambia. Based on these estimates, the average per hectare carbon stock in The Gambia is approximately 1.7 megagram or metric tons with carbon content highest in my study region. Across sub-Saharan Africa, forests contain 44-66 billion tons of carbon, depending on the definition of what constitutes a forest. Nearly 80% of forest carbon content is stored in aboveground biomass (i.e., leaves, branches, and trunks) (Butler, 2011; Saatchi et al., 2011).

Land-use change and land cover conversion contribute to terrestrial-based carbon emissions in The Gambia. Before the year 2000, the land-use change and forestry sub-sector served as a sink of $C0_2$ instead of a net emitter (Urquhart, 2016). According to the Gambia Climate Change Policy (2016), besides the energy sector, land-use change and forestry account for the most substantial discharge of $C0_2$ in The Gambia (Urquhart, 2016). In 2000, land-use change and forestry sub-sector emitted 110 Gg CO_2, representing 34% of total emissions (Urquhart, 2016).

The above evidence supports findings of this chapter that the forestry and land-use sub-sector is currently a net emitter of $C0_2$ and has emitted nearly 21,824 tons of carbon between 2003 and 2020. The change in carbon stock is associated with an economic value loss ranging from US$521,526 to almost US$7 million in the study area (see Table 3.12 above). Under the BAU and NCC scenarios, forest degradation and land-use change will respectively, contribute to the emissions of 24,499 and 45,474 metric tons of carbon by 2050 relative to 2020 level, corresponding to an average economic cost of US$7.6 million and approximately $11million (using Stern's valuation parameters). These losses of biodiversity and ecosystem service values can be grossly minimized if the SUST scenario is considered. Under the SUST scenario, the region has the capacity to absorb and retain 21,128 tons and 42,103 tons more carbon from the atmosphere than the BAU and NCC scenarios, respectively.

3.6 Conclusion

The rate of forest degradation and land-use change will continue in the southwestern region if BAU persists. An aggressive sustainability intervention is required to avoid such non-substitutable losses of critical natural capital generating essential ecosystem service benefits to society for poverty alleviation. Lack of state intervention will exacerbate the depletion of forest resources, contribute to the destruction of wildlife habitats, and accelerate the loss of ecosystem services for the benefit of humanity and global climate change regulation. Urbanization, industrialization, and economic prosperity are the critical drivers of deforestation in the southwestern region of The Gambia.

In chapter two, we learned that 52% of Gambians identified the West Coast Region (situated in the study region of this chapter) as the most strategic location for building the next capital city of The Gambia. If the government eventually selects a site in this region for developing a new capital city (NCC scenario), a considerate area of forests will be decimated, and ecosystem services such as carbon sequestration will be significantly undermined. With the establishment of a new capital city, the forest protection and conservation efforts identified in the SUST scenario will be difficult, if not impossible, to accomplish. This study recognizes Gambians' desire to build their new capital in the southwestern region of the country. However, I recommend that, under such a development scenario, the government formulates a comprehensive master plan, outlining measures to reserve some forestlands for conservation easements, protect closed and open forest parks, and preserve grassland areas for urban agriculture and horticultural production. The master plan should also consider developing green infrastructure initiatives to mitigate flood risk, reduce urban heat island effects, and enhance the overall livability of the urban ecosystem.

Overall, this analysis reveals a forest cover loss of 22,408 ha from 1985 to 2020 in the southwestern region of The Gambia. The deforestation and land-use change between 2003 and 2020 have contributed to the emissions of 21,824 metric tons of carbon, corresponding to an average loss economic value of over roughly US$7million, using Stern's valuation approach. In general, loss of ecosystem diversity, species diversity, and genetic diversity of the region will be most extensive under the NCC scenario, followed by the BAU, and then SUST scenario. Forest ecosystem extermination and extinction of threatened, endangered, and critically endangered species are most likely first under the NCC and the BAU, relative to the SUST scenario.

This study recommends that the government immediately grant protected areas (PAs) status to all open forest parks in the study area. Given that these forestlands are community-managed but legally considered state-owned, the government has the power to develop a co-management system with the local communities within the legal jurisdiction of redefined PAs status. Second, the study recommends the consideration of all the management proposals of the SUST scenario by the state and non-state actors. Doing so will uphold the region's carbon storage and sequestration capacity, enhance biodiversity protection and conservation, sustain favorable precipitation patterns, recharge underground aquifers, reduce urban flood risks, and minimize urban heat island effect.

There are a few limitations to this analysis. First, I could not find a reference map to use for accuracy assessment. Second, the InVEST carbon model is based on a simplified carbon cycle, which assumes a linear change in carbon sequestration over time. Also, there is still an unsettled debate on the marginal damage cost of a tons of carbon emitted and the discount rate to use for long-term climate change interventions (Tol, 2006; Weitzman, 2007; Nordhaus, 2007; Heal, 2009; Almansa & Martínez-Paz, 2011; NatCap, 2020).

Chapter Four

Eliciting People's Willingness to Pay (WTP) for Improved Coastal Protection against Climate Change Impacts (Coastal Erosion) in The Gambia

4.1 Introduction

Global climate change is projected to affect coastal land areas, resources, communities, and livelihoods adversely. According to Amuzu, Jallow, Kabo-Bah, & Yaffa, (2018b p.24), "by the end of this century, under a 1m SLR scenario, the total land to be lost due to inundation is 12.46 km2 (1,246 ha) with a corresponding economic loss of ~US $788 Million (GMD 37 Billion) over The Gambia's coastal zone." The study aims at estimating the economic value of coastal ecosystem services (CES) for the benefit of beach users and non-users in The Gambia. Over 55% of The Gambia's total population resides in less than 25km from the coastline. Climate change and associated sea-level rise and storm surge threaten public structures and tourism infrastructure. Climate change impacts are also associated with loss of revenue to the government and private hotel operators, lack of recreational opportunities, destruction of livelihood opportunities for nearby communities, loss of cultural and historical sites, and the loss or migration of aquatic and endangered species (Mamat, Yacob, Noor, Ghani, & Fui, 2013; Alves, Rigall-I-Torrent, Ballester, Benavente, & Ferreira, 2015; Castaño-Isaza, Newball, Roach, & Lau, 2015; A. Gomez, 2015; Dribek & Voltaire, 2017; M. L. A. Gomez, Adelegan, Ntajal, & Trawally, 2020)

Globally, over 30% of the world population lives in coastal zones with a population density three times higher relative to inland residents (Castaño-Isaza et al., 2015). A recent global analysis Chaplin-Kramer et al. (2019), finds that coastal risk increases in every region with projected sea-level rise due to climate change. More than 500 million globally and over 20 million people in Africa will be exposed to coastal risk factors by 2050 (Chaplin-Kramer et al., 2019).

Coastal beaches around the world attract millions of visits mainly for recreational ecosystem services (ES) benefits such as picnicking, walking, swimming, and birdwatching (Castaño-Isaza, Newball, Roach, & Lau, 2015; Halkos & Matsiori, 2012). Coastal tourism and recreation do not only contribute to the GDP of countries, but also provide socio-economic benefits to residents at the micro-level (Alves, Rigall-I-Torrent, Ballester, Benavente, & Ferreira, 2015; Castaño-Isaza et al., 2015; Birdir, Ünal, Birdir, & Williams, 2013; Halkos & Matsiori, 2012). According to the World Travel & Tourism Council (2019), travel and tourism generate 10.4% of world GDP and provide 319 million jobs (one in ten jobs) globally. Since the 1960s, The Gambia's tourism industry has been one of the fastest-growing sectors of the economy, contributing 12% of GDP in 1989 (Thompson, O'Hare, & Evans, 1995), now estimated to be nearly 20% (World Travel and Tourism Council (WTTC), 2018). The growth in tourist arrivals risen from 528 visitors in 1966 to 162,000 in 2017 (Farver, 1984; Thompson et al., 1995; World Bank, Database 2018). Overall, the tourism sector supported 107,500 Gambian jobs, including 42,000 direct jobs in 2017. The industry's contribution grows by 3.5% yearly (WTTC, 2018).

The term ecosystem services (ES) coined by Ehrlich and Ehrlich (1981) has been widely used in this study (Feeley et al., 2016). Ecologists and environmental economists use the term to classify various services nature provides to people and society in general (see Hueting, 1980; De Groot, 1987; Folke et al., 1991; Costanza et al., 1997; Daily, 1997 all cited in Kumar, 2010; Polasky & Segerson, 2009). Nature provides these ES for improving human wellbeing, reducing poverty, and accelerating economic development, and enhancing environmental sustainability (MEA, 2005; Polasky, Lewis, Plantinga, & Nelson, 2014; Grant, Hill, Trathan, & Murphy, 2013; McCartney et al., 2015; Bhandari et al., 2016; Potschin-Young et al., 2018). According to the Millennium Ecosystem Assessment report(MEA, 2005), ES can be categorized into four areas; (a) provisioning (e.g., food, fuel, natural medicines, freshwater, timber, fiber, etc.), (b) regulating (e.g., air-quality regulation, climate regulation, water regulation, natural hazard regulation, etc.), (c) recreational/cultural (e.g., cultural heritage, recreation, and tourism, aesthetic values), and (d) intermediary or supporting (e.g., habitats, primary production, nutrient cycling; soil formation). The recent IPBES report reclassifies ES to the first three (Diaz et al., 2019).

To assess the economic value of coastal ecosystem services (CES), researchers, particularly natural resource economists, have applied contingent valuation methods to elicit willingness-to-pay (WTP) for improved coastal protection against coastal hazards such as rising sea levels and pollution. Contingent valuation (CV) method is a widely used non-market valuation approach. CV uses a hypothetical market scenario to estimate respondents WTP for the protection and improvement of public goods (Dribek & Voltaire, 2017; Johnston et al. 2017; Bhandari et al. 2015; Kumar, 2010; Halkos & Matsiori, 2012; Birdir, Ünal, Birdir, & Williams, 2013; Afroz et al. 2007; Bateman et al., 2006; Carson 2000; Mitchell & Carson 1989). Since the first CV application by Robert K. Davis in the 1960s, researchers continue to apply the method in social, natural, and environmental sciences studies (Carson & Hanemann, 2005; Mitchell & Carson, 1989). Over 2000 studies have applied CV (Carson, 2000), including over 40 reviews on beach ES protection within the past two decades and 37 on coastal waters (see Torres & Hanley, 2016).

Many CV studies investigate factors that influence decisions to visit coastal areas as well as their WTP to protect those sites. According to Halkos & Matsiori (2012), decisions to recreate on coastal beaches are mainly influenced by the environmental conditions of the area. Other determinants include site characteristics, safety, friendliness, as well as less tangible ones like family traditions, personal preferences (Parsons et al., 2000; Roca et al., 2009 in Halkos & Matsiori, 2012; McKenna et al. 2011 in Alves et al., 2015). These studies provided evidence that improvements in the quality of the biophysical environment of the beach can affect recreational value (Halkos & Matsiori, 2012).

The vast majority of CV studies are conducted in the developed world (US & Europe) due to access to data, methods, tools, and management framework (Johnston et al. 2017; Bhandari, KC, Shrestha, Aryal, & Shrestha, 2016; Birdir, Ünal, Birdir, &

Williams, 2013). I could not trace evidence of any previous WTP study regarding coastal protection in Africa. Like many coastal beach ecosystems, The Gambia's coastline provides direct and indirect livelihood benefits for Gambians and non-Gambians, and this chapter offers a critical assessment of the value of coastal ecosystem services (CES) in one of the world's most climate-threatened regions.

People in developing countries, especially in Africa, are reported to have lower average WTP for coastal protection relative to people in Asia, Europe, and North America (Liu & Stern 2008). Liquidity constraint has been considered as leading factors for such a lower WTP (Jacobsen & Hanley, 2009). This case study provides evidence that contradicts the assertion that people in poor developing countries have an insignificant value or less WTP for protecting public goods and natural resources.

The chapter has five sections. Section one introduces the study objectives, the main research questions, and the study area. Section two outlines the study methodology. It includes contingent valuation survey design issues, data collection procedures, and data analysis strategies. Section three presents the study results. The results are divided into four sub-sections. The first presents the descriptive statistics of the survey. The second outlines the econometrics model and results from the advanced statistical analysis. The third sub-section provides the willingness to pay results and compares it to a different valuation estimation using the travel cost method. The fourth shows the cost-benefit analysis results. Section four discusses the study findings and relates them to other studies. Section five concludes by summarizing the key findings, recommendations, and limitations of the study.

4.2 Study Areas: Senegambia Beach (Coastal Cell 6)

The Senegambia beach area, which is at the epicenter of the tourism industry, is located within the jurisdiction of the Brikama Area Council (BAC). The BAC local government region accommodates nearly 40% of the country's total population (688,744 inhabitants in 2013). The region has a population density of 390 persons per sq.km and registered the highest annual population growth rate of 5.7% across the country (GBoS Data Portal, 2018).

The study site is one of the nine classified coastal cells along the open ocean coastline of The Gambia (see Map 4.1). The Senegambia beach area (cell 6) has one of the broadest sandy beaches, attracting thousands of visitors and tourists each year. Some of the tourist infrastructure and resorts in this area were built since the 1980s (Coates & Manneh, 2015). Significant uses of the beach site include; swimming, canoeing, sea viewing, picnicking, walking, sunbathing, beach sports (physical exercise), religious or spiritual functions, traditional and cultural programs, and social networking (see Figure 4.1).

Since the 1990s, coastal erosion due to rising sea levels continues to affect large areas of Senegambia beach (Jallow et al., 1996; Bijl, 2011; Hills & Manneh, 2014; Amuzu et al., 2018a). Increases in impermeable surfaces upland also contribute to higher rates of surface runoff, further exacerbating beach erosion. According to Bijl (2011), “the computed present erosion rate in front of Senegambia is of the order of 3 m/yr.” The width of the beach in cell six has reduced by almost 90% from 155.5 meters in 2003 to ~17 meters in 2010 (Jallow A. 2016). The erosion rate of the beach has been threatening tourism infrastructure, undermining hotel guest access to the beaches, and adversely affecting Gambians who directly obtain their livelihood sources from the areas. Temporary defense structures such as sandbags, geotextile tubes filled with sand, wooden walls, and concrete walls are failing, exposing beach users to the risk of hazardous debris (Bijl, 2011; Coates & Manneh, 2015). Coates & Manneh (2015) concluded that without any integrated coastal zone adaptation strategy, significant assets such as accommodation houses, beach bars, gardens, and swimming pools would be lost along the shorefront.

Map 4.1. Coastal Cells/Zones of The Gambia

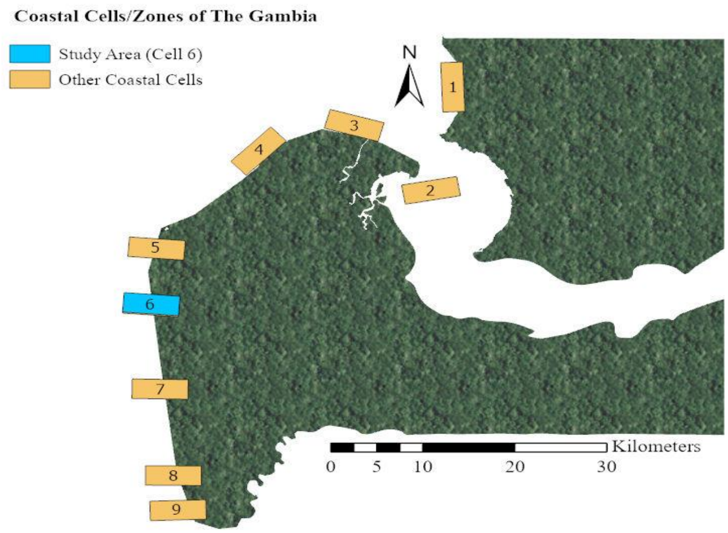
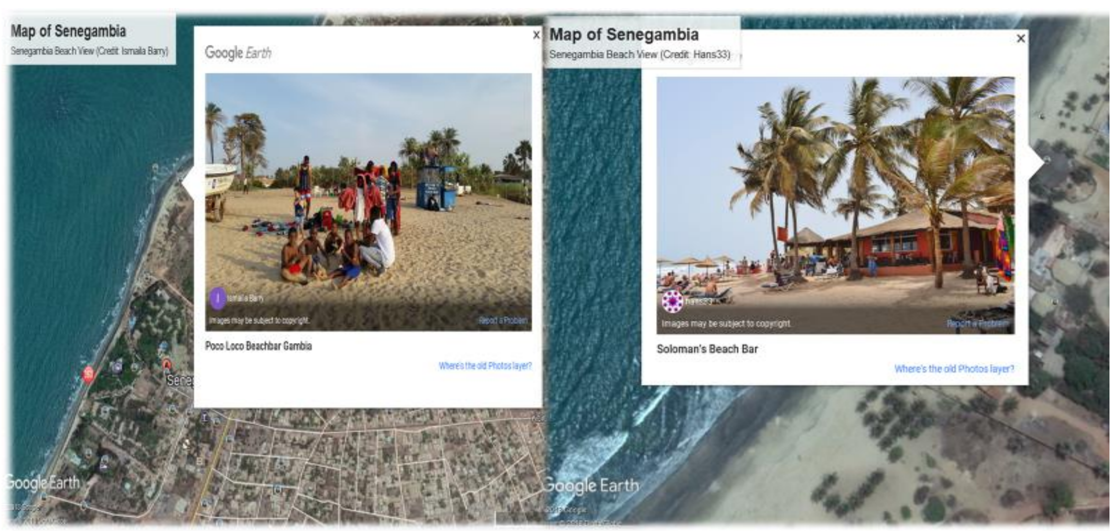


Figure 4.1. Example of Recreational Images from Senegambia Beach Area (Coastal Cell 6)



4.2.1 Study Aim & Objectives

The study aims at estimating the economic value of coastal ecosystem services (CES) for the benefit of users and non-users of the Senegambia beach areas. The specific objectives of this study are. First, is to apply a contingent valuation (CV) survey method to estimate willingness-to-pay (WTP) for improved coastal protection against erosion attributed to global climate change impacts such as the sea-level rise and extreme precipitation events. Second, is to provide recommendations to authorities for informing climate and environmental policy design, implementation, and evaluation processes.

The primary research questions are.

1. *Are people willing to pay for improved coastal protection against climate change impacts (e.g., coastal erosion)?*
2. *Is the aggregate WTP (welfare value) greater or less than the total cost of a project design to protect the Senegambia beach areas against coastal erosion?*

4.3 Methodology

4.3.1 Survey Design & Data Collection Methods

The target population of this survey includes people living in nearby communities of the coastline and visitors found at the study site when administrating the survey instrument. I applied a stratified random sampling method based on the on-site and off-site division of the study area to account for variation between those found using the beach (on-site), and others found off-site (within a radius of 20 kilometers). I used structured questionnaires to interview (face-to-face) all potentials respondents. On-and-off-site direct interviews targeted 70, and 30% of potential survey respondents, respectively. The primary field data collection started on the 7th and ended on the 10th of September 2018 (Friday to Monday). Weekdays/weekends from 9 am to 7 pm were intentionally chosen to reflect different users' visitation patterns (Alves et al., 2015). I approached 350 individuals and obtained a response rate of 94%, of which 68% were found on the beach (on-site).

Before the primary field data collection, the interviewers (11 undergrads) from the University of The Gambia underwent a two-week intensive training on CV application, proceeded with a full-day pretest exercise in which 40 individuals were interviewed. Pretesting is a central part of context validity in CV studies, as it helps to authenticate the survey instrument and facilitates the removal of redundant and unnecessary questions to avoid survey fatigue (Johnston et al., 2017). In conducting the pretest, I applied a double-bound dichotomous choice elicitation procedure to determine appropriate bid vectors for the main survey (for details see, Johnston et al., 2017; Afroz et al., 2009; Bateman & Willis, 1999; Mitchell & Carson 1989). The overall survey instrument was improved and validated based on pretest feedback. The results of the pretest show WTP amounts ranging from D0 (US$0) to D1000 (US$21.73). Although, when administrating the primary survey, I decided to limit my highest bid price to D500 (US$ 10.86) instead of including the maximum WTP bid vector elicited by respondents during the pretest. The omission of the highest bid vector (US$21.73) results in an unforeseen underestimation of people's average WTP (see the results section below).

4.3.2 Critical Methodological Issues

It is salient to highlight some of the critical methodological issues considered and addressed in this study. First, determining whether the valuation should be a household decision (Carson et al., 1992; McConell, 1995) or an individual (Kealy et al., 1990; Imber et al., 1993) is a critical factor in WTP studies (all cited in Afroz et al., 2009). Wilks (1990) recommends that the ultimate decision of taking either is a function of the payment vehicle chosen and whether such payments are primarily household decisions or an individual (Afroz et al., 2009). Since I used voluntary payment, also known as a contingent donation as the payment vehicle, using the individual as the unit of analysis would be most realistic in the context of my study. Johnston et al. (2017) stated that "payment vehicle selected should be realistic, credible, familiar, and binding for all respondents." They further noted that there is "no single objective criterion that identifies what payment vehicle is best for a particular application."

Second, although the voluntary payment (donations) is nonbinding and may be associated with free-riding tendencies as noted by Johnston et al. (2017), however, they added that nonbinding mechanisms might be "unavoidable in some context." Thus, in the context of this study, I was concerned about the imposition of any legally binding payment vehicle type such as taxes or user fees because the study was conducted at the very beginning of a political and institutional transition following two decades of oppressive and dictatorial governance by the former administration. I suspected public mistrust (in the "New Gambia") if a government institution like the National Environment Agency (NEA) is proposing a mandatory payment of taxes or user fees for recreating on the beach (i.e., a public good). A legally binding payment vehicle may result in a higher protest tendency from respondents. Given the local realities, I adhered to (Gibson, Rigby, Polya, & Russell, 2016 p.702) guideline, which explicitly stated that "respondent experience should be carefully considered when selecting a payment vehicle," especially in the developing world context.

A contingent donation as payment vehicle has been applied in many other studies (Dribek & Voltaire, 2017; Bateman et al., 2003 cited in Bateman, Cole, Georgiou, & Hadley, 2006; Champ, Bishop, Brown, & Mccollum, 1997; Foster, Bateman, & Harley, 1997). As Champ et al. (1997 p.152) underscored, "donations are useful mechanisms for CV because they offer a plausible means of providing small-scale public goods." In The Gambian context, even though there is less liquidity availability (low per capita income), the motivation of donating to address a public outcry is entrenched in the people's culture and religion, as the majority are quite religious. For instance, in Islam, giving out one's wealth (e.g., donations), no matter how meager for public benefits, equates to purifying and protecting one's soul from the torments of hell-fire in the hereafter (Islamic Relief USA, 2019).

Finally, in terms of payment frequency, instead of asking for a periodic payment, I believed that lumpsum amount, as applied in Polomé et al., (2005) case study in Venice and Halkos & Matsiori (2012) study, would be most reasonable and attainable for my study context. According to Liu & Stern, (2008) meta-analysis, studies using annual payment frequency have lower nominal WTP estimates relative to lumpsum payments. Among the four main procedures; open-ended, bidding game, single-bound dichotomous-choice, and double-bound dichotomous-choice applied in numerous studies (Uddin & Gotoh, 2006; Foster et al., 1997), I applied single-bound dichotomous-choice procedure in the main survey of this study. Respondents were presented with a single bid, and they either vote in favor of or decline to offer. I rejected using an open-ended elicitation approach to avoid free-riding behavior among the public (Liu & Stern, 2008; Carson et al., 1999, cited in Bateman et al., 2006). Colored visual aid materials, depicting both current and the improvement scenarios, were presented to all respondents during the interviews, as recommended by (Johnston et al., 2017; Mitchell & Carson 1989).

4.3.3 Description of Survey Questionnaire

The survey questionnaire had six sections; (1) presenting the study objectives and soliciting respondents' consent, (2) reminding respondents' about the basic site facts and asking questions around visitation and participation in various recreational and non-recreational activities, (3) eliciting respondents' perceptions of recreational and cultural ES (including non-consumptive & non-use values), climate change impacts as well as institutional trust and responsibility using the conventional five-point Likert scale (Halkos & Matsiori, 2012), (4) presenting the WTP Scenario for improved coastal protection, (5) assessing respondents' attitude towards the scenario and the survey in general, and (6) collecting demographic and socioeconomic characteristics of respondents (see the entire survey instrument in Appendix G below). Presenting the sections in the above chronological order follows the standard CV guidelines and outlines of previous studies (Johnston et al., 2017; Marzetti et al., 2016; N. Jones, Clark, & Malesios, 2015; Bateman et al., 2006; Carson & Hanemann, 2005; Carson, 2000; Carson & Mitchell, 1993; Hanemann et al., 1991).

The coastal adaptation scenario (WTP for coastal protection against climate-induced impacts) used in the survey was extracted from Coates & Manneh (2015) report. The adaptation scenario is arguably the most feasible solution for addressing coastal erosion in the study area. The scenario was identical to the local adaptation strategy observed in similar studies elsewhere (Jones et al., 2015; Halkos & Matsiori, 2012). The adaptation or WTP scenario was explained to all respondents before eliciting their WTP.

The WTP scenario reads:

"To address coastal erosion and its impacts (see Figure 4.2), suppose a joint proposal from the NEA & BAC asked people to donate money for protecting the Senegambia beach areas; the government would provide 60 % of the project funds, and all individuals will be asked to contribute the remaining 40% for the project to be implemented; remember, this may be the only possible way to protect this beach area; also, we can be 100% sure that all the monies donated will be used solely for implementing the proposed project below resulting to the following expected outcomes (See Figure 4.3 & the project details below).

Project Description

This proposed project will continue to increase the width of the beach by building 'detached breakwaters,' 'a rock revetment,' and 'sand nourishment'(Coates & Manneh, 2015, see details[13])

Expected Outcomes/Benefits *(Coates & Manneh, 2015).*

1. *The beach width will increase by 30 m at high tide and shall last for at least 30 years*
2. *Large beach area would be available for recreational and other uses*

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[13] Key elements of the proposed project (Coates & Manneh, 2015).

1. *Phase 1. 'construct a rock revetment along the full frontage, extending northwards for several hundred meters towards Kololi Point, with a 10 m wide backfill of sand (sand nourishment[13]) to create an elevated sun-bathing area and protect the frontage from the risk of ongoing erosion' (Est. USD 2 million equivalent to (GMD 96.1 million, 2018).*
2. *Phase 2. 'build four detached breakwaters[13] of about 150 m length set about 150 m from the present shore, placed along the full Senegambia frontage and place a modest sand nourishment that would build out the low tide beach by about 10 m between each breakwater and by about 100 m in the lee of the breakwaters.' (Est. USD 11 M equivalent to (GMD 528.6 million, 2018)*
3. *Total capital costs proposed at USD 13 million (equivalent to GMD 624.6 million 2018) plus maintenance costs of USD 3million (equivalent to GMD 144.2 million) over 30 years.*
4. *Removing debris from existing coastal protection measures*
5. *integrate storm water run-off channels through the revetment at four points;*
6. *Monitor beach and maintain the structures*

3. *Tourists visiting Senegambia will have access to bath in the Sand, under Sun & in Sea (the 3S)*
4. *The coastline is protected at least for one more generation to see and use*

Anticipated Drawbacks/Negative Effects *(Coates & Manneh, 2015).*

1. ***Recreationists may have difficult access crossing rock revetment and possible erosion of bays back to the revetment.***
2. ***If the project is not fully funded & completed, then the revetment will fail, and the beach will be compromised.***

WTP Question

Based on the above project details, would you be willing to make a <u>*onetime*</u> *DONATION OF ….*

a) *{D50} YES or NO*
b) *{D100} YES or NO*
c) *{D300} YES or NO*
d) *{D500} YES or NO*

To Interviewers: Systematically pick one option for each respondent starting from low to high on rotational basis)

…to BAC for implementing this project ***<u>within a period of one year?</u>***

Figure 4.2. Visual Aid: Coastal Erosion Business as Usual Scenario (Coastal Cell 6)

Figure 4.3. Visual Aid: Improvement Scenario (Coastal Cell 6)

4.3.4 Data Analyses

I used the STATA software package and Qualtrics (Stats IQ) for analyzing the survey data. Qualtrics is an online survey design tool that provides descriptive statistics of the collected data (Qualtrics, 2020). STATA is a statistical software package that allows advanced econometric analysis of various kinds of data, including survey data (STATA, 2020).

4.4 Descriptive Statistics Results

4.4.1 Demographic & Socioeconomic Characteristics

The study collected data on key demographic and socioeconomic household characteristics such as gender, age, ethnic identity, estimated monthly income, and highest education level completed. Results show that about 73% of household respondents are male. Most of them (77%) are within their youthful ages. About 44% are fully employed, 26% are employed as part-time workers (seasonal), and 17% currently unemployed. Over 57% of respondents earn less than D5,000 ($109) monthly. I present detailed information on the demographic and socioeconomic characteristics of the respondents in Table 4.1.

Table 4.1. Demographic & Socioeconomic Characteristics

Respondents' Characteristics	**N**[14]	**Freq. %**	**Respondents' Characteristics**	**N**	**Freq. %**
Sex			**Have Children**		
Male	245	73.3	No	191	58.6
Female	89	26.7	Yes	135	41.4
Age Bracket			**Marital Status**		
Under 24	117	35.2	Single	222	67.1
25-35	138	41.6	Married	90	27.2
36-45	60	18.1	Divorced	18	5.4
Above 45	14	5.1	Widowed	1	0.3
Employment Status			**Education Completed**		
Full-time	146	44.1	None	16	4.8
Part-time	87	26.3	Primary	19	5.7
Unemployed	57	17.2	Middle	59	17.8

[14] *Total number of observations is 334*

Student (full-time)	36	10.9	High	135	40.7
Home Caregiver (full-time)	3	0.91	BA	21	6.3
Retired & Other	2	0.60	MA	5	1.5
Income Bracket (monthly)			**Language Used for Interview**		
2,001-5,000	104	31.5	Wolof	163	49.1
Below 2,000	64	19.4	English	87	26.2
5,000-10,000	47	14.2	Mandinka	71	21.4
Don't Know	44	13.3	Fula	5	1.5
10,001-15,000	25	7.6	Jahanka	3	0.9
15,000 Above	25	7.6	Serere	2	0.6
No Income	21	6.4	Jola	1	0.3
Nationality			**Language understood both parties**		
Gambian	313	95.1	Yes	322	98.5
Non-Gambian	16	4.9	No	5	1.5
Member of Environmental Organization			**Interview Location**		
No	282	85.2	On the beach site	228	68.3
Yes	49	14.8	Off the beach site	106	31.7
Descriptions of Survey			**Oath by Respondents (i.e., Info. is True)**		
Very interesting	300	87.3	Yes	327	99.1
Interesting	37	11.2	No	3	0.9
Difficult or time-Consuming		1.5			

4.4.2 Visitation & Participation in Beach Activities

According to my findings, 28% of respondents visit the beach daily, 30% visits at least twice a week, and 23% visit at least once per month. The most frequently visited beaches, accordingly, are Pocoloco, Palma Rima, and Senegambia beach. The most popular coastal recreational activities include walking/trekking, swimming, social networking, picnicking, sports, birdwatching, dating one's partner, meeting tourists, and sunbathing (see Table 4.2).

Table 4.2. Participation in Beach Recreational Activities

Recreational & Cultural Ecosystem Services				**Always**	**Often**	**Sometimes**	**Rarely**	**Never**
	Rank	N	Weighted Mean %	%	%	%	%	%
Walking & Trekking	1	318	64	21	20	34	7	17
Swimming	2	318	62	26	15	25	10	24
Social Networking	3	318	59	18	14	37	7	25
Picnicking	4	318	55	14	14	33	11	29
Beach Sports	5	315	56	21	14	23	8	34
Bird & Wildlife Viewing	6	318	50	11	15	26	7	42
Dating One's Partner	7	317	50	15	12	24	5	44
Meeting Tourists	8	316	52	22	9	18	8	44
Sun-bathing	9	317	47	12	11	22	8	47
Horse Riding	10	318	36	6	6	15	10	62
Tradition & Cultural activities	11	318	38	7	9	15	5	64
Religious & Spiritual Reasons	12	316	36	7	6	12	7	69
Fishing	13	318	35	6	8	12	3	71
Canoeing	14	318	31	5	5	9	4	77

4.4.3 Value of Ecosystem Services (Perception)

Coastal ecosystem services assessed with the most beneficial value described as "extremely and very important" to Gambians, according to the study in ascending order of importance are; clean water, fresh ocean breeze, biodiversity protection, landscape beauty, swimming, beach sports, sea viewing, meeting tourists, walking/ trekking, social networking, picnicking, and dating one's partner (see Table 4.3).

Table 4.3. Assessment of Coastal ES Values (Recreational & Cultural Services)

Recreational & Cultural Ecosystem Services (ES)				**Extremely Important**	**Very Important**	**Moderately Important**	**Slightly Important**	**Not at All Important**
	Rank	N	Weighted Mean %	%	%	%	%	%
Clean Water	1	327	88	68	16	9	3	5
Fresh Air / Breeze	2	329	88	64	22	7	4	3
Biodiversity Protection	3	331	85	58	21	12	5	5
Landscape Beauty	4	331	80	49	24	13	5	8
Swimming	5	332	72	37	24	16	7	16
Beach Sports	6	330	68	30	26	17	7	19
Sea Viewing	7	331	67	27	25	24	6	17
Social Networking	8	327	63	25	20	25	6	23
Meeting Tourists	9	329	62	25	23	18	5	28
Walking & Trekking	10	329	62	22	24	22	6	25
Dating One's Partner	11	327	58	22	18	20	10	29
Picnicking	12	328	64	20	25	28	7	20
Sun-bathing	13	332	56	17	20	24	6	33

Birdwatching & Wildlife Viewing	14	332	55	15	21	22	10	32
Horse Riding	15	328	49	13	13	22	12	40
Traditional & Cultural Activities	16	331	48	12	16	19	7	46
Religious & Spiritual Reasons	17	330	47	12	15	15	10	48
Canoeing	18	332	44	11	14	13	9	53

4.4.4 Other Important Valuation Issues

Overall, the majority of respondents (97%) agree that the present generation has the responsibility to protect the Senegambia beach area for the benefit of the next generation, even if protection requires the former to incur substantial costs in doing so (bequest value). Likewise, they also agree that, if “unique” and “endangered” flora and fauna live around the beach or in the Sea, then it’s worth protecting the area (existence value). Similar results are generated for safeguarding and maintaining the quality of the beach for others’ use (altruistic value) as well as the possibility to use the beach in the future if needed (option value).

In terms of institutional responsibility for coastal protection, 61% of respondents believe that only the government should be responsible for adaptation measures against sea-level rise and coastal erosion. Regarding trust, 55% of respondents claim to have some level of trust in public institutions mandated with coastal protection responsibility. Respondent’s perception of property rights is essential in valuation studies for understanding the rationale behind people’s WTP or otherwise. In this study, 45% of respondents describe the Senegambia beach as a public good, meaning it’s nonrestrictive and non-rival. In comparison, 33% report that the beach is privately-owned by the municipality responsible for the area.

Also, respondents' perception of the root causes of coastal erosion is paramount to assess the validity of the results. I find that 57% of respondents either always or usually hear about climate change, while 30% say they sometimes hear about climate change impacts. 36% believe that climate change is caused by Allah (natural factors), 35% considers both natural and anthropogenic causes, 22% attributes it to anthropogenic activities alone (human factors). On the perception of sea-level rise and coastal erosion, 83% of respondents agree that rising sea levels with increasing coastal erosion will pose severe threats to them and their ability to use the beach for recreational purposes. Finally, when asked about climate-related loss and damage payments, 80% agree that the developed world should pay for climate damages.

4.5 Econometrics Analysis & Results

4.5.1 Estimation Strategy

I used the multivariate Probit regression analysis to estimate the respondents' WTP for the improved coastal protection scenario. I used probit because my response variable (WTP) is a binary one, meaning respondents can only offer to pay or refuse to pay for the improvement project. I compared probit results to logistic regression and Ordinary Least Square (OLS) in ensuring estimation consistency and robustness of results. Unlike OLS, both probit and logit are nonlinear statistical models in the parameters (Griffiths, Hill & Judge, 1993; Hanck et al., 2019).

OLS model on a household's willingness to pay (WTP) for improved coastal protection has the general form:

$$Y_i = \beta_0 + \beta_1 x_1, + \cdots + \beta_n x_n + \varepsilon_i \qquad \text{Eq. (1)}$$

Where Y_i is the dependent variable representing a household's WTP, x_1 through x_n are the independent variables representing demographic, household characteristics, and respondent's perception of the importance of coastal ecosystem services and participation in coastal recreational activities. $\beta_0 + \beta_1$ through β_n are the regression coefficients, and ε_i is the residual term.

Likewise, in chapter one, the dependent variable (WTP) in this analysis is a binary one. I avoided using relying on the standard OLS functional form for the same reasons stated in chapter one (under the estimation strategy). The probit model relates the choice probability P_i of the binary dependent variable to independent variables in such that the likelihood remains in the interval of [1, 0] (Griffiths, Hill & Judge, 1993) (see eq. 2 below). The regression slopes quantify the relationship of the independent variables to WTP using the odds ratio parameter. The odds ratio is the probability that WTP will occur divided by the probability of it not happening (Halkos & Matsiori, 2012).

The probit model is represented as $\Pr(Y = 1|X) = F(X'\beta)$

Where:

Pr(Y = 1|X) is the probability that the dependent variable, Y, takes a value of 1 given the vector of independent variables,

X, X' is the transpose of X (so that it has dimension 1xN), and β is a vector of coefficients.

In the probit model, the cumulative density function F(.) is assumed to have a normal distribution.

4.5.2 Independent variables of the regression model

The model parameters were determined from the survey data collected from The Gambia in September 2018. Covariates include demographic and socioeconomic variables, recreational activities, and respondents' perception of coastal ecosystem service (CES) protection for use and non-use values. I included variables on recreational activities with the fundamental assumption that people who are participating (either always, usually, or sometimes) in beach recreational activities might be willing to pay more relative to others who rarely or never engage in those activities. Similarly, the same assumption holds for people with a high perception of the importance of beach ecosystem service protection. I specify the variables and their descriptions in Table 4.4. All variables are covariate except WTP (dependent variable).

Table 4.4. Variable Name, Definition, and Description

Variable	**Definition**[15]	**Dummy Var. (1)**
WTP	Yes or No	Yes
Employed-Part-Time	Employment status	Part-time
Employed-Full-Time	Employment status	Full-time
Education	Highest level of education completed	Above High Sch. (Vocational, college & university)
Age-lower	Age bracket (Lower)	Under 25 years
Age-middle	Age bracket (Middle)	Between 25-45 years
Age-upper	Age bracket (Upper)	Above 45 years
Income-lower	Income bracket (Lower)	Below D5000, including no income
Income-middle	Income bracket (middle)	Between D5001 and 15,000
Income-upper	Income bracket (upper)	Above D15,000
Gender	sex	Male
Location-offsite	Location of the interview (where the respondent was met)	Off-site meaning outside of the beach area
Nationality	Respondent's nationality (either "Gambian" or "non-Gambian")	Gambian

[15] *Details on options used for each variable are included in description statistics (see* ***Error! Reference source not found.*** *above)*

Responsible-all	Who is responsible for protecting the beach	If they mentioned that all stakeholders are jointly responsible
Picnic-p	Participation[16] in picnicking when visited the beach	If they “usually, always, sometimes" picnic on the beach
Sun-Bath-p	Participation in sunbathing when visited the beach	If they “usually, always, sometimes" bath under the Sun while on the beach
Tourist-attraction-p	Participation in meeting tourist when visited the beach (locally called “bomsing”)	If they “usually, always, sometimes" engage in meeting tourist on the beach
Spiritual-p	Participation in spiritual activities when visited the beach	If they “usually, always, sometimes" engage in spiritual activities on the beach
Wildlife-p	Participation in wildlife viewing when visited the beach	If they “usually, always, sometimes" engage in wildlife viewing on the beach
Horse-riding-p	Participation in horse riding when visited the beach	If they “usually, always, sometimes" engage in horse riding on the beach
Swim-p	Participation in swimming when visited the beach	If they “usually, always, sometimes" engage in swimming when visited the beach

[16] *All participation variable share the same five options- “always”, “usually”, “sometime”, “rarely”, and “never”*

Ocean-Breeze-Import	The importance of Fresh air received on the beach	If agreed[17]
Landscape-beauty-Import	The importance of landscape beauty around the beach	If agreed
Sport-Import	The importance of beach sports	If agreed
Dating-Import	The importance of dating one's partner on the beach	If agreed
Swim-Import	The importance of swimming at the beach	If agreed

4.5.3 Hypothesis Testing & Modelling

In estimating the model, I systematically built the model starting with models 1, 2, 3, and 4. In my primary model (4), I combined all list of variables, including household characteristics, with variables on the respondent's perception of the importance of recreational beach services and their participation in undertaking or enjoying those coastal ecosystem services (CES) when visited the beach (See model 1-4, in Table 4.5). The discussion of these results relies on my primary model (model 4).

4.5.4 Econometric Results

The signs of the marginal effects are either increments or decrements vis-à-vis the dependent variable (WTP). A positive sign means a higher value of that covariate is correlated with greater WTP. The opposite is true for a negative sign. None of the signs with a statistically significant impact have contradicted theory to the best of my

[17] *Neutral response were excluded from the analysis*

knowledge. In terms of functional form comparison, I find probit to be a better fit specification compared to logit and, of course, OLS (see Table 4.6).

Table 4.5. Probit Regression (Heteroscedasticity-Corrected Standard Error Test, Robust Applied)

VARIABLES	(Model 1) Marginal effects	(Model 2) Marginal effects	(Model 3) Marginal effects	**(Model 4) Marginal effects**
Employed-Part-Time	0.139***	0.157***	0.144***	**0.170*** **
	(0.0504)	(0.0523)	(0.0495)	**(0.0529)**
Employed-Full-Time	0.0566	0.0611	0.0634	**0.0732***
	(0.0416)	(0.0420)	(0.0401)	**(0.0415)**
Education-Above-High-Sch	0.0536	0.0528	0.0537	**0.0464**
	(0.0421)	(0.0475)	(0.0399)	**(0.0431)**
Age-Lower	-0.0233	-0.754***	-0.0860	**-0.778*** **
	(0.0909)	(0.128)	(0.0875)	**(0.134)**
Age-Middle	-0.0386	-0.770***	-0.0868	**-0.788*** **
	(0.0885)	(0.130)	(0.0869)	**(0.135)**
Income-Lower	-0.0757*	-0.0975**	-0.0748*	**-0.0980** **
	(0.0460)	(0.0481)	(0.0446)	**(0.0475)**
Income-Upper	0.0278	0.0275	0.0354	**0.0538**
	(0.0768)	(0.0775)	(0.0702)	**(0.0736)**
Gender-Male	0.0214	-0.00267	0.0326	**0.00624**
	(0.0381)	(0.0399)	(0.0388)	**(0.0430)**
Location-Offsite	-0.0281	-0.0308	-0.0248	**-0.0314**
	(0.0351)	(0.0372)	(0.0336)	**(0.0376)**
Nationality-Gambian	0.0786	0.172**	0.101	**0.199** **
	(0.0738)	(0.0740)	(0.0785)	**(0.0798)**
Responsibility-All	-0.0542	-0.0295	-0.0805*	**-0.0411**
	(0.0420)	(0.0438)	(0.0411)	**(0.0410)**
Picnic-Participates		0.0627*		**0.0560***
		(0.0345)		**(0.0326)**
Sun-Bath-Participates		-0.0896**		**-0.0823** **
		(0.0375)		**(0.0359)**
Tourist-attraction-Participates in “bomsing”		0.0375		**0.0284**
		(0.0369)		**(0.0350)**
Spiritual-Participates		0.0638		**0.0777**
		(0.0486)		**(0.0492)**
Wildlife-Participates		0.0198		**0.0378**
		(0.0325)		**(0.0340)**
Horse Riding-Participates		0.0443		**0.0369**
		(0.0429)		**(0.0424)**
Swim-Participates		-0.0274		**0.000559**
		(0.0364)		**(0.0354)**

Ocean-Breeze-Important			0.110***	**0.112*** **
			(0.0396)	**(0.0380)**
Landscape-beauty-important			0.0802	**0.104***
			(0.0569)	**(0.0575)**
Dating-Important			0.0867	**0.0531**
			(0.0599)	**(0.0598)**
Swim-Important			0.0501	**0.0380**
			(0.0357)	**(0.0366)**
Beach-sport-Important			0.000959	**0.0166**
			(0.0382)	**(0.0444)**
Observations	285	270	284	**269**

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4.6. Functional Form Comparison

VARIABLES	(1) OLS	**(2) probit**	(3) logit
Employed-Part-Time	0.166***	**0.170*** **	0.193***
	(0.0572)	**(0.0529)**	(0.0603)
Employed-Full-Time	0.0985*	**0.0732***	0.0878*
	(0.0573)	**(0.0415)**	(0.0462)
Education-Above-High-Sch	0.0538	**0.0464**	0.0647
	(0.0433)	**(0.0431)**	(0.0523)
Age-Lower	-0.124*	**-0.778*** **	-1.197***
	(0.0649)	**(0.134)**	(0.190)
Age-Middle	-0.132**	**-0.788*** **	-1.210***
	(0.0603)	**(0.135)**	(0.190)
Income-Lower	-0.0548	**-0.0980*** **	-0.104*
	(0.0411)	**(0.0475)**	(0.0565)
Income-Upper	0.0321	**0.0538**	0.0505
	(0.0538)	**(0.0736)**	(0.0795)
Gender-Male	0.0221	**0.00624**	-0.00305
	(0.0482)	**(0.0430)**	(0.0450)
Location-Offsite	-0.0335	**-0.0314**	-0.0407
	(0.0409)	**(0.0376)**	(0.0407)
Gambian	0.165	**0.199*** **	0.211**
	(0.113)	**(0.0798)**	(0.0862)
Responsibility-All	-0.0476	**-0.0411**	-0.0495
	(0.0546)	**(0.0410)**	(0.0416)
Picnic-Participates	0.0633	**0.0560***	0.0592*
	(0.0390)	**(0.0326)**	(0.0344)
Sun-Bath-Participates	-0.0757*	**-0.0823*** **	-0.0930**

	(0.0401)	**(0.0359)**	(0.0384)
Tourist-attractive-Participates in "bomsing"	0.0198	**0.0284**	0.0297
	(0.0391)	**(0.0350)**	(0.0392)
Spiritual-Participates	0.0433	**0.0777**	0.0817
	(0.0385)	**(0.0492)**	(0.0589)
Wildlife-Participates	0.0161	**0.0378**	0.0460
	(0.0384)	**(0.0340)**	(0.0358)
Horse Riding-Participates	0.0306	**0.0369**	0.0417
	(0.0397)	**(0.0424)**	(0.0470)
Swim-Participates	-0.00728	**0.000559**	-0.00448
	(0.0404)	**(0.0354)**	(0.0357)
Ocean-Breeze-Important	0.0951**	**0.112*** **	0.117***
	(0.0398)	**(0.0380)**	(0.0402)
Landscape-beauty-important	0.0764	**0.104***	0.0987
	(0.0468)	**(0.0575)**	(0.0617)
Dating-Important	0.0298	**0.0531**	0.0359
	(0.0599)	**(0.0598)**	(0.0643)
Swim-Important	0.0299	**0.0380**	0.0369
	(0.0366)	**(0.0366)**	(0.0406)
Beach-sport-Important	0.0118	**0.0166**	0.0284
	(0.0450)	**(0.0444)**	(0.0477)
Constant	0.543**		
	(0.261)		
Observations	269	**269**	269
R-squared	0.123		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.6 Willingness to Pay Results

4.6.1 WTP Distribution

The results show that 90% of respondents expressed a positive WTP for the coastal adaptation scenario. Considering that over 90% of respondents indicate a positive WTP for the highest bid vector, I conclude that the average WTP for enhanced coastal protection is above D500 (US$ 10.86) per person. This is a conservative average WTP value, at least among urban dwellers and tourists in The Gambia.

In theory, WTP decreases as the prices or bid vector increases (Halkos & Matsiori, 2012; Castaño-Isaza, Newball, Roach, & Lau, 2015). Compliance with this theory is violated as per the descriptive statistics in Table 4.7, as WTP and price show no systematic relational direction. However, in the advanced econometric analysis, I find that WTP increases with more income. The violation of the theory is due to my subjective approach to reducing people's initial WTP as reported during the pretest (for more details, see methods section). In a nutshell, in the main survey, the maximum WTP vector was 50% less than what was recorded from pretest results. Hence, it is not entirely surprising that among respondents asked to pay D500 (US$10.86), 94% responded in the affirmative. If the payment were to be recurring, it is my opinion that such a high % WTP would decline. It should also be considered that this is a one-time lump sum payment. Equally essential to factor in is the religious significance of giving a charity (a donation) among Gambians.

Table 4.7. WTP Distribution

Bid Price	**WTP bided (row %)**	
	NO	YES
D50 ($1.08)	20 (19%)	84 (81%)
D100 ($2.17)	6 (6%)	89 (94%)
D300 ($6.52)	2 (5%)	42 (95%)
D500 ($10.86)	5 (6%)	84 (94%)
Total n =332	33 (10%)	299 (90%)

4.6.2 Travel Cost Comparison to WTP

Another way of establishing the validity of this estimation is to compare the result to the estimated travel cost of visiting the beach (a revealed preference method). Knowing the place of residence of my survey respondents, I calculated a mean public transportation cost of D90 (US$ 1.95) per visit to the beach. Similarly, I also know that from the survey that, 81% of respondents visit the beach at least once a month. In fact, of these visitors, 28% visit daily, and 30% visit at least twice a week. Using a conservative approach of one visit per month, on average, I estimated the annual mean public transportation cost of visiting the beach to D1,080 (US$ 23.48). This yearly cost of beach visitation is conservative in the sense that some of the visitors travel using their own cars or paying for a round trip ranging from nearly D300 (US$6.5) to D600 (US$13) on private ‘Uber’ known as “town trip” in The Gambia. Besides, other related expenses of visitation include buying new outfits or the laundry costs of cleaning used clothes as well as the prices of drinks and food incur by an average beach visitor.

Consequently, if the average beach user is willing to spend nearly D1,440 (US$31) to over D3,600 (US$78) per year, accounting for the costs of transportation and other consumables, it is reasonable to find that 94% of the respondents are willing to pay a single lumpsum amount of D500 (US$ 10.86). This is equivalent to spending D41.67 (US$0.90) per visit, assuming that the average beach user visits the beach at least once a month. Therefore, I conclude that my estimated upper WTP vector D500 ($10.86) for enhanced coastal protection against climate change impacts is an underestimation of people’s maximum WTP.

4.6.3 Aggregation of WTP Estimates

One of the objectives of CV studies is to extrapolate welfare estimates of a given population for aggregating the total valuation of policy intervention (Dribek & Voltaire, 2017). My goal is to have an estimate for determining the benefit-cost ratio and the overall social acceptability of the project for appropriate policy intervention. The aggregated WTP estimate in this study can be generalized to account for the welfare benefit of improved coastal protection to all Gambians and non-Gambians. This is justified given their stated high preference for bequest and option values of the beach areas as well as the indirect benefits of the tourism sector to the local economy. I added in my estimation, the total number of tourists arrived in The Gambia in 2017, according to The Gambia Bureau of Statistics, for establishing the aggregate WTP values for non-Gambians. However, this bias my estimates downward since I could not account for the population of non-Europeans, mostly foreign nationals from other African countries who visit the country via different routes for beach tourism. Although, that number is expected to be relatively small.

To calculate the total benefits from the policy intervention, I multiplied my highest WTP bid value, D500 (US$ 10.86), by 90% of the urban population and 88% of tourist arrivals in 2017, who respectively express positive WTP for improved coastal protection. The estimated metropolitan urban population, which is 61% of the total population of The Gambia, covers residents residing less than 20 kilometers from the beach sites. The total WTP welfare value for only urban-settlers and non-Gambians is estimated at 647.763 million (US$14.082 million) for enhanced protection and the preservation of The Gambia's open coastline (see Table 4.8).

The above estimate excludes rural Gambians' WTP for coastal protection. I cannot assume that the rural population who indirectly benefit from beach tourism and other related activities has zero WTP value. To factor the rural welfare benefits, I used my lowest WTP bid value D50 (US$ 1.08), to estimate their WTP for coastal protection. Given that I do not collect data from rural Gambians, I interpolated that only 50% of them might express positive WTP. Supposedly that this is reasonable, I estimated a total welfare value of D20.475 million (US$ 445.108) among rural dwellers for improved coastal protection.

When welfare values are all combined (see Table 4.8), I find a total WTP estimate of 668.2 million (US$ 14.5 million) among all Gambians (rural and urban combined) and non-Gambians for improved coastal protection. It is important to emphasize that this is a conservative value of benefits, as stated above. Given the evidence on WTP distribution discovered in this study, it is important to stress that this is a lower-bound estimate for determining the welfare benefits of improved coastal protection in The Gambia.

Table 4.8. Aggregate WTP for Gambians (Urban and Rural) & Non-Gambians

% of Population with + WTP	Population	WTP Est. (D)	Aggregation Value in (D)	Aggregation Value in (US$)
Urban (90%)	1,152,900	500	576,450,000	12,531,522
Rural (50%)	409,500	50	20,475,000	445,109
Tourists (88%)	142,626	500	71,313,000	1,550,283
Total (Gambian & Non-Gambians)	1,705,026		668,238,000	14,526,913

4.7 Cost-Benefit Analysis (CBA) Results

As earlier stated above, estimating the aggregate welfare benefit of enhanced coastal protection would be useful to compare with the cost of the project. The objective is to determine if the intervention has a positive net present value or benefit-cost ratio greater than 1. I used the project cost information from Coates & Manneh (2015) report. For details on project cost specifications, see the methods section above under the study description. During the survey implementation, I proposed that the public will only be responsible for paying only 40% of the total project cost of US$13 million. In fulfilling its part, the government, with the support of its development partners, will contribute by paying for the remaining 60%.

I estimated the net present values (NPV) and benefit-cost ratio (BCR) of the beach improvement project based on two different scenarios. Scenario 1 estimates the NPV and BCR of the project supposed the public pays for only 40% of the total project. In contrast, scenario 2 assumes that the public will pay for the overall project cost. I find positive NPVs for scenarios one and two, respectively. In terms of BCR, I find 2.79 and 1.12, respectively, for scenarios one and two. Given my analysis, I conclude that the beach improvement project is socially desirable since the aggregate welfare benefit outweighs the total project cost (See Table 4.9). The NPV and BCR results for both scenarios remain positive and greater than 1 even if I ascribe zero WTP value to the rural population of Gambians. If I constrained the aggregate welfare benefits to only Gambians in comparison to the total project cost, the NPV and BCR for scenario one still stay positive and greater than 1, respectively.

Table 4.9. Cost-Benefit Analysis (Project Cost Vs. Aggregate Welfare Value)

Indicator	**Cost (US$)**	**Benefit (US$)**	**NPV (US$)**	**B/C Ratio**
Total Project Cost	13,000,000			
40% Of Project Cost Paid By The Public	5,200,000			
Aggregate Welfare Value (WTP Est.)		14,526,913		
Scenario				
Scenario 1. (40% paid by the public)			9,326,913	2.79
Scenario 2. (100% paid by the public)			1,526,913	1.12

4.8 Discussion

4.8.1 Determinants of WTP

One of the objectives of economic valuation studies is to investigate factors that influence WTP. My study findings are in line with the determinants of WTP results reported in several other studies. First, I find a statistically significant relationship between both part-time and full-time employment and WTP. Compared to different employment statuses (e.g., unemployed, retired, student, etc.), ceteris paribus, part-timers are on average more inclined to pay (17%), followed by full-timers (7%). Evidence suggests that the majority of part-timers are employed in the tourism industry where their employment is dependent on the seasonal arrival of European tourists, mainly visiting to enjoy the sunny sandy beaches of The Gambia.

Second, studies revealed that the age variable had recorded both positive and negative effects on WTP (Seip & Strand, 1992; Halkos & Matsiori, 2012; Alves et al., 2015). According to these three studies, the age variable has a negative effect on WTP. They argue that unlike younger people, older people have more substantial financial needs and higher economic dependence upon retirement (Halkos & Matsiori, 2012). However, In contrast, my results show that the younger ones are nearly 78% less willing to pay for improved coastal protection relative to older people (above 45yrs. old). These results might be somewhat surprising to some as they would expect that the younger generation to have a greater WTP, assuming that they would be more financially stable relative to the older ones. However, one should also be mindful that the youth group in The Gambia suffers from a high unemployment rate, and they are believed to have more financial needs than older people. Similarly, according to Alves et al. (2015) study, if percent WTP and average WTP were compared, younger ones became less willing to pay.

Third, economic theory suggests that WTP tends to increase with income (Halkos & Matsiori, 2012). Therefore, the higher the income level, the greater one's WTP. According to Halkos & Matsiori (2012), "more income indicates that people would be willing to pay more." I find the same effect in my econometric analysis. Relative to middle and upper-income earners, the lower-income group is nearly 10% less likely to pay for improved coastal protection along the open beaches of The Gambia. The income variable has a significant effect on WTP for coastal zone quality improvement in Central Greece (Volos) (Halkos & Matsiori, 2012). A meta-analysis by Schläpfer (2006) found the income variable statistically significant in 30 out of 83 scenarios in 64 CV studies (cited in Halkos & Matsiori, 2012). However, the effect of income on WTP was insignificant in Blakemore & Williams (2008) study in Turkey.

Fourth, economic theory suggests a positive relationship between education and WTP (Langford et al., 1998, cited in Halkos & Matsiori, 2012). Educated people are expected to express relatively higher WTP based on the theoretical assumption that educated people tend to understand the significance of environmental protection for enhancing the socio-economic development of any nation than their uneducated counterparts (Halkos & Matsiori, 2012; Alves et al., 2015). My findings agree with the direction of the statistical relationship, but the variable was not significant.

Also, my gender variable has no statistically significant effect on WTP. Again, my results are consistent with Blakemore & William's (2008) study in Turkey. Although, in Dribek & Voltaire's (2017) study, men were less willing to pay compared to their women counterparts. Likewise, Seip & Strand, (1992) study reported that the mean WTP is somewhat (about 50 NOK) higher for women than for men. However, gender and WTP in my model shows the opposite direction, but very weak to explain the relationship.

Besides, Gambians' WTP for improved coastal protection is positive and statistically significant. On average, Gambians are 20% more willing to pay than non-Gambians. This result is consistent with other studies, respectively, in Venice (Polomé et al., 2005), in Abu Dhabi (Blignaut et al., (2016), and in Tunisia (Dribek & Voltaire, 2017). They all found nationals with a relatively higher WTP. Irrespective of the location (whether on the beach or in places off the beach), I find no statistically significant difference in terms of WTP for improved coastal protection, respectively, between on-site and off-site respondents. However, the off-site group seems to have less WTP than the group found on the beach on the day of the survey.

Regular participation in beach recreational activities such as picnicking seems to influences a positive reaction on WTP for coastal protection. On average, respondents are 6% more willing to pay, if they report their participation in picnicking as always, usually and sometimes. Other recreational activities like horse-riding, swimming, and wildlife viewing show a positive but insignificant relationship with WTP. Sunbathing shows a significantly negative effect on WTP. My respondents are 8% less inclined to pay if they participate in sunbathing during their beach visits relative to those who disengage in sunbathing. Of course, substitutes for sunbathing are not inadequate in such a climate.

Among the variables regarding respondents' perception of the importance of coastal ecosystem services, I find the pleasure of receiving ocean breeze when on the beach and the presence of a beautiful coastal landscape statistically significant in determining WTP for improved coastal protection. On average, respondents' are 11%

more willing to pay if they agreed to have been benefiting from these recreational benefits.

Finally, other studies highlighted that previous experience with a natural resource or ecosystem benefits, and knowledge of their preservation influences one's WTP (Giraud et al., 2002; Kotchen and Stephen, 2000 (Halkos & Matsiori, 2012). I recommend subsequent CV studies to include those as covariates.

4.8.2 Impacts of Economic Valuation

The effects of the proposed improvement project designed for my study site also include protection of coastal properties, preservation of assets of cultural heritage, reduction of sandy beach erosion, prevention of saline intrusion, and sedimentation as well as restoration and conservation of habitats (Polome et al., 2005). Consequently, the expected output of the project will create continuous and additional recreational opportunities for both Gambians and non-Gambians. Other co-benefits of the project may include employment opportunities, water quality improvement, and benefits stemming from non-use and option values derive from preservation and restoration efforts.

Evidence suggests that the valuation of coastal recreation can provide compelling justifications for designing, funding, and implementing coastal protection programs by policymakers (Ledoux & Turner, 2002; Halkos & Matsiori, 2012). Implementing the beach improvement project is likely to reduce over-crowdedness of narrow beach areas and increase visitation rates amongst local users and international tourists. My results are consistent with similar studies in Florida and Georgia which found the economic value of beach recreation or beach access increases with increasing beach width, associated with nourishment (Shivlani et al., 2003; Landry et al. 2003; cited in Gopalakrishnan, Landry, Smith, & Whitehead, 2016). Similarly, in New Jersey, Silberman & Klock (1988) indicated that visitation rates increase significantly on nourished beaches relative to others (Gopalakrishnan et al., 2016).

Moreover, beaches generate significant economic value for both resident and non-resident populations. With climate change impacts such as rising sea levels, erosion of coastal beaches is substantially undermining CES benefits and the economic value received from such habitats. For instance, a study revealed that Barbados beaches were worth over US$13million to the local economy (Dharmatratne and Braithwaite, 1998, cited in (Castaño-Isaza et al., 2015). A similar study reported tourists' unwillingness to return to the island and pay the same price if the beaches continue to be destroyed by climate change impacts (Uyarra et al., 2005 cited in Castaño-Isaza et al., 2015). Another significant benefit of beach preservation is the protection of coastal properties, which has substantial benefits to private property owners and direct co-benefits to tourists and other beach users (Dribek & Voltaire, 2017). Finally, other scholars reveal evidence that property values tend to decrease in high-erosion prone areas than others (Dribek & Voltaire, 2017).

4.8.3 Comparison with Other WTP Studies

Given the evidence in many beach valuation studies, I find this study results comparable to other studies, taking into account country dynamics and local realities (see Table 4.5 above). Some of these other studies include WTP estimates for several coastal protection studies from Polomé, Marzetti, & van der Veen (2005) in Italy; Koutrakis et al., (2011) study in Greece, France, and Italy; Rulleau and Rey-Valette (2013) study in the French Mediterranean; Raybould & Lazarow (2009) study in Gold Coast, Australia; and Logar and van den Bergh (2014) in Crikvenica, Croatia; Whitmarsh et al., (1999) WTP study in Hampshire (UK) (Dribek & Voltaire (2017). For a detailed comparison of WTP estimates across countries using different valuation methods (see Table 4.10).

In terms of WTP between residents and non-residents (tourists), my findings agreed with many other studies. I find 12% negative WTP among non-Gambians compared to 10% among Gambians. Similarly, Dribek & Voltaire (2017) study revealed that 43 and 15% of tourists and residents expressed negative WTP. In the same survey, protest votes were higher amongst tourists than residents. Also, similar findings were reported in the Venice's WTP case study by Polomé et al., (2005) and Blignaut et al., (2016) study in Abu Dhabi, where annual amenity values for residents and tourists were estimated at US$218,500 and US$4,900 respectively, with the availability of an alternative site. In the event of no alternatives, the amenity values were $1,090 500 for residents and US$ 119,330 for tourists.

Table 4.10. Literature Review of WTP Studies for Improved Coastal Protection & Maintenance

Author (Year)	**Coastal Ecosystem Service Protection**	**Study Area (Country)**	**Valuation Method**	**WTP Value**
Silberman and Klock (1999) cited in (Dribek & Voltaire, 2017)	Use-value & existence value of beach re-nourishment	New Jersey (USA).	CV	mean 'use-value' and mean 'existence value' of beach re-nourishment (USA) at $3.90 and $16.31, respectively
Landry et al., (2003) cited in Dribek & Voltaire, (2017)	Beach erosion management alternatives	Georgia (USA)	CV	daily mean marginal WTP falls between $6.75 and $9.92
Lew & Larson (2005, 2008) cited in Gopalakrishnan et al., (2016).	Beach erosion control	San Diego County (USA)	CV	"The value of avoiding erosion of sand that exposes cobblestones is $6 per trip."
Shivlani et al., (2003) cited in (Dribek & Voltaire, 2017)	Beach nourishment	South Florida (USA)	CV	mean WTP value for a beach nourishment project in ranges from $1.69 to $2.12

Silberman et al., 1992 cited in (Dribek & Voltaire, 2017)	Beach nourishment	New Jersey (USA).	CV	mean WTP for users of project beach ranges from $15.21 to $31.98 mean WTP for non-users of project beach ranges from $9.34 to $23.87.
Petrolia and Kim (2011) cited in (Barbier, 2016)	Preventing future coastal land losses,	Louisiana (USA)	CV (2009 est.)	Mean WTP (2016 $) $53 per household $628 per ha
Huang et al. (2007) cited Gopalakrishnan et al. (2016).	preservation of sandy beach	New Hampshire and Maine (USA)	Choice experiment	Each beach mile saved is valued at about $4 annually per respondent
Whitmarsh et al., (1999) cited in Dribek & Voltaire (2017)	Beach nourishment	Hampshire (UK)	CV	Mean gain from beach nourishment £1.07 per visit
Polomé, Marzetti, & van der Veen (2005)	Coastal defense	Venice (Italy)	CV	Mean of €4.85/yr./person
				Day visitors' mean WTP at €3.95 while the tourists' mean WTP is €5.56
Alberini et al., (2005) cited in (Dribek & Voltaire, 2017)	Preservation of lagoon, beach (via nourishment) and infrastructure	Island of S. Erasmo (Italy)	CV	median and mean WTP are €20.39 and €66.61, respectively
Koutrakis et al., (2011) cited in	beach protection in		CV	The mean WTP is €1.49 - €1.99 for Greece,

(Dribek & Voltaire, 2017)	three European countries	Nestos Delta coastal zone (Greece)		
		Languedoc-Roussillon Region (France)		€0.77 - €3.94 for France
		Emilia-Romagna Region and Liguria Region (Italy)		€0.50 - €2.86 for Italy
Birdir et al., (2013) cited in Alves et al. (2015)	Beach preservation	Mersin (Turkey)	CV	Mean WTP at €1.77 - €2.33 per adult per visit
Rulleau and Rey-Valette (2013) cited in (Dribek & Voltaire, 2017)	Beach protection	French Mediterranean	CV	mean WTP at €36.4 per household per year
Alves et al. (2015)	Beach preservation	Cadiz (Spain)		mean WTP at €1.66, with the median value being €1/adult/visit
Logar and van den Bergh (2014) cited in (Dribek & Voltaire, 2017)	Beach erosion prevention	Crikvenica (Croatia)	CV	mean WTP at €1.26 - €1.69 for paid beach and €1.84 - €2.08 for free beach
Blakemore and Williams (2008) cited in (Alves et al., 2015)	Beach maintenance & improvement	Olu Deniz beach resort (Turkey)	CV	average WTP £0.90 to visit Olu Deniz beach resort

Dharmaratne & Brathwaite (1998) cited in Raybould & Lazarow (2009)	Access value of all coastline recreational activities	Barbados	CV (1993-1994 data)	Net benefits from the west- and south-coast beaches = $28.99 for first-time and $22.45 for repeat visitors when water quality was below the desired level
Raybould & Lazarow (2009)	Value of beach recreation	Gold Coast (Australia)	Travel Cost	Average btw $0.50 and $2.30/visit/person
Blignaut, Mander, Inglesi-Lotz, Glavan, & Parr (2016)	Value of coastal and marine resources to beach visitors	Abu Dhabi Emirate	CV	Value range from US$8.3million/ha to US$13.8million/ha based on the beach size

4.9 Conclusion

People in developing countries, especially in Africa, are reported to lower average WTP for coastal protection relative to people in Asia, Europe, and North America (Liu & Stern 2008). Liquidity constraint has been considered as leading factors (Jacobsen & Hanley, 2009; Gibson et al., 2016). This case study provides evidence that contradicts the assertion that people in poor developing countries have a nominal value or less WTP for protecting public goods and natural resources.

This study finds evidence for a substantial positive WTP for improved coastal protection in The Gambia. Overall, I estimated an aggregate WTP value of D668.238 million (US$14.527million) for enhancing the protection and preservation of The Gambia's open coastline (i.e., coastal cell six). Consequently, based on the result of a positive NPV, I conclude that the beach improvement project outlined in Coates & Manneh (2015) study is socially desirable since the estimated aggregate welfare value outweighs the overall cost of the project.

The key takeaway of this study is that contrary to other studies, corroborated evidence suggests that low-income individuals have a significant WTP value for protecting public goods for shared intergenerational benefits. Therefore, liquidity constraints in developing countries should not be the primary justification for undervaluing poor people's WTP value for protecting natural resources and ecosystem services they heavily depend on for leisure and survival needs.

Although not hypothetically feasible for this study, others are now applying alternative methods such as willingness to work (WTW) to appraise poor peoples' WTP value (Gibson et al., 2016). Using the WTW approach, a study by Abramson, Becker, Garb, & Lazarovitch, (2011) substantiates my findings, emphasizing that low-income people do not necessarily have 'absence of demand' to improve or protect public goods. Alternatively, future studies may use the willingness to accept (i.e., compensation) CV approach in similar study contexts to assess people's welfare value for enhanced coastal protection against climate change impacts.

Economic valuation and CBA are essential policy tools for providing information about the social costs and benefits of alternative policy interventions. This enables decisionmakers to prioritize among projects, strengthen economic efficiency, and improve the effective decision-making process for enhanced coastal protection and preservation. My results highlight the substantial economic value and recreational and cultural ecosystem service benefits provided by the country's beach ecosystem, not just for the benefit of Gambians but non-Gambians as well (i.e., tourists). My benefit-cost analysis justifies any government's investments towards protecting the coastline against climate change impacts such as coastal erosion. Best practices in doing so include but not limited to Integrated coastal zone management (ICZM) as well as adopting both hard engineering and ecosystem-based solutions, where possible. Given the findings mentioned above, I also recommend that planning and policy decisions involve and account for coastal ecosystem services values into national development blueprints.

Finally, the determinants of WTP provide public policy implications. For instance, employment status in my study offers an incentive for the protection of public goods (beach site) in The Gambia. This is particularly important for part-time employees whose livelihoods depend on the country's beaches, which attracts tourists and promotes the local tourism industry. Another implication for not protecting the beaches means residents (i.e., families) would lose the utility they derive from participating in various recreational activities, as mentioned above. For example, recreational activities like picnicking and swimming are highly undertaken at these beaches. In the event of loss of beach site, substitutability may not be easily attainable.

The main limitation of this study is the underestimation of the WTP bid values as discussed above. Future studies should twice increase their upper bid vector compared to what has been used in the primary survey for this study.

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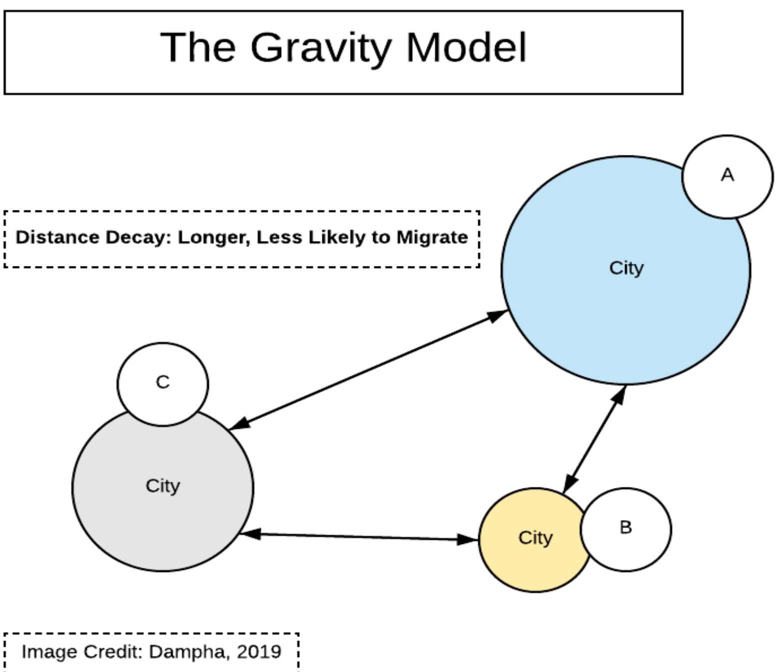
Appendices

6.1 Appendix A. Literature Review & Conceptual Modelling of Climate Change and Migration Nexus (Chapter One)

Theoretical Framework of Migration

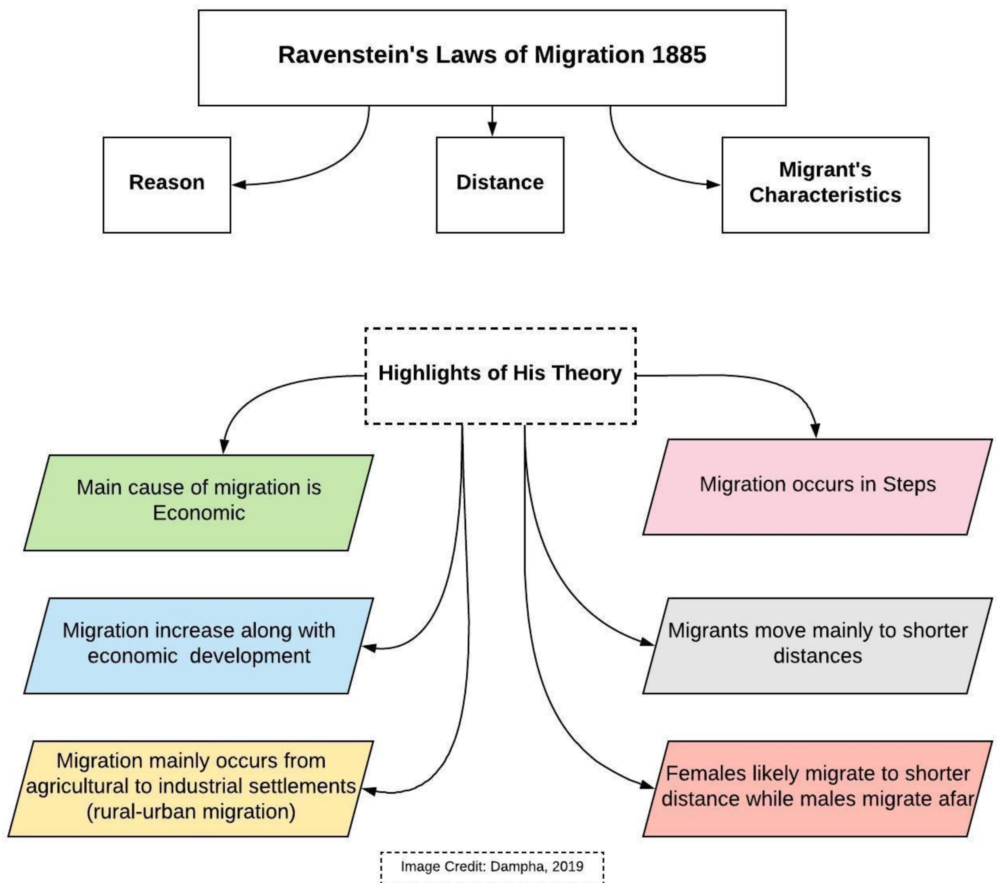
One of the earliest and simplest migration models was the In- and Out-Migration model, which focuses on the in-flow and out-flow of migrants into or from a specific region regardless of the original destination (Perch-Nielsen, 2004). Another early migration model was the gravity model, informed by Isaac Newton's law of universal gravitation (1687), which states that "every point mass attracts every single point mass by force pointing along the line intersecting both points. The force is directly proportional to the product of the two masses and inversely proportional to the square of the distance between the point masses." (Krampf, 2019). As in Figure 1-Appendix A., the diagram illustrates that migration is directly related to the populations of places and inversely related to the distance between them. This model predicts spatial interaction between destinations on the pretext of population size and distance between the destinations. The model suggests that migrants tend to move to larger cities with attractive facilities than smaller ones. However, the longer the distance, the lesser the propensity to migrate, a phenomenon referred to as 'distance decay' in the migration literature.

Figure 1-Appendix A. The Gravity Model



Following the gravity model, came the famous laws of migration (published in the late 1800s), by a German migration scholar, Ernst Georg Ravenstein. Ravenstein's laws of migration are founded on three cardinal pillars. First, there is a reason for all types of population movements. Second, distance is a crucial determinant of migration destination. Third, migrants' characteristics influence the extent and nature of migration they consider. In Figure 2-Appendix A., I provide some other highlights of Ravenstein's laws of migration. Another earlier migration theory was the Push and Pull theory of migration, developed by Everett Lee in 1966. The theory suggests that each destination possesses a set of positive (pull) and negative (push) factors that attract or repel people. However, there are intervening obstacles such as distance, terrestrial, climatological, and hydrological conditions, which affect migrant's ability to move.

Figure 2-Appendix A. Highlights of Ravenstein's laws of migration

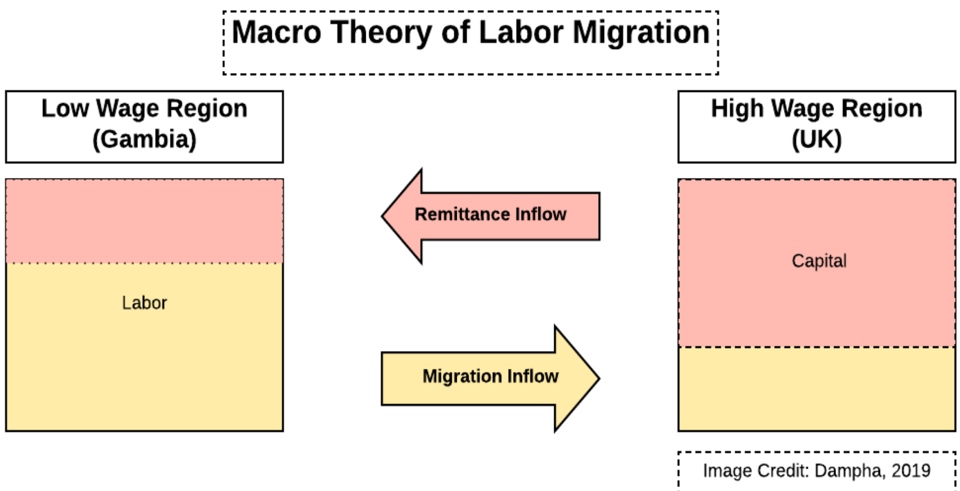


One of the recent migration models includes the Neoclassical Economics model. On the one hand, the micro theory of the model views individuals as rational decision-makers who will weigh their migration decisions based on a positive net present value from financial cost-benefit analysis (Castles & Miller, 2009; Perch-Nielsen, 2004). The theory was expanded to include an individual's interest to maximize utility instead of relying solely on monetary value to inform the migration decision-making process

(McLeman, 2014; Perch-Nielsen, 2004; Bilsborrow, 1998). Maximizing the household's utility as the basis of migration includes; property ownerships such as land, employment, investment opportunities, availability of public goods and services as well as favorability of climate and environmental conditions (Massey et al., 1993a).

On the other hand, it is the macro theory of the neoclassical economics model (also referred to as Dual Labor Market Theory), which perceives migration as a function of a labor market demand and supply disequilibrium. Labor migrants will move from low-wage to high-wage regions, and overtime wages will decline when labor supply is in surplus (UN/POP/EGM-URB, 2008; Perch-Nielsen, 2004; Massey et al., 1993) (See Figure 3-Appendix A.). The theory further argues that migration is jointly determined by local conditions and continuous international demand for cheap and unskilled labor from developing countries. It assumes that immigrants in developed countries will have no problem in accepting low paying jobs associated with no social status (Castles & Miller, 2009; Perch-Nielsen, 2004; Massey et al., 1993). Cheap labor means immigrants have less bargaining power and often overexploited by capitalist agents in developed countries. Similarly, the Lewis Dual Sector model explains internal labor migration between rural agricultural regions and urban industrialized areas. The Lewis theory can better inform the motivation for increasing rural-to-urban migration in The Gambia.

Figure 3-Appendix A. Macro Theory of Labor Migration



Another recent migration theory of is the World Systems Theory, which claims that "the penetration of capitalist economic relations into peripheral, non-capitalist societies creates a mobile population that is prone to migrate abroad" (Massey et al., 1993, p. 444, cited in Perch-Nielsen, 2004). This theory was developed by Wallerstein (1984) anchored on the dependency theory, which has its intellectual roots in the Marxist political economy (Castles & Miller, 2009). It argues that the advancement of 'core' capitalist regions in the global north comes to the expense of less developed and overexploited 'periphery' regions in the global south. The theory also explains international migration as a factor of the socio-historical ties that exist between former colonies and colonizers (e.g., Gambia- Britain and Senegal-France relations) (Perch-Nielsen, 2004).

More recently, the Transnational theory of migration attributes mobility to waves of globalization through which rapid enhancement in communication and transportation technologies have significantly facilitated growing migration rates between origin and destination regions. Arguably, the concept of transnationalism has contributed to the recent growth of circular migration not necessarily for economic reasons but more so for political, cultural, and religious reasons (Castle and Miller, 2009). This theory is of the many migration theories that emphasize migrant's high level of agency to make individual decisions since most transmigrants are influential and powerful actors in society. However, the notion of transnationalism is found to be quite ambiguous, which requires further research, according to Castle and Miller (2009).

Finally, it is pertinent to stress that each migration type is either barricaded or facilitated by some macro, meso, and micro structures. Macro-structures are large-scale political and institutional structures, including policies and regulations. Meso-structures are intermediary factors that connect macro conditions to micro-structures. Micro-structures are small-scale individual networks, practices, and beliefs possessed by migrants (Castle and Miller, 2009). The interaction between macro-, meso- and micro-structures defines what Castle and Miller (2009) call the migration systems approach. An example of a micro-structure migration systems approach is chain migration, which has been used widely to explain the rapidly growing internal and international population movement. Chain Migration is a conceptual notion that migration drives itself. It argues that first migrants facilitate the migration of their families and friends and increases their likelihood of securing a permanent residency at the final destination (McLeman, 2014; Castle and Miller, 2009; Perch-Nielsen, 2004). Chain migration has significantly contributed to the socio-economic development of both original and final destinations (Perch-Nielsen, 2004). For more on migration network theories (e.g., transnational theory of migration), read Castles and Miller (2009).

Theoretical Nexus Between Climate and Migration

Researchers describe both climate and migration as very complex systems or processes, often influenced by various feedback hoops (e.g., ‘beaten path effect’ & water vapor feedback) (Tacoli, 2009; Perch-Nielsen, 2004). They both require interdisciplinary research for better policy formulation (Perch-Nielsen, 2004). However, unlike climate models (e.g., Atmosphere-Ocean General Circulation Models), migration models (e.g., neoclassical theories, push-pull theory, new economics theory) are competing philosophical worldviews based on time and space (Massey et al., 1993b). Unfortunately, environmental and climate change impacts are not well integrated into migration theories, as they are described to be complicated and hard to predict. Hence a theoretical gap exists which (McLeman, 2014; Perch-Nielsen, 2004) tries to model conceptually for understanding climate-and-migration interactions, including the feedback effects (McLeman, 2014; Perch-Nielsen, 2004), to provide decision-making tools for climate adaptation planners (Black et al., 2006). Building off on conceptual models in McLeman (2014) and Perch-Nielsen et al., (2008), this dissertation conceives migration as a possible risk reduction strategy for a household to consider (chapter one). As described in Models 1 and 2, families may not necessarily migrate as a reaction response to environmental and climate change impacts such as flooding. Still, they can decide to relocate due to a perceived climate risk factor (e.g., SLR).

The aim of using conceptual models is to simplify our worldviews of real systems, provides transparency, clarifies boundaries, identifies connections, integrates knowledge, enable better communication across disciplines, and facilitates the identification of research gaps (Perch-Nielsen et al., 2008). The objectives of using a conceptual model are to; (a) explicitly indicate how migration as a risk reduction strategy connects to climate change through perceived risk factors associated with flooding and SLR, and (b) investigate the appropriate model or theory of human migration that explains the rapid out-migration recorded from the island capital city of The Gambia, Banjul.

Flood Causes and Impacts

Flood risk frequency and strength are primarily influenced by climate change hazards such as increased precipitations and rising sea levels (Nawrotzki and Bakhtsiyarava, 2017; Fu and Song, 2017; Perch-Nielsen et al., 2008; Raleigh et al., 2009). Other non-climate factors that influence flood risk and impacts include topographic conditions (sloppiness), soil and rock types, land use and land cover conditions, rapid urbanization, landscape modification, and the presence of green and grey infrastructure within an area (McLeman, 2014; Perch-Nielsen, 2004). For instance, the presence of green infrastructure (GI) in cities can reduce flood risk and mitigate potential impacts. GI also increases infiltration and percolation rates. At the same time, it contributes to groundwater recharge. In contrast, cities with impervious surfaces, without proper stormwater infrastructure systems, are at high risk of flooding (Perch-Nielsen, 2004) and its associated impacts such as forced migration. Such impervious systems are mainly prevalent in poorly designed urban settlements with overcrowded conditions like in Banjul, Dakar, Lagos and Accra to name but a few.

In The Gambia, 11 severe flood events, including flash, riverine, and coastal flooding, had affected 93,469 people, including 70 deaths between 1999 and 2018 (CRED-Database, 2018). In 1999 alone, 32,000 people had been affected by extreme flooding resulting in the temporal displacement of 5000 inhabitants and death records of 53 people in The Gambia. Between 2007 and 2013, riverine flooding had affected 57,219 people, including16 deaths. Unfortunately, since 1999, no date was collected on flood induced migration as well as economic damage attributed to its impact on The Gambia. In contrast to Senegal, over 850, 000 people had been affected by 11 flood events, mainly riverine, including 80 deaths, and about 6500 were temporarily displaced between 2002 and 2013 (CRED-Database, 2018). In Senegalese capital city, Dakar, “more than 40% of new migrant populations are located in high-risk flood zones” (Foresight 2011, cited in Neil Adger et al., 2014).

In Banjul, frequent and extreme flood events have been reported to influence out-migration as private properties and public infrastructure are destroyed and damaged, including injuries and loss of lives. Destructions include damage to houses, household assets, roads, water, and electricity supply systems (see Figure 1-Appendix A.). According to data from the National Disaster Management Agency (2017), 3355 people have been severely affected by intense precipitation and extreme windstorm events in Banjul since 2010. The result from my survey shows that over 85% of Banjulians report that the city experiences destructive flood events annually, and the majority of my respondents highlight 'city flooding' as one of the most significant drivers of rising out-migration rates since the 1990s. Immediate permanent migration after a flood event is often not the case. Households in Banjul tend to choose voluntary relocation in the aftermath of seasonal flood events to mitigate future inundations. Likewise, in Banjul, Nawrotzki & DeWaard (2016) study in Mexico found that migration might be delayed, and perhaps later considered, when households exhaust all in situ adaptive capacities at their disposal.

Due to Banjul's high exposure and vulnerability levels to climate and environmental hazards combined with its disappearing social capital and rising per capita income levels, I postulate that by 2050, over half of the city's current population will migrate to avert potential climate change impact projections, if business as usual continues. Among over 60% of expected environmental migrant households in Banjul, according to my survey findings, I predict that over 75% will likely migrate to the West Coast Region since there is limited or virtually no space for incoming migrants in the Kanifing Municipality. The remaining percentage will possibly move to other regions while some will emigrate abroad.

Figure 1-Appendix A. Example of Flood Damage at Household Level

Image Credit: Drammeh, 2017

In Africa, extreme flood events had left over 2 million people homeless, the majority of who had been temporarily displaced between 1999 and 2018, according to the International Disaster Database (CRED-Database, 2018). During the same period, there had been nearly 600 flood occurrences, leading to almost 13,000 deaths, 10,000 injuries, and over 41 million people had been affected in other ways (see Table 1-Appendix A.). Flood events in Africa cost an estimated total economic loss of nearly US$ 6 billion from 1999 to 2016. On average, a single flood disaster costs total economic damage of over US$ 7 million in Africa (UNISDR-PreventionWeb, 2018)**.**

Table 1-Appendix A. Various Flood Subtypes & their Impacts in Africa 1999-2018

Period/Yr	Disaster subtype	Occurrence	Total deaths	Injured	Affected	Homeless	Total affected	Total damage ('000 US$)
EASTERN AFRICA								
1999-2016	Riverine Flooding	183	4,267	1,447	14,705,060	549,807	15,256,314	$ 1,497,318
1999-2016	Flash Flooding	39	1,194	474	1,291,924	150,700	1,443,098	$ 35,920
2001-2007	Coastal Flooding	5	157	3	1,200,826	-	1,200,829	$ 42,700
Total	**All Flood Types**	**227**	**5,618**	**1,924**	**17,197,810**	**700,507**	**17,900,241**	**$ 1,575,938**
WESTERN AFRICA								
1999-2016	Riverine flood	143	2,167	3,932	15,214,010	433,882	15,651,824	$ 1,068,211
1999-2016	Flash flood	21	462	617	234,976	129,607	365,200	$ 7,805
Total	**All Flood Types**	**164**	**2,629**	**4,549**	**15,448,986**	**563,489**	**16,017,024**	**$ 1,076,016**
NORTHERN AFRICA								
1999-2015	Riverine Flooding	57	2,016	1,588	3,438,746	263,280	3,703,614	$ 1,776,900
1999-2016	Flash Flood	16	488	90	491,900	110,000	601,990	$ 420,061
2007	Coastal flood	1	12	-	-	-	-	$ -
Total	**All Flood Types**	**74**	**2,516**	**1,678**	**3,930,646**	**373,280**	**4,305,604**	**$ 2,196,961**
MIDDLE AFRICA								
1998-2014	Riverine Flooding	71	810	390	2,501,660	266,311	2,768,361	$ 22,059

1999-2016	Flash Flooding	16	496	1,007	379,837	93,343	474,187	$ 16,000
Total	**All Flood Types**	**87**	**1,306**	**1,397**	**2,881,497**	**359,654**	**3,242,548**	**$ 38,059**
SOUTHERN AFRICA								
1999-2014	Riverine Flooding	36	555	321	1,889,197	47,200	1,936,718	$ 905,104
1995-2016	Flash Flood	9	265	12	24,600	2,500	27,112	$ 123,300
Total	**All Flood Types**	**45**	**820**	**333**	**1,913,797**	**49,700**	**1,963,830**	**$ 1,028,404**
AFRICA								
1999-2016	Riverine Flooding	490	9,815	7,678	37,748,673	1,560,480	39,316,831	$ 5,269,592
1999-2016	Flash Flooding	101	2,905	2,200	2,423,237	486,150	2,911,587	$ 603,086
2001-2007	Coastal Flooding	6	169	3	1,200,826	-	1,200,829	$ 42,700
Total	**All Flood Types**	**597**	**12,889**	**9,881**	**41,372,736**	**2,046,630**	**43,429,247**	**$ 5,915,378**

Source: (CRED-Database, 2018)

Across the continent of Africa, Eastern and Western African countries are the most vulnerable and worst affected by all types of floods. From 1999 to 2018, nearly 18 and 16 million people had been affected by various flood types in Eastern and Western Africa, respectively (see Table 1-Appendix A.). Each flood event affects nearly 74,000 people on the continent and kills 28 people on average (UNISDR-PreventionWeb, 2018). For example, around October 2017, over 200,000 people had been affected by flooding in Niger, including 56 deaths (UN-OCHA, 2017). Likewise, in East Africa, a recent catastrophic flood event had at least led to 100 fatalities and displaced nearly 260,000 people in Kenya (Feingold & Thornton, 2018). According to the UN estimate, nearly 500,000 people had been impacted by the flood event in the neighboring Somalia region, and close to 175,000 people had been displaced from their homes (Feingold & Thornton, 2018).

Globally, extreme flood events have impacted billions of people. In 2011 alone, nearly 136 million people had been affected by 156 climate-related flood events, leading to the displacement of millions and the deaths of thousands of people, according to the International Disaster Database (CRED-Database, 2018). For example, seasonal flooding has increased out-migration rates in the Vietnamese city of Mekong Delta (Dun, 2011, cited Neil Adger et al., 2014). Similarly, in Bangladesh, “22% of households affected by tidal-surge floods, and 16% affected by riverbank erosion, moved to urban areas” (Neil Adger et al., 2014). Due to extreme flood-related events, a single hurricane (Harvey, 2017) cost more economic damage (US$95 billion) to the United States (Kishore et al., 2018) than the total global economic damage cost (70 billion, in original US$ values) by flood impacts in 2011 (CRED-Database, 2018). For more on flood-induced migration in other continents, see McLeman, 2014, p113-133.

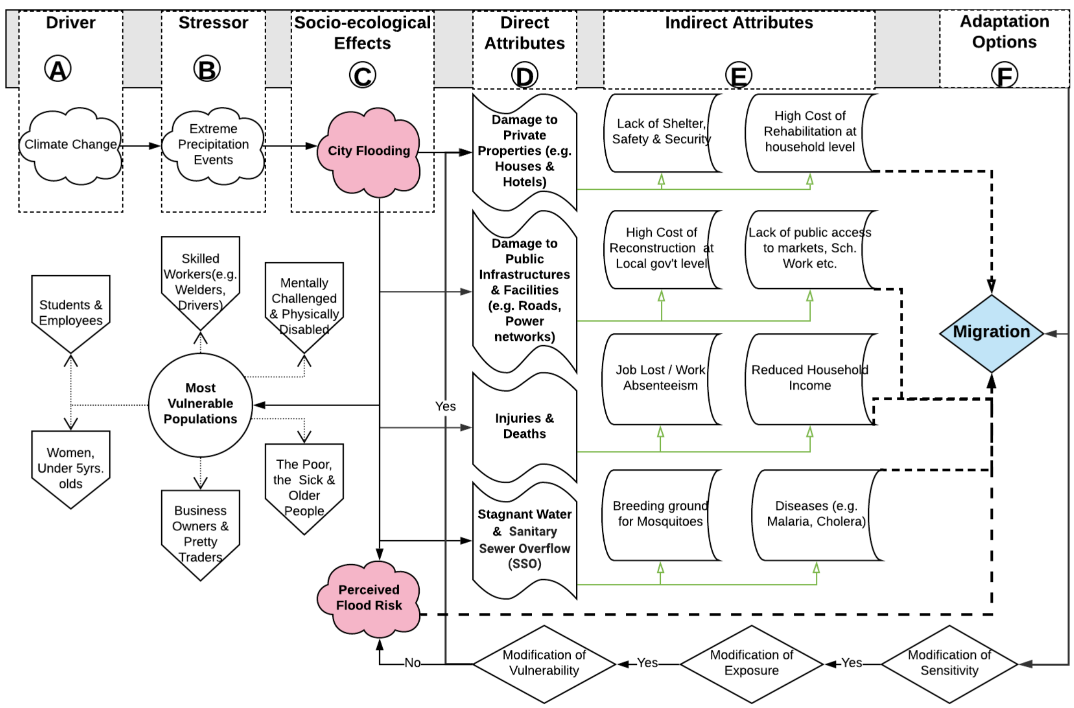
Flood and Migration Nexus

The above evidence and other studies show that the effects of extreme climate-related flood events are among the key factors that inform one’s decision to migrate (R. A. McLeman & Hunter, 2010; Perch-Nielsen et al., 2008). Although, majority of environmental migrants following flood disasters usually migrate temporarily, often to short distance places, and returnees try to rebuild their lost properties (McLeman, 2014; Raleigh et al., 2009; Perch-Nielsen et al., 2008; Piguet, 2008; Perch-Nielsen, 2004). In Banjul, over 75% of expected environmental migrant households are likely to relocate to short distance places from the city. Since nearly 80% of residents are renters, not homeowners, they are less likely to return and pay rents or rebuild damaged housing units in Banjul, unless if current conditions drastically changed.

Notwithstanding, households’ decision to stay or migrate after being hit by a devastating climate-related flood event depends on the magnitude of loss and damage caused, cost and benefit of potential migration, access to support systems, social ties, and psychological attachment to ‘home’ as well as their financial ability to rebuild and modify their exposure and vulnerability levels. If most of these conditions are unfavorably satisfied, migration is more likely an option. For instance, on the one hand, more permanent migrants from New Orleans were generated due to the destructive effects of hurricane Katrina in 2005 (McLeman, 2014; Perch-Nielsen et al., 2008). On the other hand, lack of transportation means unfortunately trapped some Katrina migrants in New Orleans (Piguet, 2008). Similarly, in Bangladesh, permanent migration is more likely an option for households with weak social ties (Afsar, 2003).

As conceptually described in conceptual model 1, the connections between climate change and migration through flooding in Banjul is explicitly illustrated in Figure 2-Appendix A. Likewise, Perch-Nielsen et al., (2008) conceptual model, which influences these two models, boxes-and-arrows are used to connect climate change impacts to migration. As in conceptual models 1 & 2 below, boxes represent relevant factors and arrows show influences, but not their strength.

Figure 2-Appendix A. Conceptual Model 1. Linking climate change and human migration through Rainfall Flooding



Conceptual Model of the Influence of Climate Change on Migration through City Flooding
Built on Perch-Nielsen model (2004) by Nfamara K. Dampha, 2019

The square headers in (models 1 & 2 in Figure 3 and 5) are model descriptors, according to Jordan (2016) they are defined as; (A) driver (external driving forces that have large scale influences on systems), (B) stressors (changes caused by drivers within managed systems), (C) socio-ecological effects (responses induced by the stressors), attributes (known impacts of stressors, can be either (D) direct or (E) indirect), and (F) adaptation options (people's reaction towards stressors). The rest of the model describes as follow:

- Climate change →extreme precipitation events → flooding (city)

- City flooding → damage to private properties → lack shelter, safety, and security → high rehabilitation cost at the household level→ which overall affects household income, food security, kid's education, and health care provisions → **migrate** **<u>or</u>** households build their resilience by modifying exposure, vulnerability, and sensitivity levels.

- City flooding →damage/undermine to public infrastructure, facilities, and services (e.g., roads, bridges, schools, health centers, water and electricity systems) → high rehabilitation cost at the levels of local and central government →undermines public access to markets, healthcare facilities, schools, workplaces, etc. → which overall affects household income, food storage, and security, kid's education, and health care provisions → **migrate** **<u>or</u>** build household's resilience by modifying exposure, vulnerability and sensitivity levels.

- City flooding →causes injuries and mortalities →work absenteeism or fewer work opportunities→ reduced household income → , which overall affects household income, food security, kid's education, and health care provisions → **migrate** **<u>or</u>** households build their resilience by modifying exposure, vulnerability, and sensitivity levels.

- City flooding →Stagnant water & Sanitary Sewer Overflow (SSO) → diseases → , drinking water pollution → sickness, fatalities → , fewer work opportunities, and reduced income →which overall affects household income, food security, kid's education, and health care provisions → **migrate** **<u>or</u>** household's build their resilience by modifying exposure, vulnerability and sensitivity levels.

- **Perceived flood risk** → **migrates**, especially when the household's ability to modifying exposure, vulnerability, and sensitivity levels are less feasible.

- The most vulnerable populations affected by various impacts of flooding include; the poor, kids, physically disabled, mentally challenged, students, formal employees, skilled workers, pregnant women, under five years old, the sick, the older people, business owners, and petty traders due to their lack of access to venture into productive economic, social, and political activities (Smith, 2001; Perch-Nielsen, 2004).

The conclusion of this modeling recognizes that the exit to migration due to extreme flood events is not an easy decision to make. Often people would utilize all kinds of resources available to their disposal before resorting to migration as an adaptation strategy. In general, household's decision to migrate due to flooding will be primarily informed by the maximum utility they expect to gain from migration, considering their overall adaptive capacity and ability to modify their state of exposure, vulnerability, and sensitivity towards flooding (see direct attributes, model 1, figure 2-Appendix A. above)

(Stojanov et al., 2017; Nawrotzki & DeWaard, 2016; McLeman, 2014; Perch-Nielsen et al., 2008).

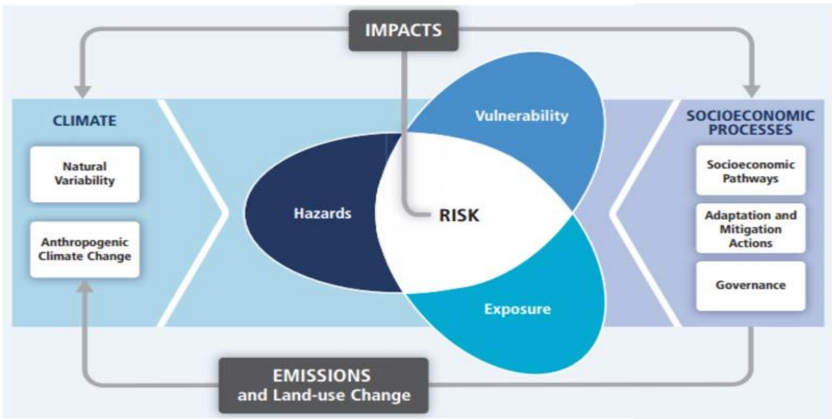
Flood Adaptation Strategy (Modification of Exposure & Vulnerability)

Besides migration, the most frequent adaptation strategies devised by households include modification of exposure, sensitivity, and vulnerability conditions towards a potential climate-induced flood risk (see conceptual model 1 above) (Martine et al., 2008; Perch-Nielsen et al., 2008). In general, the modification strategy includes efforts from all critical stakeholders from household to national levels. Therefore, modifying exposure and vulnerability to flood risk may consist of; flood abatement diversion techniques, flood insurance schemes, engineering and watershed management practices, land-use planning, building techniques, community preparedness, forecasting, and early warning systems in place as well as social support networks established by households (Perch-Nielsen et al., 2008).

According to the IPCC (2014), vulnerability is defined as “the propensity or predisposition to be adversely affected” (IPCC, 2014 p. 28). While sensitivity is the “degree to which a system is affected by a given exposure” (Perch-Nielsen et al., 2008), and exposure, on the other hand, is conceptualized as “the presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected”(Banerjee et al., 2018). Finally, the adaptive capacity of a system is defined as its “ability to adjust to potential damage, to take advantage of opportunities, or to respond to consequences” (Banerjee et al., 2018; IPCC, 2014 p. 2)

For example, an extreme rainfall event (a climate hazard) resulting in severe flood (risk) is determined by the interaction between vulnerability, exposure, and sensitivity (see Figure 3-Appendix A.). Risk is often defined as the probability of occurrence of hazardous events (likelihood) multiplied by the impacts (or consequences) if these events occur (CoastAdapt, 2017).

Figure 3-Appendix A. Interaction between Vulnerability, Exposure, and Hazard Leading to Climate Risk Impacts



Source: IPCC 2014 (Fifth Assessment Report, Working Group 2, Chapter 19, Figure 19-1).

Sea Level Rise (SLR) Causes and Impacts

Global warming increases as the earth's temperature rises primarily due to anthropogenic causes of climate change. Increased global warming causes an average global mean sea level rise (MSLR) of 3mm per year (Rigaud et al., 2018; McLeman, 2014). The significant drivers of SLR are the thermal expansion of oceans, melting of glaciers, and loss of the ice masses in Greenland and Antarctica, as well as changes in terrestrial water storage (Brown et al., 2011; Kebede and Nicholls, 2011; IPCC, 2007). Relative SLR (sea level relative to the land) is affected by eustatic SLR (changes of ocean water volumes) as well as the movement of land vertically (Perch-Nielsen et al., 2008; Perch-Nielsen, 2004). Relative SLR is projected to be higher than eustatic SLR (Perch-Nielsen, 2004). By 2100, there is very high confidence (>9 in 10 chance) that global mean sea level will rise at least 0.2 m (8 inches) and no more than 2.0 m (6.6 feet) (IPCC, 2007).

The scientific community indicated that MSLR impacts would adversely affect major cities and countries, especially those in low-lying coastal areas with high population density from Florida (US), Bangkok (Thailand), Dhaka (Bangladesh) to Shanghai (China), from Rio de Janeiro (Brazil), Jakarta, (Indonesia) to Osaka (Japan), and from Malé (Maldives), Lagos (Nigeria) to Banjul (The Gambia) (Stojanov et al., 2017; McLeman, 2014; Horowitz, 2013; Silvern and Young, 2011; Khan, 2010; IPCC, 2007). Corroborated evidence found increasing displacement of people from most of these countries, especially in Maryland and Alaska in the US, Bangladesh, Papua New Guinea, etc. (Neil Adger et al., 2014). Besides, scientists estimated that 275 million people globally live at places likely to be flooded in a 3-degree level of warming. Under such a highly probable climate scenario by 2100, the majority of coastal settlers will be forced to migrate elsewhere. From Paris (COP21) to Madrid (COP25), experts argue that attaining the Paris Climate Agreement aimed at limiting global warming to 2C above pre-industrial levels is highly unlikely. However, there are some uncertainties about temperature changes and the rate of ocean heat uptake.

Sea Level Rise (SLR) Trends in Banjul, The Gambia

The irreversible rise in global MSLR is one of the most challenging climate risk factors threatening the existence of The Gambian economy. Recently, Brown et al. (2011) predicted: "sea-level rise of 0.13m in 2025, 0.35m in 2050, 0.72m in 2075 and 1.23m in 2100" for The Gambia" (Drammeh, 2013 p. 41). Based on 1996 SLR estimates, Jallow et al., (1996) predicted that with 1.0m MSLR, the city of Banjul would be underwater by the end of this century, if no aggressive mitigation measures are undertaking (IPCC, 2014; Jallow et al., 1996). This is highly attributed to Banjul's vulnerability to climate change impacts, as a large part of the city is less than 1.0 m above the global mean sea level (Jallow et al.,1996). Jallow et al., (1996) concluded that if nothing is done, 1.0m SLR will lead to property loss of US$217 million by 2050 (between Banjul and Kololi Beach Hotel), which is equivalent to nearly 40% of the country's current GDP, in 2020 dollars. Recently, Amuzu, Jallow, Kabo-Bah, & Yaffa, (2018b p.24), restated that "by the end of this century, under a 1m SLR scenario, the total land to be lost due to inundation is 12.46 km2 (1,246 ha) with a corresponding economic loss of ~US $788 Million (GMD 37 Billion) over The Gambia's coastal zone." Besides, Norman Myers, a British environmentalist, pinpointed The Gambia as one of the most vulnerable places at risk of climate migration even under a moderate degree of SLR scenario (Black, 2001). Another fragile settlement, Jinack Island, located northwest of Banjul (about 10 kilometers), is already experiencing inundation as a direct result of rising sea level (see Figure 4-Appendix A.).

Figure 4-Appendix A. Madiyana Hotel located on Jinack Island is at high risk of SLR

Source: Green World Warries, 2018 (Image Credit: Kawsu Jammeh)

Sea Level Rise (SLR) in Sub-Saharan Africa

The vulnerability to MSLR cuts across the tropical climate belt of many Sub Saharan African countries (Brown et al., 2011). Serdeczny et al. (2016) indicated that local SLR projections tend to be higher in Sub Saharan Africa compared to the global average by roughly 10%. Likewise, The Gambia, many other Sub Saharan African countries' economies are significantly affected by MSLR (Brown et al., 2011). Major infrastructures such as tourism facilities, coastal trading centers, seaports, roads, and bridges are massively at risk of damage due to MSLR impacts. These include facilities located in Mombasa (Kenya), in Dakar (Senegal), in Lagos (Nigeria), in Dar es Salaam

(Tanzania), in Cotonou (Benin), and Abidjan (Côte d'Ivoire) (Serdeczny et al., 2016; Brown et al., 2011; Kebede and Nicholls, 2011).

Mean Sea Level Rise (MSLR) and Migration Nexus

Based on the above scientific evidence, studies have indicated that MSLR is one of the most threatening causes of forced migration or displacement of people in coastal communities and small island nations (Rigaud et al., 2018; Stojanov et al., 2017; McLeman, 2014; Neil Adger et al., 2014; Piguet, 2008; IPCC 2007; Perch-Nielsen, 2004; Myers, 2005). For example, according to Jacobson, in 1988, a meter rise in sea level could produce up to 50 million environmental refugees (Black, 2001). Across Africa, with an MSLR of 0.38m (under Rahmstorf scenario), over 15 million people per year in 2050 could be flooded annually without proper adaptation compared to only ~140,000 if adaptation is considered (Brown et al., 2011). Similarly, without adaptation measures, over 7 million people will be forcefully displaced per year in 2050, relative to 22,000 with adaptation, under Rahmstorf scenarios (Brown et al., 2011). By 2100, the countries with the highest risk of climate migration due to MSLR without additional adaptation are Tanzania, Nigeria, and Mozambique, respectively (Brown et al., 2011).

As conceptualized in model 2 below, MSLR is also predicted to exacerbate inland riverine flooding, coastal erosion, and city inundation, resulting in devastating damage to major infrastructures, human settlements, and private facilities, as well as the salinity of groundwater sources. These will severely affect the wellbeing and livelihood options for millions of people each year (McLeman, 2014; Raleigh et al., 2009; PerchNielsen et al., 2008; Perch-Nielsen, 2004; IPCC, 2007). Such losses and damage can increase out-migration knowing very well that population is higher in coastal settlements on average (Perch-Nielsen et al., 2008; Perch-Nielsen, 2004; Leatherman, 2001 cited in Perch-Nielsen, 2004). Forced migration as a direct result of flooding is considered one of the most challenging forms of population movement, which comes with less agency and dignity (McLeman, 2014). This type of migration due to riverine flooding is described as a threat but not necessarily the primary causal of the rapid out-migration in Banjul. However, evidence from this study suggests that some islanders had migrated from North Banjul due to riverine flood risk, as direct effects of rising sea levels. The out-migration recorded in Banjul is considered as a proactive risk reduction strategy. Such strategies allow vulnerable households to escape the risk of flooding through voluntary migration or what I call migration with dignity.

As described in conceptual model 2, the connections between climate change and migration through SLR in Banjul are explicitly explained as follows (see model illustration in Figure 2-Appendix A.).

- Climate change → Global warming → thermal expansion of oceans, melting of glaciers, and loss of the ice masses in Greenland and Antarctica, as well as changes in terrestrial water storage →SLR

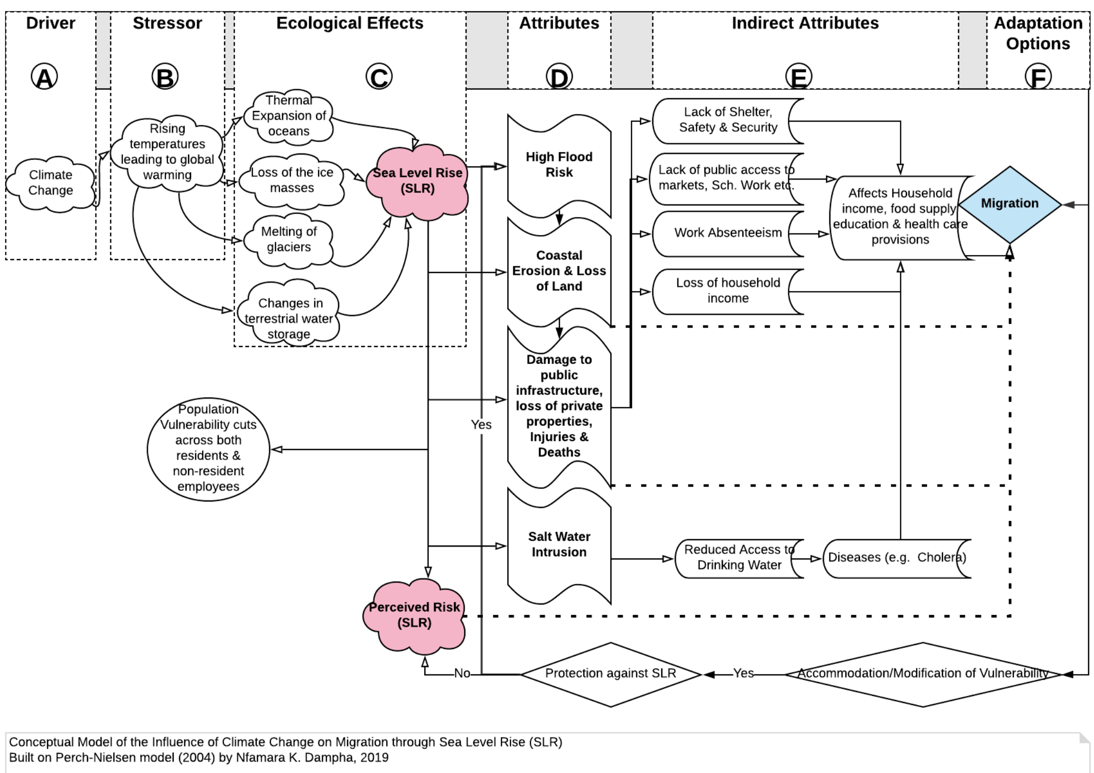
- ➢ SLR→ high flood risk → coastal erosion & loss of land → damage to public infrastructure, loss of private properties, injuries, deaths →lack of shelters, safety, and security; lack of public access to public facilities; joblessness; loss of income → affects household food supply, education, and health care provisions → **migration (an option)**

- ➢ SLR →saltwater intrusion → affects urban farming or affects drinking quality → disease outbreak → **migration (an option)**

- ➢ Perceived SLR risk → **migrates**, especially when the household's ability to modifying exposure, vulnerability, and sensitivity levels are less feasible.

- ➢ Adaptation options → a) protection strategies such as building hard engineering solutions like seawalls, floodgates, dikes, revetments as well as soft solutions like beach nourishment and restoration of wetland or/and → b) accommodation measures such as modifying land use types and improving building designs or → c) migration which can either be planned or unplanned resulting in the abandonment of degraded land (Fu & Song, 2017; Perch-Nielsen et al., 2008; Perch-Nielsen, 2004)

Figure 5-Appendix A. Conceptual Model 2- Linking climate change and human migration through MSLR



Mean Sea Level Rise (MSLR) and Migration (Case Studies)

Whether MSLR will increase permanent migration or temporary relocation or if other adaptation efforts (e.g., coastal protection measures) be enough to lessen its impacts is a challenging question to predict (Raleigh et al., 2009; Tacoli, 2009). Evidence of mass migration, due to SLR impacts, is still quite limited to draw substantial conclusions. The plausibility of sporadic migration as a response to MSLR threats is quite notable. Anecdotal evidence shows that inundations relocated thousands of people in Kazakhstan, according to George's (1994) study cited in (Perch-Nielsen et al., 2008). Also, a large area of the Chesapeake Bay islands (USA) was abandoned, and residents resettled after that, according to Leatherman (2001) cited in (Perch-Nielsen 2004).

Similarly, Gibbons and Nicholls (2006) investigated Holland Island, where a rise of nearly 20 cm over a period of 70 years caused severe erosion and eventual abandonment of the island by almost 300 residents, after trying various protection measures, which unfortunately had failed (cited McLeman, 2014; Perch-Nielsen et al., 2008). Also, the Scottish island of St Kilda and Papuan island of Bougainville were abandoned, and residents migrated elsewhere for better living and livelihood opportunities (McLeman, 2014). Moreover, a massive land loss leading to migration was evident in Bangladesh following an eroding river bank (Mahmood 1995, cited in Perch-Nielsen et al., 2008). Davis, (2014) study found that permanent inundation and land lost as a contributing factor to out-migration from the Marshall Islands, mainly to Hawaii, Arkansas, and Washington in the United States. For example, under the RCP 6.0 scenario, “74% of the land could become fully inundated, and 68% of the total Rita population faces permanent displacement”(Davis, 2014). Furthermore, in Ghana, coastal erosion has devastated the small town of Keta in 1995, resulting in the migration of nearly 20 families to temporary accommodation (Perch-Nielsen, 2004). These case studies support the assumption that MSLR impacts such as damage to and loss of infrastructure and buildings could trigger mass migration (McLeman, 2014; Perch-Nielsen et al., 2008).

Several studies predicted that millions of people would become climate migrants or refugees due to MSLR impacts. According to Nicholls and Leatherman (1995) cited in (Perch-Nielsen et al., 2008), over 20 million people are at risk of being inundated by 1 m MSLR (holding population growth constant) in only three countries (Bangladesh, Egypt and Nigeria). Myers’s update for people at risk of flooding by 2050 is 200 million people, including 73 million in China, 26 million in Bangladesh, 20 million in India, and 12 million in Egypt (Gemenne, 2011). Other estimated predictions of environmentally displaced persons (EDPs) by 2050 include 143 million (Rigaud et al., 2018) and 300 million (Christian Aid report, 2007 cited in Gemenne, 2011). For example, in Egypt alone, SLR is projected to displace almost 15 million people, as nearly 10 million people are currently residing 3 feet above high tide, according to Myers (Perch-Nielsen, 2004). In small island nations, over 2 million people are at risk from SLR (Byravan & Rajan, 2017). Also, Islands such as Tuvalu, Fiji, Samoa, and the Maldives are just a few feet above sea level (Byravan & Rajan, 2017). The risk of coastal flooding due to SLR is not merely a developing country crisis. Developed countries are equally at risk. For instance, the predicted percentage of site abandonment in the US had increased from 7% up to 20% to 45%, when sensitivity analysis assumed higher protection costs. (PerchNielsen et al., 2008). Also, when the East Anglian coast in the UK was subdivided and analyzed, instead of overall coastal areas analysis, the predicted percentage of retreat increased from 0% up to 17% to 37% accordingly (PerchNielsen et al., 2008).

Mean Sea Level Rise (MSLR) and Migration from Banjul

In The Gambia, over 35,000 residents in Banjul are at risk of becoming environmental migrants with 1.0m MSLR by 2100 if no aggressive actions are implemented. Since climate change coping mechanisms are often decided at the household level (Raleigh et al., 2009), migration from Banjul is one of the survival strategies employed by residents. However, the risk of environmental and climate-induced displacement can be minimized through an integrated approach towards disaster risk reduction (DRR), climate change adaptation (CCA), and proper development planning (Türk et al., 2015). MSLR can be controlled gradually by strengthening the adaptive capacity of vulnerable communities (Türk et al., 2015; Raleigh et al., 2009; Piguet, 2008). For instance, evidence shows that burden sharing, government policies, resilient development efforts, financial availability, evacuation opportunities, economic assets, social relations and networks, topographic conditions of land and hard engineering protection measures will significantly reduce the possibility of climate-induced migration due to MSLR (McLeman, 2014; Türk et al., 2015; Raleigh et al., 2009; Tacoli, 2009). These coping strategies could probably minimize out-migration from the island city of Banjul in the short and medium terms.

For long-term sustainability, adaptation strategies will include individuals, households, and governments to encourage voluntary internal migration or plan for a managed state-funded retreat program. Both are plausible alternatives for Banjulians and The Gambia government to consider since overwhelming evidence shows that migration from disaster-prone areas can eradicate exposure to climate hazards (PerchNielsen et al., 2008). Similarly, managed retreat through mass migration could be the best adaptation strategy for populations in the following countries; Kiribati, the Maldives, the Marshall Islands, Tokelau, and Tuvalu. In fact, according to Raleigh et al. (2009), a "number of islands have established a disaster exit option through dependency and migration agreements with other neighboring countries." The Gambia doesn't necessarily have to make such bilateral agreements since the country as a whole is not an island. Still, the government should highly consider an internal disaster exit strategy for Bunjulians. Lessons drawn from the Nansen Initiative show that designing and implementing appropriate policies can prevent and prepare a country in dealing with increased future displacement (Türk et al., 2015). Hence, it is time for The Gambia government to incorporate and implement a climate change policy with an objective aimed at exploring various adaptation options, including migration, for holistically addressing SLR and other related problems.

Managed retreat, as a response strategy to environmental and climate change problems, has been a policy challenge for governments and their development stakeholders, due to lack of public support (Raleigh et al., 2009). However, I find a different reaction from Banjulians. For instance, 64% of Banjulians who express positive willingness to migrate from the city by 2050, and over 80% of them believe that public support will be received for any planned government relocation program. Besides, over 70% believe that the government can execute a future relocation of vulnerable households in Banjul, if well planned. However, my respondents might not foresee what Raleigh et al. (2009) call hidden costs involved in actual resettlement. Whether through voluntary or involuntary relocation efforts, individuals and governments tend to face development challenges in relocating people to the new locations, hence the increased return flow of migrants might arise (Raleigh et al., 2009). An example of such a reversed flow of migrants was evident in China mainly due to inadequate compensations and lack of public facilities in new locations (Hemin, Waley, and Rees, 2001:199-200, cited in Raleigh et al., 2009).

To avert such challenges, countries like The Gambia should learn lessons from successful relocation project in Bangladesh, China, Nepal, Vietnam, and Scotland (McLeman, 2014; Zaman, 1996 and Badri et al., 2006, all cited in Raleigh et al., 2009). According to Raleigh et al., (2009) such lessons included; (a) careful attention to be given to social, economic and health issues, (b) active stakeholder engagement and participation in the entire process, (c) appropriate compensation strategy with flexible packages (such as offering cash, grants, land, employment), (d) recognition of all types of losses, (e) highly vulnerable populations should be given priority with individual attention, (f) a vibrant institution should oversee the process from design to evaluation stages, and (g) a reasonable time frame should be specified for the project (Badri et al., 2006, cited in Raleigh et al., 2009).

Yes, it’s not too early to start such vigorous stakeholder consultation in The Gambia. Even though scholars consider planned relocation as a final adaptation option after all plausible efforts are exhausted in protecting vulnerable populations at high risk, they do confirm that planned relocations have been occurring (Türk et al., 2015; McLeman, 2014).

Comparing SLR & Rainfall Flooding to Migration

I examined the household’s response to SLR in comparison to flooding through migration based on evidence from previous studies. Having mentioned that both SLR and intense flood events can induce migration, it is essential to distinguish the effects. First, rainfall floods are more immediate, while flooding from SLR is farther into the future. Second, climate-induced displacement due to rising sea-levels is indeed an inevitable adaptation option in worst-case climate scenarios than flood-induced forced migration, especially without proper protection strategies. Third, flood victims may survive living through flood impacts without utilizing proactive adaptation measures for years. In contrast, coastal and island residents cannot risk living through sea-level rise impacts without investing in coastal protection measures for effective adaptation. Fourth, the aftermath of floods can be managed, but SLR can be nearly irreversible. Hence migration becomes the only alternative with the latter. Finally, the connection between SLR and forced displacement is stronger compared to the displacement caused by rainfall flood events, as the former is more associated with loss of land (McLeman, 2014; Perch-Nielsen et al., 2008; Piglet, 2008).

Based on my findings in chapter one, islanders in Banjul are slightly more willing to migrate due to current flood impacts than perceived threats of SLR. Among those who think that the most severe environmental challenge in Banjul is city flooding due to massive rainfall events, 67% are expected environmental migrants compared to 60% among those who consider SLR has the biggest resilient threat facing the city. In conclusion, it is crucial to indicate that Banjulians can live through extreme rainfall flooding, but they can't survive SLR impacts by 2100. Therefore, voluntary or planned government retreat is one of the most appropriate risk reduction strategies for sustainability reasons in Banjul.

Policy Actions

Enough evidence substantiates the argument that migration is not necessarily a reactive response to climate change impacts. Instead, migration can be employed as a proactive strategy for risk reduction in the context of climate change adaptation. Since this consideration is excluded as an adaptation option in The Gambia national Climate Change Policy (2016), I recommend a policy review to include strategies for voluntary migration (short-term) and managed retreat for islanders in Banjul (long-term).

I also recognized that migration as an adaptation option would be gradual and perhaps slower because migration is highly dependent on the household's overall decision while accounting for the associated costs and benefits involved. Meanwhile, I highly recommend the government's consideration of in situ adaptation solutions, especially for Banjul. These include flood abatement techniques including improved stormwater drainage systems, green infrastructure solutions, improved waste management systems, provision of flood insurance schemes, implementation of hard engineering solutions for coastal protection, provision of forecasting and early warning systems as well as the establishment of social support networks and community preparedness campaigns.

For example, the 2003 beach nourishment project implemented to mitigate coastal erosion along the northern part of the city has minimized coastline erosion and protected shoreline properties, including the major highway that connects Banjul city to the Kanifing Municipality (Coates & Manneh, 2015). This project has drastically mitigated potential SLR damages to private properties and public infrastructures. Therefore, consideration of hard engineering solutions such as seawalls could save Banjul and its inhabitants from the devastating impacts of rising sea levels for at least half of a century. Protecting Banjul could potentially minimize the risk of climate and environmentally induced migration/displacement. Further studies should focus on the costs and benefits of protecting Banjul from SLR in the medium term as well as the costs and benefits associated with building a new capital city for The Gambia as a long-term sustainability plan.

6.2 Appendix B. Literature Review on Methodological Framework Used in Chapter 2

Land Suitability Analysis

Land or site suitability analysis is a hierarchical analytical process of determining the ‘fitness’ of a specific land area for a defined use (Steiner, McSherry, et al. 2000, cited in Al-Shalabi et al., 2006; Akinci et al., 2013). Land suitability analysis is a fundamental prerequisite for land-use planning (Akinci et al., 2013). Suitability modeling involves the consideration of various objectives and criteria (Abdullahi et al., 2014). The process often replies on “remotely sensed data, geographical information system (GIS) and multicriteria analysis (MCA) tools such as analytical hierarchy process (AHP), and in some cases prediction techniques like cellular automata (CA) or artificial neural networks (ANN)”(Abdullahi et al., 2014). GIS-based land suitability mapping uses a weighted overlay technique based on MCDM (Feizizadeh & Blaschke, 2013).

An essential part of land suitability assessment is the selection and prioritization of a set of criteria among multiple options (Al-shalabi et al., 2006). The site selection process for suitability analysis requires a wide-ranging consideration of several factors and harmonization of numerous objectives in determining the most suitable location for a specific land-use purpose (Al-shalabi et al., 2006). It “starts with the identification of geographic areas of interest” (Al-shalabi et al., 2006). In some instance, site selection must satisfy not just a list of physical, socio-economic, and environmental characteristics, but also national and local regulations (Al-shalabi et al., 2006). If carefully done, land suitability analysis can influence growth and enhance development.

At the core of land suitability assessment is the fusion of data on locations, development gains, demographic compositions, economic conditions, and environmental factors (Abdullahi et al., 2014; Azizi et al., 2014). The site characteristics studied from the analysis are also used for evaluating alternative locations (Case & Hawthorne, 2013).

The suitability mapping project should cover the entire study area, and the exclusion of any field should be based on predetermined constraint conditions. The constraint area is classified as the land area that is entirely unsuitable for any use development purpose. The area should be ignored in MCDM procedures (Abdullahi et al., 2014). Some level of criteria must be met before a site is classified as an exclusion zone (EZ). Several studies have factored in the complete elimination of the EZs in their analysis. Bennui et al. (2007) site suitability study for wind turbines is a great example.

Multicriteria Decision-making (MCDM) Procedures

The multicriteria decision-making (MCDM) procedures are simply the analytical techniques adopted over time for complex decision analysis (Al-shalabi et al., 2006). MCDM procedures started emerging as a decision-making framework in the 1960s (Feizizadeh & Blaschke, 2013). MCDM is also referred to as multicriteria analysis (MCA) (Abdullahi et al., 2014) or multicriteria evaluation (MCE) (M. G. Collins et al., 2001; Hossain et al., 2007; Jankowski & Richard, 1994; Mustafa et al., 2011; Nas et al., 2010). Since the 1960s, the objective of the framework focuses on ways to assess and integrate information from several criteria to reach a "single index of evaluation'' (Yu et al. 2011a, 131 cited in Feizizadeh & Blaschke, 2013). The MCDM procedures show the relationship between the input and output map layers (Feizizadeh & Blaschke, 2013). The technique integrates geographic data with the decision maker's preferences based on defined decision rules (Malczewski 1999a cited in Feizizadeh & Blaschke, 2013).

The MCDM techniques have improved the spatial decision-making process among choice possibilities (Cover, 1991, cited in Mustafa et al., 2011; Dawod, 2013). MCDM techniques like AHP has reduced the complexities and difficulties involved in site selection problems (Badri 1999, Korpela and Tuominen 1996, cited in Al-Shalabi et al., 2006; Al-Hanbali et al., 2011). However, considering the different priorities among stakeholders, conflict of interest can slow or impede the weighting process. The conflict between or among stakeholders can be effectively negotiated through weights associated with the criteria they care about before adopting the required weight values (Al-shalabi et al., 2006).

MCDM can be a repeatable process. Different groups of stakeholders can undergo the process with their own defined objectives and priorities (Al-shalabi et al., 2006). The MCDM results, when mapped, show the spatial extent of the most suitable area among alternative locations. The negotiating teams can compare and contrast their results by overlaying the maps which reflect their own set of preferences (Al-shalabi et al., 2006; Youssef et al., 2011; Kihoro, Bosco, & Murage, 2013; M. Kumar & Shaikh, 2013).

Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) was first suggested in 1977 by Myers and Alpert (Gumusay et al., 2016). In the 80s, Thomas Saaty developed the AHP technique as a pairwise comparison tool for assigning weights in land-use suitability analysis (Alfy, Elhadary, & Elashry, 2010; Akinci et al., 2013; Abdullahi et al., 2014; Gumusay, Koseoglu, & Bakirman, 2016; Baseer et al., 2017). Overall, the assigned weights represent the relative importance of different sub-criteria in the analysis (Jankowski & Richard, 1994; Malczewski, 2004; Collins et al., 2001; Bennui, Rattanamanee, Puetpaiboon, Phukpattaranont, & Chetpattananondh, 2007; Hossain et al., 2007; Abdullahi et al., 2014).

The AHP is the most widely used MCDM technique (Saaty 1977, 1980, Saaty and Vargas 1991, Jankowski and Richard 1994, Wu 1998, Marinoni 2004, Ohta et al. 2007, cited in Feizizadeh & Blaschke, 2013). Others referred to it as a weighted linear combination (WLC) (Al-Hanbali et al., 2011). Since the early 1990s, AHP has been used increasingly in GIS-based suitability analysis (Abdullahi et al., 2014; Al-shalabi et al., 2006; Chandio et al., 2013; M. G. Collins et al., 2001; M. Kumar & Shaikh, 2013; Latinopoulos & Kechagia, 2015; Malczewski, 2004; Miller, Collins, Steiner, & Cook, 1998; Mishra et al., 2015; Pearson, 2007; Qaddah & Abdelwahed, 2015; Sharifi et al., 2009). I provide a summary of GIS/MCDM (AHP) applications in different disciplines and places of study (see Tables 1-2-Appendix B).

The final AHP product is a pairwise comparison matrix that normalizes the required weights. As in Akinci et al. (2013), this study “obtains the normalized pairwise comparison matrix by dividing the columns elements of the matrix by the sum of each column. The row elements are aggregated, and the total value is divided by the number of row elements” (Akinci et al., 2013). This process creates a “weight vector” (Tombus, 2005)or “Eigenvector” (Bagaram et al., 2016) with 0-1 range, and their aggregate equal to 1 (Malczewski, 1999; Öztürk and Batuk, 2010, cited in Akinci et al., 2013). The final step in the AHP procedure is to use a GIS-based weighted overlay tool to identify possible locations for the land-use purpose on a map (Youssef et al., 2011; Wang et al., 2009; Akinci et al., 2013; M. Kumar & Shaikh, 2013; Mighty, 2015; Mishra et al., 2015).

Table 1-Appendix B. Summary of GIS/MCDM (AHP) Applications in Specific Places

Summary of GIS/MCDM (AHP) Applications in Specific Places

<table>
<tr><th>Application</th><th>Primary Criteria & Parameters Used Across Studies</th><th>Place, Country</th><th>(Authors, Year)</th></tr>
<tr><td>Land suitability analysis</td><td rowspan="3">Critical criteria selected in several studies ranges from hydrogeological, geomorphological climatological, geomorphological, environmental hazards, to socio-economic impacts, and geotechnical factors.
Sub-criteria or parameters:
Soil parameters; soil fertility, soil PH, great soil group, soil depth, organic matter content Topographic: digital elevation model (DEM), slope, aspect.

Hydrologic: water properties, water supply, groundwater, surface water.</td><td>Tabriz County, Iran; and Adana, Turkey</td><td>(Feizizadeh & Blaschke, 2013) and (Tudes & Yigiter, 2010)respectively</td></tr>
<tr><td>Urban development, including industrial development</td><td>Mussoorie municipal area, India; and Egypt</td><td>(M. G. Kumar, Agarwal, & Bali, 2008)and (Youssef et al., 2011) respectively</td></tr>
<tr><td>Agriculture land suitability analysis for site identification from coffee growing to organic farming areas</td><td>Agra district, India; 3 counties in Kenya; Jamaica India and Darjeeling district, India</td><td>(Mustafa et al., 2011; Akinci et al., 2013);(Kihoro et al., 2013);(Mighty, 2015); (Mishra et al., 2015); and (Pramanik, 2016)respectively</td></tr>
</table>

Building future tourist infrastructure and ecotourism potential sites	*Climate:* temperature, precipitation, wind speed and direction, other climate-related hazards (e.g., food hazard) *Land:* land use, land cover:-built up area, bare ground, grassland, forest zone, vegetation cover, scenic area, and land costs. *Ecologic:* endangered or threatened species and wildlife presence, and reservation, protection, species diversity, environmental damage and costs transferred to far-distant generations. *Infrastructure:* roads, electricity, water supply, etc.	Al-Hada city, southwest Saudi Arabia; Hai An, Quang Nam Province, Vietnam; and Surat Thani Province, Thailand	(Dawod, 2013); (Pareta, 2013); and (Bunruamkaew & Murayama, 2011)
Comparative Business Site-Location (Kowalski's Markets)		In seven-counties Twin Cities metropolitan area, MN, USA	(Pearson, 2007)
Geotechnical site investigations for possible urban extensions		Suez City of Egypt	(Arnous, 2013)
Suitability of Landfill Sites for Solid Waste Treatment		Damaturu town Nigeria	(Babalola & Busu, 2011)
Wind farm site selection	*Accessibility:* distance to existing urban areas, distance from waste generation source, distance from airport, distance to residential, religious and archaeological sites, distance to surface waters	Saudi Arabic, Greece, Denmark, USA, UK, Germany, Poland, Vietnam, and Sweden, Greece	(Baseer et al., 2017) (Latinopoulos & Kechagia, 2015)Other studies cited.
Site selection for large wind turbine		Thailand	(Bennui et al., 2007)
Locations for utility-scale solar projects	Community characteristics: demographics, socio-economic costs and benefits	Southwestern USA	(Brewer, Ames, Solan, Lee, & Carlisle, 2015)
Housing Site Suitability Assessment		Sana'a city Northern-central part of Yemen	(Al-shalabi et al., 2006)
Locations of Cork Oak Regeneration		Maamora Forest, Morocco	(Bagaram et al., 2016)

Solid waste disposal sites, hazardous waste landfill options, and wastewater treatment placement	Mafraq City, Jordan; Kurdistan Province, western Iran; and northeastern Greece	(Al-Hanbali et al., 2011); (Sharifi et al., 2009); (Demesouka et al., 2013)and respectively
Promising Technological Achievements	USA	(M. G. Collins et al., 2001)
Solar photovoltaic (PV) site suitability analysis	Oman; Iran; and Turkey	(Charabi & Gastli, 2011)and (E. Noorollahi, Fadai, Akbarpour Shirazi, & Ghodsipour, 2016); and (Uyan, 2013) respectively
Landfill site suitability selections	Polog Region, Macedonia; and in Konya City (Turkey); and Beijing, China	(Gorsevski, Donevska, Mitrovski, & Frizado, 2012); (Nas et al., 2010); and (Wang et al., 2009) respectively
Aquaculture site selection (Nile tilapia or Oreochromis niloticus)	Sitakunda Upazila (sub-district), Bangladesh	(Hossain et al., 2007)
Subsurface dam construction Locations	Boda-Kal- vsvik, Sweden	(Jamali, Olofsson, & Mörtberg, 2013)
Rural buildings site selection	Hervás (northern Extremadura region), Spain.	(Jeong et al., 2013)
Emergency Evacuation Shelters locations	Southern Florida	(Kar & Hodgson, 2008)
Petrol filling stations	Perak state of Malaysia	(Khahro, Matori, Chandio, & Talpur, 2014)
Hospital locations	Qazvin, city Iran; and Dhaka City, India	(Abdullahi, Mahmud, & Pradhan, 2014); and (M. G. Collins et al., 2001) respectively
Groundwater recharge sites and water harvesting structures locations	Al-Baha province, Saudi Arabic; Ajmer District, India	(Mahmoud, 2014)and (Prasad, Bhalla, & Palria, 2014)

Table 2-Appendix B. More References on GIS-based MCDM /MCA Applications

Applications	**Methods Used**	**Authors (Year)**
Coastal land-use development	ANP/GIS	Pourebrahim et al. (2011)
Eco-environmental quality	AHP/GIS	Ying et al. (2007)
Forest conservation planning	MCDM/GIS	Phua and Minowa (2005)
General	GIS	Peuquet and Marble (1990)
Greenway land suitability	MCA/GIS	Miller et al. (1998)
Habitat suitability	MCA/GIS	Store and Kangas (2001)
Housing Site Suitability Assessment	MCA/GIS	Al-Shalabi et al. (2006)
Land information system	GIS	Klosterman (1995)
Land suitability	MCA/GIS	Baban et al. (2007)
Land suitability	Suitability analysis	Steiner et al. (2001)
Land suitability evaluation	Land Classification/GIS	Kalogirou (2002)
Land suitability of urban forest	MCA/GIS	Gul et al. (2006)
Landfill site	MCA/GIS	Nas et al. (2010)
Land-use assessment	AHP/GIS	Marinoni (2004)
Land-use changes	MCA/AHP	Bakhtiarifar et al. (2008)
Land-use classification	AHP/GIS	Hossain et al. (2007)
Land-use planning	MCE/GIS	Trung et al. (2006)
Land-use planning	AHP/GIS	Tudes and Yigiter (2010)
Land-use suitability	Overview	Collins et al. (2001)
Land-use suitability	AHP/GIS	Duc (2006)
Land-use suitability	MCA/GIS	Joerin et al. (2001)
Land-use suitability	OWA/GIS	Malczewski (2006b)
Land-use suitability	AHP/GIS	Mendoza (1997)
Location science	GIS	Church (2002)
LSA in agriculture land	MCA/AHP/GIS	Chen (2009)
LSA Urban green space planning	MCA/AHP/GIS	Uy and Nakagoshi (2008)
MCDA	Review GIS/MCA	Malczewski (2006a)
MCDM	MCDM/GIS	Jankowski (1995)
Parks suitability	AHP/GIS	Chandio et al. (2011)
Site selection	MCE/GIS	Carver (1991)
Site selection SW	MCA/GIS	Rahman et al. (2008)
Site suitability	AHP	Banai-Kashani (1989)
Site suitability Of urban development	AHP/GIS	Aly et al. (2005)
Suitability evaluation of land	MCA	Zhou et al. (2005)
Urban development	AHP/GIS	Mohit and Ali (2006)
Urban development	AHP/GIS	Youssef et al. (2010)
Urban development suitability	AHP/GIS	Dong et al. (2008)
Urban development suitability	AHP/GIS	Lotfi et al. (2009)
Urban renewal	AHP/GIS	Lee and Chan (2008)

Source: modified table from Chandio et al. (2013)

6.3 Appendix C. Literature Review on Deforestation & Forest Ecosystem Services (Chapter 3)

Global Forest Targets

Forests, accounting for roughly 31% of the Earth's surface, play a significant role in climate change mitigation (Dampha et al., 2017). Between 1990 and 2015, 129 million ha of forest area was lost globally, which is roughly the size of South Africa (WWF, 2015 cited in Dampha et al., 2017). Globally, curbing deforestation is one of the quickest and most significant climate change mitigation measures available. Parties to the United Nations Framework Convention on Climate Change (UNFCCC) at COP 13, 2007 called on developing countries to restore and reduce their emissions from deforestation and land degradation (Pradhan, Chaichaloempreecha, & Limmeechokchai, 2019). Reducing Emissions from Deforestation and Forest Degradation (REDD+) is considered one of the most cost-effective options for mitigating climate change (Smith et al., 2014). The New York Declaration on forests aims at ending forest loss by 2030 and restoring 350 million ha (WWF, 2015, cited in Dampha et al., 2017). The Sustainable Development Goal (SDGs) number fifteen reinforces this global effort. Most recently, all parties and countries were encouraged to implement REDD+ based on Article 5 of the Paris Agreement (Mongabay, 2015, cited in Dampha et al., 2017). The United Nations Convention on Biological Diversity calls for an international agreement on the establishment of Protected Areas (PAs) based on national laws. The Convention recommends that 10% of national territory be protected for the conservation of biodiversity (Dampha et al., 2017).

Deforestation and Land-use Change (The Gambia)

Forest type categories and their share of the total land area in The Gambia are presented in table 1-Appendix C. below. Since 1946, the country has lost nearly 50% of its forest cover. According to First National Climate Communication (NCC), 2003), the rate of deforestation stands at about 6% per annum. Records show that as closed forest areas shrunk due to bushfires and land-use change, shrubland/grassland increased, especially in the 50s, the 60s, and the 90s (Sillah, 1999) (see Table 2-Appendix C.). The significant loss of closed forestland (2,700 ha per year) is due to forest degradation and, in some regions, conversion to agricultural land (Sillah, 1999). Increased in the total forest cover in the 90s compared to the 80s is attributed to the land-use reversion of former farmland into tree and shrub savannah (Sillah, 1999). For mangrove forest areas, an annual loss of 650 ha was reported across the national boundary (Sillah, 1999). The reasons were ascribed to disturbed water exchange, illegal exploitation, and land-use changed from mangroves to rice fields (Sillah, 1999). Recent findings revealed a net decline of 11,100 ha of forest in The Gambia between 2001 and 2013 (Hansen et al. 2013, cited in Heß et al., 2018). According to FAO (2011), forest and other woodlands declined by 19% between 1998-2010 (Heß et al., 2018).

Table 1-Appendix C. The proportion of Forest Categories under Different Management Systems

Forest Cover Categories	**Area ha**	**Area %**	**Description**
Private Forests	100	0.09	Forest growing or planted on privately owned lands
Community forests	17,387	3.3	Forest managed by designated communities
Forest parks	32,729	6.5	Forest reserves managed by Forestry Department
Protected forests	74,000	14.4	All mangroves and riverine forests managed by Forestry Department
State forests	388,284	75.7	All other remaining forest under the control of the Forestry Department except if they exist in national parks or nature reserves
Total	512,500	99.99	

Source: Based on Danso 1998, cited in (Sillah, 1999)

Table 2-Appendix C. Development of Forest Cover from 1946 to 1999

Forest Cover Types	**1946**	**1968**	**1980**	**1993**	**1999**
Closed woodland (%)	60.1	6.0	1.3	1.1	0.7
Open woodland (%)	13.3	17.6	10.7	7.8	6.2
Savanna (%)	7.8	31.7	24.8	31.8	34.6
Total forest cover (%)	81.2	57.3	36.8	40.7	41.5
Population					
Population density (person per km^2)	25.0	35.0	57.0	91.0	108

My analysis in chapter three finds a total national forest cover loss of 58,532 ha, relative to the 1983 estimates reported in The Gambia's Second National Climate Communication Report (2012). This excludes changes in mangrove forests (see Table 3-Appendix C). The 58,532 ha forest degradation includes areal losses of nearly 26,312 ha of open and closed forestlands and 32,219 ha of shrub/grasslands. According to the country's Second National Climate Communication Report (2012), mangrove forest accounts for 6.5% of the national territory. Using that as my reference, I infer that wetlands (including some water bodies) cover roughly 104,485 ha of the total national land area, corresponding to 9.5% of the land area. Given the above analysis, I conclude that national forest cover is approximately 42.5% or less of the total land area, instead of 44-48%, as previously determined by FAO and earlier studies (Second National Climate Communication, 2012). Similar estimates to my result include 41.7% (Mongabay, 2006) and, more recently, 40% and 38%, according to Heß et al. (2018) and Saatchi et al. (2011), respectively.

Table 3-Appendix C. Comparison of Forest Cover in 1983 and 2019

Class Name	**2nd NCCR[18] (1983 data) ha**	**2nd NCCR (1983 data) Percent**	**My Est. (2019 data) ha**	**My Est. (2019 data) Percent**
Grassland/Bush	347,000	33	314,781	30%
Mangrove	68,000	6.5	-	-
Wetland/ Mangrove[19]	-		172,485	16%
Forest (Open & Closed)	89,400	8.5	63087	6%
Total	504,400	48%	550,353	52%

Forest Management, The Gambia

Forest, as a public good, creates the tragedy of the commons problem leading to deforestation (Dietz et al., 2003 cited in Heß et al., 2018). Deforestation rates are increasingly growing, particularly in developing nations, where the majority of the people's livelihood depends on forest products (NAPA Gambia, 2007: Hansen et al., 2013, cited in Heß et al., 2018). Different forest management approaches have been experimented in various regions of the world, including privatization of common-pool forests, centralized control system by national governments, and co-management schemes with the local communities (Ostrom & Cox, 2010).

Forest management in The Gambia falls under "control" and "no control" management systems. According to Thomas & Sillah (1999), about 7% (30,691 ha) of national forest territory is under a controlled management scheme (Sillah, 1999). In the West Coast Region (study area), only 13% of the total forested areas are controlled and managed by the authorities. The local communities manage the majority (64%) of forestland under the control management system in the region (see Table 4-Appendix C.).

[18] NCCR stands for the Second National Climate Ccommunication Report (2012).

[19] Given that most mangrove forests are generally situated in wetlands, we combine these two classes as a single classification unit in our geographic information system (GIS) based analysis.

Table 4-Appendix C. Forest Management Structure by Region, The Gambia

Region	**Forested** land[20] (ha)	**Control management (ha)**					**No control management (ha)**			
		Forest parks	Community forests	Private forest	Total ha	%	Forest parks	Forest reserves	Total ha	%
WCR	73,300	3,355	6,203	100	9,658	13.2	512	63,130	63,642	86.8
LRR	66,500	1,758	3,465	0	5,223	7.9	4,431	56,846	61,277	92.1
CRR	154,600	7,233	5,924	0	13,157	8.5	10,412	131,031	141,443	91.5
URR	113,200	858	1.565	0	2,423	2.1	2,178	108,599	11.,777	97.9
NBR	41,200	0	230	0	230	0.6	3,290	37,680	40,970	99.4
Total	448,800	13,204	17,387	100	30,691	6.8	20,823	397,286	418,109	93.2

Source: Thomas & Sillah (1999), cited in (Sillah, 1999)

The Gambia government seeks to redress deforestation by promoting community forest management initiatives. According to Camara et al. (2011), over 350 villages have implemented a community forest management scheme since the 1990s (Heß et al., 2018). The ecosystem-based adaptation (EBA) project (2017-2023) is equally promoting a community-based forest resource management regime. The EBA project is "establishing 166 natural resource-based businesses" for not only strengthening the adaptive capacity of local communities but also regenerating 1% of lost forest area in The Gambia (Nyangado & Pouakouyou, 2017). The process transfers legal management and ownership rights to local communities (Heß et al., 2018). Like the EBA project, co-management of forests economically empowers local communities and improves their environmental conditions. Evidence from the Forestry Department revealed that community forest management programs had yielded positive benefits on forest cover regeneration across all regions of the country (see Table 5-Appendix C.).

Several other studies acknowledge that giving property or harvesting rights to local forest users does not only improve forest habitat conditions but also facilitates a

[20] *Without forested national parks/reserves and without mangrove forests*

more cost-effective way of managing and policing forest resources from illegal operations (Banana & Gombya-Ssembajjwe 2000; Ghate & Nagendra 2005; Ostrom & Nagendra 2006; Webb & Shivakoti 2008, cited in Ostrom & Cox, 2010). Other studies concluded that excluding local users from the management of forests results in deforestation (Banana et al. 2007, cited Ostrom & Cox, 2010).

However, community forest management is not without limitations, especially in developing. In The Gambia, there has been gross mismanagement and various unsustainable practices in community forest management schemes (Heß et al., 2018). For example, illegal logging has been reported to take place in many community forest parks. Also, shared forest areas between communities have generated conflict over natural resources (Heß et al., 2018). Overall, in The Gambia, the tragedy of the commons problem still rears its ugly face due to lack of clearly defined property rights over lands, including forestland. The government claims legal ownership of all regional land through the State Lands Act (1991). In contrast, community members often claim traditional land ownership rights, which they considered as rightful entitlements inherited from their ancestors. This significantly contributed to deforestation and total negligence by forest stakeholders when it comes to forest protection and conservation of its biological diversity.

Table 5-Appendix C. Community Forest Management Stage Changes, 2014 - 2017

Area of Forest (ha or unit)	**Startup (ha)**		**Preliminary Community Forest Management Agreement (PCFMA) ha**		**Community Forest Management Agreement (CFMA) ha**		**Total in ha.**	**Total in ha.**	**% Area under community forest managemen t**
	2014	**2017**	**2014**	**2017**	**2014**	**2017**	**2014**	**2017**	**2017**
West Coast	726	75	3091	3022	3957	5040	7774	8,139	22.17%
Lower River	1853	1367	3326	2072	1773	4021	6953	7460	20.32%
North Bank	773	399	235	3309	122	358	1131	4065	11.07%
Upper River	669	500	470	345	1764	3267	2903	4112	11.20%
Central River South	2809	1178	1796	1239	2731	4678	7336	7094	19.33%
Central River North	283	410	2837	1510	2467	3909	5586	5829	15.88%
TOTAL	7113	3,898	11754	11,498	12815	21,273	31682	36,699	

Source: Department of Forestry (GBoS, 2020)

Protected Area Status & Biodiversity

The Gambia first introduced protected area status in 1916, when Abuko Nature Reserve was protected and later gazetted in 1968. Today, protected areas account for nearly 3.3% of the entire national territory in The Gambia (see Table 6-Appendix C.). The Parks Department policy seeks to increase the proportion to 5% (Sillah, 1999). The country's forest ecosystem is also endowed with rich biodiversity. The country has about 140 trees and shrub species from 12 families (First National Climate Communication, 2003). According to the Department of Parks and Wildlife (2013), "there are 125 species of mammals, 77 species of reptiles, 30 species of amphibians, 1005 flowering plants, 576 of birds, and 784 of insects in The Gambia" (Parks and Wildlife Policy Gambia, 2013). The majority of national flora and fauna are threatened and endangered species because of their vulnerability to climate change impacts and habitat destructions caused by human activities.

Table 6-Appendix C. Status of Protected Areas in The Gambia

Name	Status	Date Gazetted	Region	Area (ha)
Abuko	National Reserve	1968	WCR	105
River Gambia	National Park	1978	CRR	586
Niumi	National Park	1986	NBR	4,940
Kiang West	National Park	1987	LRR	11,526
Tanji Bird	Nature Reserve	1993	WCR	612
Bao-Bolong	Nature Reserve	not yet	NBR	22,000
Total				39,769

Source: NEA (1997), cited in (Sillah, 1999)

Carbon Storage & Sequestration

Atmospheric carbon content is over 750 billion metric tons. Annually, human activities such as the burning of fossil fuels and deforestation contribute approximately 6.6 billion tons of carbon into the atmosphere (Forest Ecology Network, 2020). Forests emit and absorb CO_2 globally. According to Bellassen & Luyssaert (2014), forests in the past few decades have "absorbed as much as 30% (2 petagrams of carbon per year; Pg C $year^{-1}$) of annual global anthropogenic CO_2 emissions, globally — about the same amount as the oceans." The world's forests and oceans sequester nearly half of the total emitted CO_2, and the balance remains as surplus in the atmosphere lasting for centuries. Deforestation also significantly contributes to carbon emissions (Gaston, Brown, Lorenzini, & Singh, 1998; Houghton & Hackler, 2006; Gorte, 2007). Collins & Mitchard (2017) noted that deforestation and degradation in the tropics contribute 6–17% of all greenhouse gas emissions. This is equivalent to releasing nearly 1 billion tons of carbon into the atmosphere per year (WWF, 2016, cited in Dampha et al., 2017). According to Smith et al. (2014), annual greenhouse gas flux from land-use and land-use change activities account for approximately 4.3–5.5 GtCO2eq/yr.

Forests in sub-Saharan Africa contain 44-66 billion tons of carbon, depending on how forests are defined (Butler, 2011; Saatchi et al., 2011). In Africa, a forest stores an average of 69-117 tons per ha compared to 125-175 tons/ha in Asia and 87-132 tons/ha in tropical Americas (Butler, 2011; Saatchi et al., 2011). Table 7-Appendix C. below provides mean biomass estimates for several sub-Saharan African countries. Similarly, Map 1-Appendix C. below includes information on the carbon storage in Earth's tropical forests, covering about 2.5m ha of forests over more than 75 countries. The data has been used to "assist efforts by countries to produce estimates of carbon emissions by providing relatively fine-scale stocks of carbon and their level of uncertainty." (Butler, 2011; Saatchi et al., 2011).

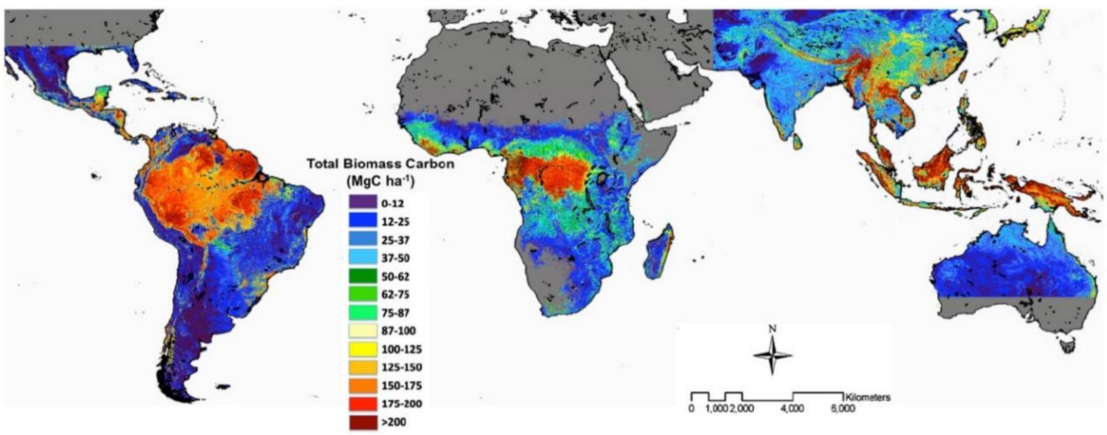
Table 7-Appendix C. Mean Biomass estimates for Sub-Saharan African Nations using a 25% Forest Cover Definition

Country	**Forest Area (million ha)**	**Aboveground forest carbon stocks (Mt C)**	**Belowground forest carbon stocks (Mt C)**	**Total forest carbon stocks (Mt C)**	**Avg Carbon Density (t C/ha)**
Angola	50	1,792	547	2,339	47
Benin	0	6	2	8	29
Botswana	1	12	4	16	19
Burundi	0	15	4	19	64
Cameroon	30	3,361	906	4,268	142
Central African Republic	42	2,145	631	2,776	66
Chad	1	20	6	26	31
Côte d’Ivoire	6	406	116	522	85
DR Congo	177	17,805	4,857	22,662	128
Guinea	2	310	82	393	160
Ethiopia	13	536	161	698	53
Gabon	22	2,820	748	3,568	164
Gambia	**0.04**	**0.3**	**0.1**	**0.4**	**12**
Ghana	3	225	63	288	94
Guinea	8	365	109	473	57
Guinea-Bissau	1	38	12	50	37
Kenya	2	86	26	111	54
Lesotho	1	13	4	17	19
Liberia	9	990	266	1,257	147
Madagascar	17	893	261	1,154	70
Malawi	2	51	16	67	40
Mali	0.28	9	3	12	44
Mozambique	35	1,124	348	1,472	42

Namibia	0.05	1	0.2	1	16
Nigeria	7	450	129	579	83
Rep. of Congo	24	3,015	802	3,817	160
Rwanda	0.33	19	5	24	73
Senegal	1	11	4	14	26
Sierra Leone	5	299	86	385	83
Somalia	0	2	1	2	34
South Africa	10	217	70	288	28
Sudan	13	433	133	567	45
Swaziland	0.49	12	4	16	32
Tanzania	17	585	179	764	45
Togo	0.19	7	2	9	49
Uganda	4	188	55	244	65
Zambia	31	1,027	317	1,344	43
Zimbabwe	6	128	41	170	30

Source: (Butler, 2011)

Map 1-Appendix C. Benchmark Map of Carbon Stored in Earth's Tropical Forests



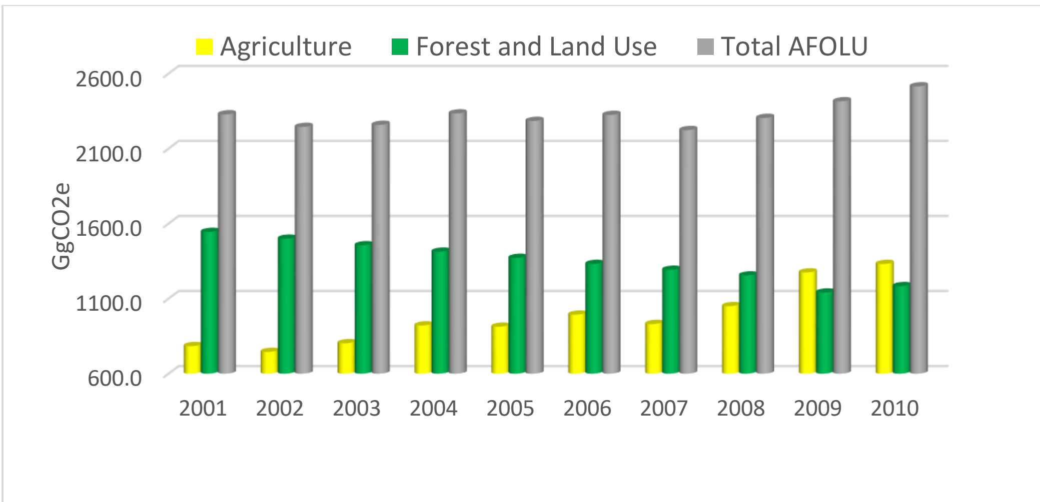
Source: (Saatchi et al., 2011)

Carbon Stock in The Gambia

The Gambia's forests contain 359,000 and 400,000 metric tons of carbon in living forest biomass, according to FAO (2015) and Saatchi et al. (2011), respectively. Its net carbon absorption from the land-use change and forestry was estimated to be over 50,000 Gg in 1993. According to the Second National Climate Communication Report (2012), The Gambia forests serve as a carbon sink from 1994 to 1998. The intervention of The Gambia-German Forestry Project and the promotion of community-based forest management have contributed to carbon sequestration in the 1980s and the 90s. However, the country has now turned out to become a net carbon source ($C0_2$ emitter/loss) since the year 2000 due to widespread forest degradation and deforestation in the past few decades

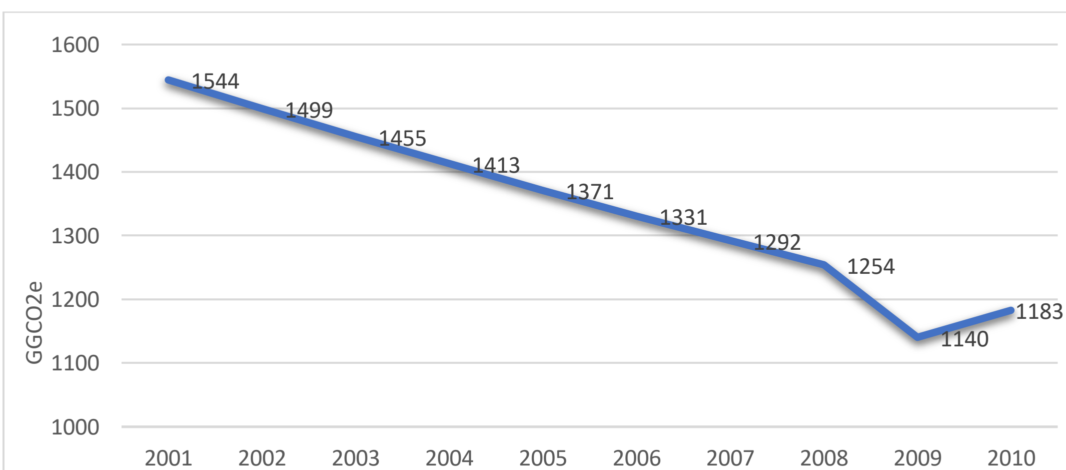
(Gambia's Second National Communication, 2012). In 2000, the forestry sector emitted about 519 Gg of carbon into the atmosphere (Gambia's Second National Communication, 2012). Figure 2-Appendix C. below presents data on emissions trends ($GgCO_2e$) from the agriculture, forestry, and other land-use (AFOLU) category in the Gambia by 2010. In 2010, emissions from the AFOLU category were about 2,514 $GgCO_2e$, of which forest and land-use sub-category account for 47% (1,182 $GgCO_2e$). Records show a declining emissions trend from the forest and land-use sub-category since 2001 (see Figure 2-Appendix C.).

Figure 1-Appendix C. Emissions trends (GgCO2e) from the AFOLU Category in the Gambia by 2010



(sources: NIR, 2010)

Figure 2-Appendix C. Annual Emissions (GgCO2e) from Forests for the period 2001 to 2010



(sources: NIR, 2010)

6.4 Appendix D. Literature Review on the Theoretical & Methodological Frameworks Used (Chapter 4)

Theoretical Frameworks

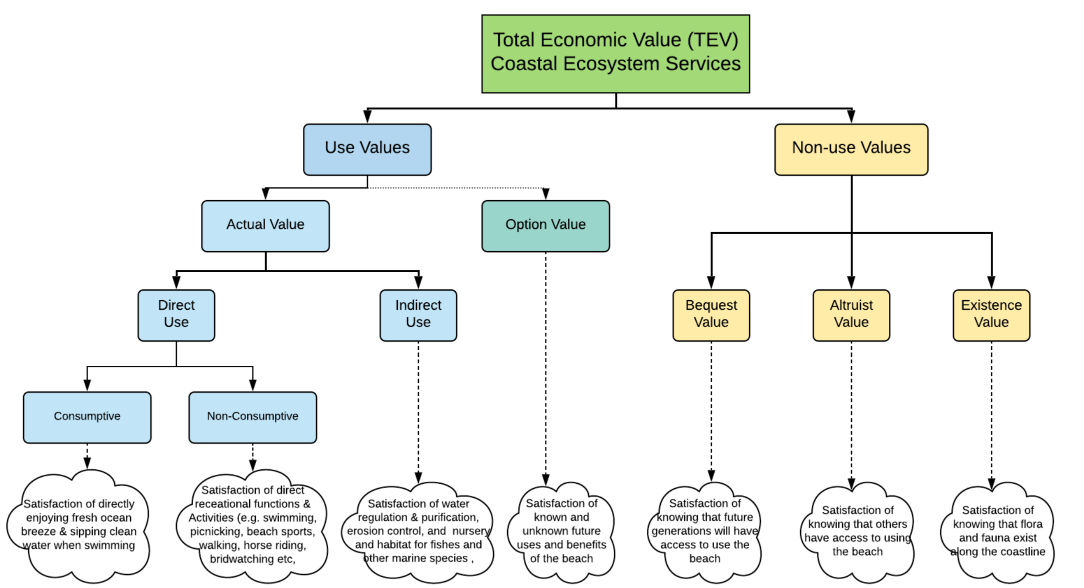
Chapter four of this dissertation uses the total economic value (TEV) framework (See Figure 1-Appendix D). The framework estimates the gain and loss in livelihood activities/wellbeing of direct and indirect beach users, due to marginal changes in ecosystem services (ES) and policy conditions (Torres & Hanley, 2016). TEV is the discounted aggregate value of all ES stocks and flows that the natural capital provides, not just for the present but also for the future generation (Ledoux & Turner, 2002; Kumar, 2010; Grant, Hill, Trathan, & Murphy, 2013). TEV is measured by willingness to pay (WTP) for a particular ES over the entire area within a defined period, using contingent valuation (CV) survey method (Mehvar, Filatova, Dastgheib, de Ruyter van Steveninck, & Ranasinghe, 2018; Kumar, 2010). Theoretically, CV can provide a reasonable estimate for both use (consumptive and non-consumptive) and non-use (bequest, altruist, and existence) ES values considered in the TEV framework (UK-Defra, 2007; Kumar, 2010). According to Kumar (2010), ecosystem service values can either be 'output' value (use and non-use) or 'insurance' values. The output value accounts for the direct aggregated value provided by a given ecosystem, while the insurance value relates to the ecosystem's resilient capacity in the face of disturbances. Similarly, others refer to nature's main value components as 'instrumental' (benefits people and society) and 'intrinsic' (benefits itself) (O'Neill, 1992; Vilkka, 1997 cited in Halkos & Matsiori, 2012). This study focuses mainly on output value, hence using a preference-based approach instead of a biophysical approach (see Kumar, 2010 p.191, for more the latter).

Our inability to consider these ES in planning and decision making is quite costly. For instance, the UK-Defra estimated that annually, ES degradation is costing the globe €50 billion, and this estimate is projected to rise to 7% equivalent of global GDP by 2050 (UK-Defra, 2007). Hence, the United Nations Sustainable Development Goals (SDGs) incorporated goals with targets to protect, restore, and integrate ES and biodiversity values into local and national planning for ensuring sustainable global development and eradicating poverty on the face of the Earth. In its attempt to integrating and Mapping Ecosystem Services to Human well-being for the Sustainable Development Goals (MESH-SDG), scientists at the Natural Capital Project linked 6 SDGs which influence changes in ecosystems; food security (SDG2), health (SDG3), water (SDG6), sustainable cities (SDG11), climate (SDG 13), and conservation of terrestrial ecosystems (SDG15). Likewise, the SGDs, the works of The Economics of Ecosystem and Biodiversity (TEEB) and the Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES) focus on promoting and mainstreaming ES or what is now referred to as nature's contribution to people (NCPs) into sectoral policies and programs (MA, 2005; Kumar, 2010; Pascual et al., 2017; Díaz et al., 2018). This integrated ecosystem-based approach to global sustainable development will positively impact human welfare and wellbeing, especially for the 70% of 1.1 billion people were living under the global poverty line and directly dependent on ES for livelihood benefits (McCartney, Finlayson, Silva, Amerasinghe, & Smakhtin, 2015)

Like many coastal ecosystems, The Gambia's coastline supports lives (e.g., for human, flora, and fauna) and provides direct and indirect livelihood benefits to various visitors including Gambians and non-Gambians. These include provisioning, regulating, and recreational/cultural services and benefits. For instance, the Senegambia beach area serves as a tourist and recreational hub for both Gambians and non-Gambians. Unfortunately, the value of these ES benefits to people is unknown and unaccounted for many developing countries in Africa, including The Gambia. Hence, planning and policy decisions often do not properly account for ecosystem services and disservices into national development blueprints such as The Gambia National Development (NDP) (2016-2020).

Given the growing research interest in ES valuation, the TEV framework is increasingly becoming relevant for the consideration of the value of ES into the System of Environmental-Economic Accounting (SEEA). The approach reflects the value of assets/services/ public goods omitted from the System of National Accounts (SNAs) of countries. The SEEA aims to promote an ecosystem-based approach to ensuring sustainable development (UNCEEA, 2011; Obst, 2018; European Commission et al., 2012)

Figure 1-Appendix D TEV Framework for Assessing Coastal ES in The Gambia.



Total Economic Value (TEV) Approach specifying value types: Source: The Economics of Ecosystems and Biodiversity (TEEB) edited by Kumar (2010). The Figure was modified by Dampha (2019) as per his valuation of Coastal ES in The Gambia.

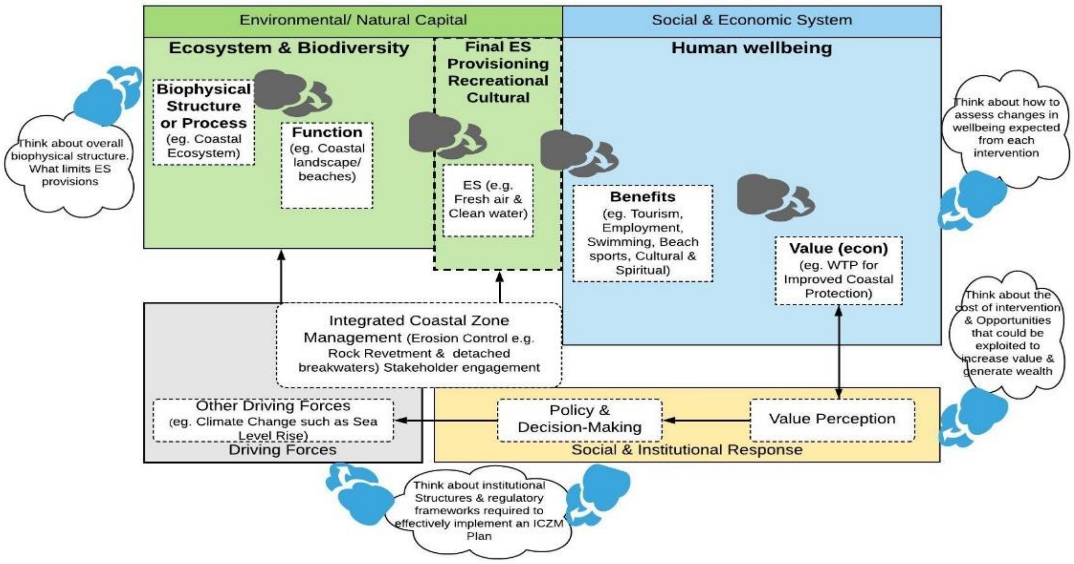
Linking Nature to People "The Cascade Model"

The Cascade model is used in the study to establish the nexus between nature and society theoretically. The model is best described as a socio-ecological model based on its systematic explanation of linking nature (biophysical elements) to people (socioeconomic ones) (Kumar, 2010; Fisher et al., 2013; Burkhard & Maes, 2017). The model suggests that understanding the ecological modus operandi of an ecosystem would be essential for identifying strategies to sustain and maintain ecosystem functions and provisions.

Based on the Cascade model, an 'ecosystem' is described by biophysical structures, processes, and functions (far left side of Figure 2-Appendix D) (Burkhard & Maes, 2017). There is consensus amongst ES researchers that ecological structures and processes of a given natural capital generate 'final' ES at one end, which has a strong linkage to enhancing human wellbeing on the other end. Ecosystem services are considered to be 'final' if they are outputs of an ecosystem that ultimately affect societal or human wellbeing (Feeley et al., 2016). Final ES can either be stocks (e.g., beach sand) or flows (e.g., recreational activities such as swimming) (Halkos & Matsiori, 2012; Burkhard & Maes, 2017) (Halkos & Matsiori, 2012). Natural capital 'stocks' are simply ecological or environmental assets, while 'flows' are the transformations or movement of various stocks (Jones et al., 2016). Non-final ES are referred to as supporting or intermediate services, as illustrated on the left side of the Cascade Model (Feeley et al., 2016). Supporting ES are the biophysical or ecological structures and processes that facilitate the provision of final ES such as regulatory, recreational, including the ecosystem benefits that enhance human wellbeing (Feeley et al., 2016).

The right side of the model describes ecosystem service benefits that contribute to enhancing agency and wellbeing (Fisher et al., 2013; Burkhard & Maes, 2017; Potschin-Young et al., 2018). Ecosystem benefits can either be valued in monetary or social terms (OpenNESS, 2016). Benefits are synonymous with 'goods' and 'products. However, the use of 'services' when referring to 'goods' connotes a very different meaning according to the Cascade model. Finally, ecosystem values are standards, often in monetary terms use by people to justify the importance of ES. Overall, the state of human wellbeing in any given socio-ecological system is subject to the aggregate output of ecosystem benefits (OpenNESS, 2016).

Figure 2-Appendix D The Cascade Model: Framework for Linking Nature to People



The Cascade Model used as Framework for Linking ES to Human Wellbeing (The Economics of Ecosystems and Biodiversity (TEEB) De Groot et al., 2010a), adopted from Haines-Young & Potschin, 2009, modified by Dampha, 2019 (informed by van Oudenhoven, 2015)

6.5 Appendix E. Survey Instrument- Migration Studies (Chapter One)

INVESTIGATING THE FACTORS RESPONSIBLE FOR PEOPLE RELOCATING FROM BANJUL SINCE 1993 &
CURRENT RESIDENT'S WILLINGNESS TO RELOCATE FROM BANJUL DUE TO CLIMATE-INDUCED SEA LEVEL RISE[21]

Designed by Nfamara K Dampha (September 3, 2018)

Study Objectives

1. To investigate the factors responsible for Banjul's rapidly declining population
2. To investigate Banjulians' Willingness to Relocate (WTR) to a region of their choice across the country due to current and future climate change threats facing the city
3. to provide results that would inform public policy and decision-making process on climate change adaptation

Interviewer's Name: ——————————— **Date: ————**

SECTION 1. APPROACH & SEEK CONSENT TO TAKE THE SURVEY

Greetings

Hello!!

I am [*Interviewer's Name*], conducting a survey for academic and policy decision-making purposes for understanding migration and sustainability issues confronting the city of Banjul. This survey is approved and supervised by the National Environment Agency and the Banjul City Council. The survey is restricted to only those who use to or are presently living in Banjul.

Introduction

I would like to ask you few questions regarding your perception about the reasons responsible for people relocating from Banjul since 1993, the importance of living in Banjul, as well as your knowledge of environmental and climate change impacts facing Banjul city. I would also like to know your willingness to continue living in or relocating from Banjul to a region of your choice across the country, should The Gambia government provide that option due to current and future risk factors and its high vulnerability level to global sea-level rise leading to coastal erosion of the city's beach and potential flooding of some areas.

Informed Consent

This survey may take about 10-15 minutes, and you may decide to stop at any time or decline to answer any question. The survey is completely anonymous, and your response to any question would not have any legal implication on you. Personal data collected will be combined with others' information for general statistical purposes.

Do you agree to take the survey?

…Yes (proceed) …No (Gently ask why? Record the reason, keep the questionnaire & end survey)

Check Gender based on identity

… Male … Female

Remind Them of The Basic Facts About Banjul

---

1. The small beautiful island of Banjul has a total land area of 2,200 km^2 with 31,301 inhabitants (GBOS, 2013)

2. Banjul population declined by 25% since 1993 (from ~41,000 to ~31,000) 10,000 less ppl

3. Currently, the city accommodates nearly 75% of key government ministries.

4. Banjul is the central engine for economic growth and development in The Gambia

5. As a capital city, Banjul symbolizes the country's rich culture and history, owing to its colonial heritage.

6. Other important landmarks in Banjul include but not limited to; the Presidential State House, the newly built National Assembly, the country's biggest hospital, major roads, hotels, schools, a major trading center, seaport, fisheries center, cemeteries, etc.

SECTION 2. PERCEPTIONS ABOUT WHY BANJULIANS ARE RELOCATING FROM THE CITY, THE IMPORTANCE OF BANJUL TO PEOPLE, CLIMATE CHANGE IMPACTS & INSTITUTIONAL TRUST & RESPONSIBILITY

There are some factors responsible for people's relocation from old to new settlements. They can be economic, social, political, environmental, demographic, security reasons.

Push Factors

a) Over-congestion
b) Lack of economic opportunities (e.g., jobs, markets)
c) Lack of safety & security threats
d) Seasonal flooding due to heavy rains
e) Riverine flooding due to sea-level rise
f) Poor environmental conditions (poor sanitation, open drains and stinky sewer flows, poor waste management)

g) Family conflict & misunderstanding
h) Other specify

Pull Factors

a) The emergence of new & attractive settlements in other areas
b) Better environmental conditions
c) Better employment opportunities (e.g., jobs outside of the city)
d) Better public service (e.g., electricity, water, amenities, public transportation)
e) The family demanded to move for good reasons
f) Built a second compound due to increase wealth & income
g) Other specify

Which of the following above or others not listed are the **1st 3 MOST IMPORTANT REASONS**, you think are responsible for people relocating from Banjul since 1993 *(Please list in order of first, second, and third most important)*

1)
2)
3)

Which of the following above or others not listed are the **2nd 3 MOST IMPORTANT REASONS**, you think are responsible for people relocating from Banjul since 1993*(Please list in order of first, second, and third most important)*

1)
2)
3)

Which of the following above or others not listed are the **3rd 3 MOST IMPORTANT REASONS**, you think are responsible for people relocating from Banjul since 1993*(Please list in order of first, second, and third most important)*

1)
2)
3)

Importance of Banjul to people Surveyed
Please consider the importance of Banjul to you as you fill out the following questions

How might the Beach be important /beneficial to you in terms of?	Not Important		Mildly Important		Very Important
Housing the State house	1	2	3	4	5
Accommodating key gov't institutions	1	2	3	4	5
Job seeking /employed in BJL	1	2	3	4	5
Recreation purposes	1	2	3	4	5
Business & Trade	1	2	3	4	5
Family living in Banjul	1	2	3	4	5
Education purposes	1	2	3	4	5
Health Reasons	1	2	3	4	5
Sports	1	2	3	4	5
Music & entertainment	1	2	3	4	5
Religious or spiritual reasons	1	2	3	4	5
Traditional and Cultural reasons	1	2	3	4	5
Community & Social networking	1	2	3	4	5
Biodiversity protection	1	2	3	4	5

From the list above, which three are most important to you? *(Please list in order of first, second, and third most important)*

1)
2)

3)

Non-use Values (Bequest & existence)

I have a responsibility to protect Banjul for future generations, even if that costs us money (Bequest Value)

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

Environment & Biodiversity Perception

What is the most important problem in Banjul?

a. Unemployment
b. Food insecurity
c. Environmental problems
d. Safety & security
e. Public education quality
f. Transport
g. Other, specify…………………..

What is the most important environmental problem in Banjul?

a. Sea-level rise& coastal erosion
b. City flooding/flashflood
c. Sanitation & hygiene
d. Drinking water pollution
e. Air pollution
f. Waste handling and disposal
g. Water pollution in the ocean
h. Other, specify…………………..

Perception of Cost-Benefit Tradeoffs

It is worth spending more money on improved coastal protection against climate change impacts such as Sea-level rise(SLR)because a protected coastline will protect Banjul from Sea-level rise

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

Perception of Institutional Trust & Responsibility

You trust the work of your Area Council on protecting Senegambia beach area

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree
f. Don't Know

You trust the work of the NEA on protecting Senegambia beach area

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree
f. Don't Know

You trust the work of the current government on protecting Senegambia beach area

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,

d. Disagree,
e. Strongly disagree
f. Don't Know

Who should be responsible for protecting the coastline of the beach?

a. Government
b. Private sector (e.g., hotels, coastal industries)
c. Non-governmental Organizations (NGOs)
d. Community-based organizations
e. Individual beach users
f. Collaboration btw stakeholders
g. Other, specify ………………

Climate Change Knowledge & Perception

How often have you heard of global climate change?

a. Always
b. Usually
c. Sometimes
d. Rarely
e. Never

What do you think are the main causes of global climate change?

a. Natural (Allah's cause)
b. Human only (anthropogenic)
c. Both Natural and Human
d. Don't Know
e. Other (Please Specify………………..)

Climate change impacts such as coastal erosion & sea-level rise pose a serious threat to you and your ability to use the beach for recreation purposes

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

Banjul experiences destructive extreme flashflood events during the raining season

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

Banjul will remain as a vibrant city for the next 50 years if all remains the same

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree
f. Don't Know

The developed world is responsible for global warming and should pay for loss & damage attributed to climate change impacts

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree
f. Other (Please Specify………………..)

The Gambia needs to develop a NEW CAPITAL CITY within the next 50 years

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

(If agreed, ask) In which region should the Gambia's NEW CAPITAL CITY be located?

a. Greater BJL Area
b. WCR
c. NBR
d. LRR
e. CRR
f. URR
g. Don't Know

SECTION 3. RELOCATION FROM BANJUL SCENARIO

This section is designed to investigate your willingness to continue living in or relocating from Banjul based on projected climate change impacts such as sea-level rise, leading to coastal erosion of the city's beach and potential flooding of some areas.

Status Quo Scenario (Business as Usual)
Did you know that: (Facts)

1) Banjul is "very highly vulnerable" to global ocean level rise and its associated coastal erosion (Hills & Manneh, 2014; Coates & Manneh, 2015).

2) Banjul would be lost by the end of this century with a 1.0m rise in global ocean level (Jallow et al., 1996)

3) A 1.0m SLR would lead to property loss of D1, 950 billion Dalasi (US$217 million) by 2050 (only accounts for Banjul to Kololi beach) (Jallow et al., 1996)

4) The width of Banjul beach crest has reduced by roughly 30 m over ten years, indicating an additional lifespan of 10-15 years (Coates & Manneh, 2015).

5) Public and private properties along the coastline are damaging due to coastal erosion

6) Since 1993, an estimated 375 households were misplaced or unfounded in Banjul largely from Banjul North (GBOS, Census Data)

Figure 1. Map showing BJL's vulnerability to climate-induced sea-level rise

Based on the status quo of Banjul and its beach areas, let's assume that government and other stakeholders, including Banjulians, maintain present protection and preservation strategies for the city against current and future global climate change impacts.

Follow-up Questions on BAU

Do you think that the current migration trend would continue to persist or likely get faster if BAU continues in Banjul?
__ YES ___No

Relocation Project Scenario: WTR from Banjul to regions of their choice

*To minimize you and your family's exposure and vulnerability levels to current challenges and projected climate change impacts, suppose a joint proposal from the National Environment Agency (NEA) and your Banjul City Council (BCC) asked all Banjul residents to relocate to a region of your choice across the country; note that everything you possess including your current housing structure and conditions will **remain the same except** that you and your family will **NOT** be living in Banjul due to the city's risk level to global climate change; you may also **NOT** be living close to your current neighbors at the relocated site; let's say the government will provide the land and pay you the present value of your house for you to build a similar structure at the relocated place of your choice; we can assume that your new home will be better protected at least from sea level rise and coastal erosion;*

Would you be able and willing to move/relocate to a suitable location of your choice for you and your family's protection?

YES or NO

If YES, Ask, why would you be willing to move?

……
……………………………………………………………………………………………..

If YES, which region of the country would you be willing to relocate to?

	a) Greater Banjul Area b) West Coast Region c) Lower River Region d) North Bank Region e) Central River Region f) Upper River Region
If No, kindly ask, for a reason ……… ………………………………………………………………………………………	

SECTION 4. ATTITUDES TOWARDS THE SCENARIOS AND THE QUESTIONNAIRE

This section intends to evaluate respondents' attitudes towards the proposed programs being asked to offer for as well as their general view of the survey.

How would you agree or disagree with the following statement?

Any future relocation program will receive strong public support

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

The government is capable of implementing a future relocation of Banjulians if well planned

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

If the government COULD NOT afford for your relocation, would you consider relocating from Banjul

a. YES
b. NO

Ask Why? (*either YES or NO*)

………………………………………………………………………………………

SECTION 5. DEMOGRAPHIC & SOCIOECONOMIC CHARACTERISTICS

1. What is your age bracket?
   a. Under 18
   b. 18-24
   c. 25-35
   d. 36-45
   e. 46-65
   f. 66 or older

2. How many people live in this household? ________

3. What is your highest level of education completed? (*If Arabic School, use the equivalent to levels below*)
   a. None

b. Primary School (Grade 1-6)
c. Middle School (Grade 7-9)
d. High School (Grade 10-12)
e. College/Vocational Training (e.g., GTTI, Gambia College)
f. University undergraduate level
g. Graduate or Professional Degree (e.g., Masters)
h. Ph.D. Holder

4. Please indicate the range of your household 2017 annual personal income (after taxes):
    a. BELOW D100,000
    b. D100,001 –200,000
    c. D200,001-400,000
    d. D400,001-500,000
    e. D500,001-1,000,000
    f. Over D1,000,000

5. Where is your main source of income from?
    a. Earned wages
    b. Remittances from outside the country
    c. Remittances from close relatives
    d. Donations
    e. Others (specify---------------------)

6. What is your ethnicity?
    a. Mandinka/Jakanka
    b. Fula/Tukulor
    c. Wollof
    d. Jola/Koroninka
    e. Serahulli
    f. Serere
    g. Creole& Aku
    h. Manjago
    i. Bambara
    j. Other Gambians
    k. None of the above

6.6 Appendix F. Public Opinion Survey[22]: Citizens' Perceptions and Preferences of Suitability Criteria, Policy Objectives, and Site identification Choices (Chapter Two)

Introduction & Informed Consent

Considering climate change impacts (i.e., rising sea-levels) exacerbated by low elevation challenges facing The Gambia's current island capital city, Banjul, a recently concluded research project recommends identifying a strategic location for building a climate-resilient city for the country (Coates & Manneh, 2015).

A Ph.D. candidate (Nfamara K. Dampha at University of Minnesota, USA) is applying a Geographic Information System (GIS) based multi-criteria decision-making procedure, using remotely sensed satellite data with multiple other geospatial layers, for conducting a site suitability analysis. The analysis aimed at identifying the 'most suitable' location for building a second capital city in The Gambia. The multi-million dollar question is what does the 'most suitable site or a strategic location' mean? In answering this question, it's true that we have differences in opinion.

This survey is designed to seek the opinions of Gambians on some of the critical issues to be considered in standard site suitability studies. The survey will provide additional evidence for supporting scientifically based research findings gathered by Dampha and his team.

The survey may take 5-7 minutes of your time. All responses are anonymous. No name or identifying information should be included. Nobody can identify you based on your answers to these questions.

As important as your opinion is in informing national policy decisions of this kind, we kindly request that you carefully read the questions before answering them. Reading some of the questions 3 times is recommended for completing this survey.

If you do not understand any question, you have the right to skip it or text Nfamara for clarification (Contact him on WhatsApp +1-612-814-3930).

Thank you for sharing your opinion in advance !!!

Q1 Are you willing to take this survey for academic reasons and for informing public policy in The Gambia?

- ○ Yes
- ○ No

Skip To: End of Survey If Q1 = No

Q2 Are you a Gambian citizen or a permanent resident in The Gambia?

- ○ Yes
- ○ No

Skip To: End of Survey If Q2 = No

Q3 Identify your highest level of education completed, (If attended Madarassa (Arabic School), use the equivalent to levels below))

- ○ Never Attended School
- ○ Primary School (Grade 1-6)
- ○ Middle School (Grade 7-9)
- ○ High School (Grade 10-12)
- ○ College/Vocational Training (e.g., GTTI, Gambia College)
- ○ University undergraduate level
- ○ Graduate or Professional Degree (e.g., Masters)
- ○ PhD

Skip To: End of Survey If Q3 = Never Attended School

Skip To: End of Survey If Q3 = Primary School (Grade 1-6)

Skip To: End of Survey If Q3 = Middle School (Grade 7-9)

Q4 The Gambia needs to develop a NEW CAPITAL CITY within the next 50 years.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Skip To: Q29 If Q4 = Strongly disagree

Q5 If you agreed that we need a new city, in which region should this next CAPITAL CITY be located?

- ◯ Kanifing Municipality (KM)
- ◯ West Coast Region (WCR)
- ◯ North Bank Region (NBR)
- ◯ Lower River Region (LRR)
- ◯ Central River Region (CRR)
- ◯ Upper River Region (URR)
- ◯ Don't Know
- ◯ Other, specify ____

Q6 The next capital city of The Gambia should be five (5) times bigger than Banjul.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Q7 When building a new capital city, the government should avoid building it in areas/sites prone to future flood inundation. (i.e., low elevation areas)

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q8 Reducing poverty should be one of the top policy agenda to consider when deciding on where to locate the next capital city.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q9 Regions with higher poverty rates should be considered more when deciding on the location of the next capital city of The Gambia compared to regions with lower poverty rates.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q10 Reducing unemployment should be one of the top policy agenda to consider when deciding on where to locate the next capital city.

- ○ Strongly agree

- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q11 Regions with higher unemployment rates should be considered more when deciding on the location of the next capital city of The Gambia compared to regions with low unemployment rates.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q12 Reducing regional inequality should be one of the top policy agenda to consider when deciding on where to locate the next capital city.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q13 Reducing urban congestion should be one of the top policy agenda to consider when deciding on the location of the next capital city of The Gambia.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree

◯ Somewhat disagree

◯ Strongly disagree

Q14 Regions with lower population density should be considered more when deciding on the location of the next capital city of The Gambia compared to highly congested regions.

◯ Strongly agree

◯ Somewhat agree

◯ Neither agree nor disagree

◯ Somewhat disagree

◯ Strongly disagree

Q15 Region or a site with a lower temperature value (relatively cooler weather) should be considered more when deciding on the location of the next capital city of The Gambia compared to a region with higher temperature values.

◯ Strongly agree

◯ Somewhat agree

◯ Neither agree nor disagree

◯ Somewhat disagree

◯ Strongly disagree

Q16 Avoiding massive displacement of current residents; sites, where fewer people will be displaced should be considered more than a site that will result in more displacement of current residents.

◯ Strongly agree

◯ Somewhat agree

◯ Neither agree nor disagree

◯ Somewhat disagree

○ Strongly disagree

Q17 Land ownership type; sites that are communal-owned or an undeveloped land areas should be considered more when deciding on where to locate the next city compared to privately-developed and owner-occupied land areas.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Q18 Preventing environmental damage and losses; sites with larger forest area should be avoided when deciding on a suitable location for building a new capital city compared to sites with less forest.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Q19 Preventing ecological damage and losses; sites with larger wetlands should be avoided when deciding on a suitable location for building a new capital city compared to other sites with less or no wetlands.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Q20 Sites with larger water bodies should be avoided when deciding on a suitable location for building a new capital city compared to sites with less or no water bodies.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q21 Reducing cost to the government; sites with a lower cost to government (e.g., for paying compensation to current landowners) should be considered more in the decision-making process than sites with a higher cost to the government.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q22 Minimizing man-made and natural disaster risks; sites with lower exposure and vulnerability levels should be considered more compared to sites with higher exposure and vulnerability levels.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q23 Reducing logistical costs to society (e.g., access to the new city, transportation opportunities along the river-way; sites with lower logistical cost should be considered more than sites with a higher logistical cost.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Q24 Reducing external threats; (e.g., distance from Senegal); sites with greater distance from the border should be considered more in the decision-making process than sites closer to the border.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Q25 Taking advantage of existing infrastructure; sites with more infrastructure (e.g. roads, schools, health facilities) should be considered more when deciding on the location of the next capital city of The Gambia compared sites or regions with less public infrastructure.

○ Strongly agree

○ Somewhat agree

○ Neither agree nor disagree

○ Somewhat disagree

○ Strongly disagree

Q26 If you were to select a land cover type to be transformed into a new capital city of The Gambia, which of the following would you pick?

○ Agricultural Land

◯ Forest land

◯ Grassland

◯ Bare Soil

◯ Already Developed Land for Human Settlement

Q27 Now, select your second choice (*Don't pick the land cover type you selected for the previous question*)

◯ Agricultural Land

◯ Forest land

◯ Grassland

◯ Bare Soil

◯ Already Developed Land for Human Settlement

Q28 Which region do you consider as your place of origin or birthplace?

◯ Banjul (BJL)

◯ Kanifing Municipality (KM) / Greater Banjul Area (GBA)

◯ West Coast Region (WCR)

◯ North Bank Region (NBR)

◯ Lower River Region (LRR)

◯ Central River Region (CRR)

◯ Upper River Region (URR)

◯ Other, specify ____

Q29 What is the name of the place you are currently staying? (e.g., Bakau)
Specify ____

Q30 In which **region are you currently staying** (if living outside of The Gambia, use the "other" option below)

- ○ Banjul (BJL)
- ○ Kanifing Municipality (KM) / Greater Banjul Area (GBA)
- ○ West Coast Region (WCR)
- ○ North Bank Region (NBR)
- ○ Lower River Region (LRR)
- ○ Central River Region (CRR)
- ○ Upper River Region (URR)
- ○ Other, (Specify the name of the Country) ________________________________

Q31 Identify your gender

- ○ Male
- ○ Female

Q32 Select your age bracket

- ○ Under 18
- ○ 18 - 24
- ○ 25-34
- ○ 35 - 44
- ○ 45 - 64
- ○ 65 or Older

Q33 If currently employed, which sector are you working for:

- ○ Gambia Gov't, Specify Department Name ________________________________
- ○ Private Sector

- NGO/CSO (Paid position)
- Volunteering for NGO/CSO
- Self-employed
- Unemployed
- Student
- Other, specify ____

End of Block: Default Question Block

6.8 Appendix G. Contingent Valuation Survey Instrument (Chapter Four)

WILLINGNESS TO PAY (WTP) FOR IMPROVED COASTAL PROTECTION AGAINST CLIMATE CHANGE IMPACTS ON SENEGAMBIA BEACH AREA (Coastal Cell 6)[23]

Designed by

Nfamara K Dampha (Ph.D. Student University of Minnesota, USA), September 3, 2018

Study Objectives

1. To estimate people's average maximum Willingness to Pay (WTP) CASH for improved coastal protection along the open ocean coastline of Senegambia areas for recreational and non-use value purposes in The Gambia (coastal cell 6)
2. To provide results that would inform public policy and decision-making process on climate change adaptation in The Gambia

Interviewer's Name: ———————————— **On-Site:** (*Circle*) **Yes or No** **Date:** ————

SECTION 1. APPROACH & SEEK CONSENT TO TAKE THE SURVEY

Greetings!

Hello!!

I am [Name], conducting a survey for academic and policy decision-making purposes to improve the coastal conditions of Senegambia. This survey is approved and supervised by the National Environment Agency (NEA) and your Area Council. The study is open to anyone (Gambian or non-Gambian) living in the coastal areas of The Gambia.

Introduction!

In connection with the **recreational, cultural, and religious uses as well as and non-use values of Senegambia beach area**, I would like to ask you a few questions to see how you value improved coastal protection against coastal erosion and sea-level rise as it relates to the recreational activities/benefits you may or may not undertake or enjoy at Senegambia beach area. Since building coastal protection come with some costs, I would present to you, a hypothetical market scenario in which you would be asked to make an offer (CASH) of how much a protected & preserved Senegambia beach area is worth to you.

Informed Consent!

This survey may take about 15-20 minutes, and you may decide to stop at any time or decline to answer any question. The survey is entirely anonymous, and your response to any question would not have

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any legal implication on you. Personal data collected will be combined with other information for general statistical purposes.

Do you agree to take the survey?

…Yes (proceed) …No (*Gently ask why? Record the reason, keep the questionnaire & end survey*)
……

Check Gender based on identity

… Male … Female

Section 2. Basic Facts, Visitation & Motivation of Beach Use
{Remind respondents about the Basic Facts of the study area (Senegambia beach)

1. The Senegambia area has one of the widest and biggest sandy beaches attracting thousands of Gambians and tourists each year
2. It can be described as The Gambia's paradise for tourism and hotshot for hospitality
3. Tourist infrastructure and resorts have been built there since the 1980s (Coates & Manneh, 2015).
4. Major uses of the Senegambia beach area include; swimming, sea viewing, picnicking, walking, sun-bathing, beach sports (physical exercise), traditional and cultural programs, social networking amongst peers, dating one's partner.

Visitation

(If found off the beach site, ask) Have you visited the Senegambia beach area in the last 12 months? *(Skip this Q for on-site interviews)*

Yes No ***(skip to Section 3)***

In the last 12 months, how many times have you visited the Senegambia beach area?

a) Every Day
b) 3 to 6 times a week
c) Once or twice a week
d) Every two weeks
e) At least once a month
f) A few times a year
g) Once a year

What is the name of the specific beach site you <u>most often visit in The Gambia</u>?

Participation in Activities
How often do you participate in the following activities when you visit Senegambia Beach?

	Never	Rarely	Sometimes	Often	Always
Swimming	1	2	3	4	5

Canoeing	1	2	3	4	5
Fishing	1	2	3	4	5
Picnicking	1	2	3	4	5
Birdwatching & Wildlife Viewing	1	2	3	4	5
Hiking /Trekking/walking	1	2	3	4	5
Sun-bathing	1	2	3	4	5
Beach sports (Physical exercise)	1	2	3	4	5
Horse Riding	1	2	3	4	5
Religious or spiritual Activities	1	2	3	4	5
Traditional and Cultural Activities	1	2	3	4	5
Social networking amongst peers	1	2	3	4	5
Dating one's partner	1	2	3	4	5
Meeting tourists	1	2	3	4	5

SECTION 3. PERCEPTIONS ABOUT RECREATIONAL AND CULTURAL ECOSYSTEM SERVICES, CLIMATE CHANGE IMPACTS & INSTITUTIONAL TRUST & RESPONSIBILITY

ES Use Values (non-consumptive)

Please consider the importance/value of Senegambia beach area to you as you fill out the following questions

How might the Beach be important /beneficial to you in terms of?	Not Important		Mildly Important		Very Important
Swimming	1	2	3	4	5
Canoeing	1	2	3	4	5
Sea viewing	1	2	3	4	5
Picnicking	1	2	3	4	5
Sunbathing	1	2	3	4	5
Beach Sports (Physical exercise)	1	2	3	4	5
Horse Riding	1	2	3	4	5
Birdwatching & Wildlife Viewing	1	2	3	4	5
Trekking or Hiking/Walking	1	2	3	4	5
Religious or spiritual reasons	1	2	3	4	5
Traditional and Cultural reasons	1	2	3	4	5
Social networking	1	2	3	4	5
Dating one's partner	1	2	3	4	5
Meeting tourists	1	2	3	4	5
Landscape beauty	1	2	3	4	5
Biodiversity protection	1	2	3	4	5
Fresh Air/breeze	1	2	3	4	5
Clean Water	1	2	3	4	5

From the previous list (Question 1), what three recreational values or uses are most important to you? *(Please list in order of first, second, and third most important)*

1)
2)
3)

Non-use Values (Bequest, existence, Altruistic value)

I have a responsibility to protect the Senegambia beach area for future generations, even if that costs us money now (Bequest Value)

a. Strongly agree,
b. Agree,

c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

If the animals and plants that live around/on the beach or in the sea are 'unique' then the area should be kept clean and protected from pollution at all costs (Existence Value)

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

Even if I don't use Senegambia beach area now for recreation & cultural, I would still like to preserve its quality so that others can benefit from its uses (Altruistic Value)

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

Option Value

Even if I don't use Senegambia beach area now for recreation & cultural activities, I would still like to preserve its quality in case I want to use it in the future, even if that costs me money now (Option Value)

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

Environment & Biodiversity Perception

What is the most important problem in the Greater Banjul Area & West Coast Region?

a. Unemployment
b. Food insecurity
c. Environmental Problems
d. Safety & Security
e. Public Education Quality
f. Transportation
g. Other, specify…………………..

Perception of Institutional Trust & Responsibility

You trust the work of your Area Council on protecting Senegambia beach area

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree
f. Don't Know

You trust the work of the NEA on protecting Senegambia beach area

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree
f. Don't Know

You trust the work of the current government on protecting Senegambia beach area

a. Strongly agree,
b. Agree,

c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree
f. Don't Know

Who has the property right over the beach?

a. The government /Area council
b. The community-owned
c. All users have equal rights (Public Good nonrestrictive & nonrival)
d. Various private entities with title deeds over specific areas
e. Jointly owned by the community & private entities
f. Jointly owned by community & gov't
g. Jointly owned by gov't & private entities
h. Do not know
i. Other, specify…………………….

Who should be responsible for protecting the coastline of the beach?

a. Government
b. Private Sector (e.g., hotels, coastal industries)
c. NGOs
d. Community-Based Organizations
e. Individual beach users
f. Collaboration btw stakeholders
g. Other, specify ………………

Climate Change Knowledge & Perception

How often have you heard of global climate change?

a. Always
b. Usually
c. Sometimes
d. Rarely
e. Never

What do you think are the main causes of global climate change?

a. Natural (Allah's cause)
b. Human only (anthropogenic)
c. Both Natural and Human
d. Don't Know

Climate change impacts such as coastal erosion & sea-level rise pose a serious threat to you and your ability to use the beach for recreation purposes

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

The developed world is responsible for global warming and should pay for loss & damage attributed to climate change impacts

a. Strongly agree,
b. Agree,
c. Neither agree nor disagree,
d. Disagree,
e. Strongly disagree

SECTION 4. IMPROVED COASTAL PROTECTION VALUATION SCENARIOS

Background

Research has shown that climate change impacts would severely affect coastal resources, communities, and livelihoods in ways that would affect the public and ecological functioning of these areas. The effects of eroded beaches include; lack of recreational opportunities, loss of revenue to the government and private hotel operators, lack of seasonal employment opportunities for youth and women, loss or migration of some aquatic and endangered species, etc.

CV Scenario: WTP for Improved for Coastal Protection against Climate-induced SEA LEVEL RISE & Coastal Erosion

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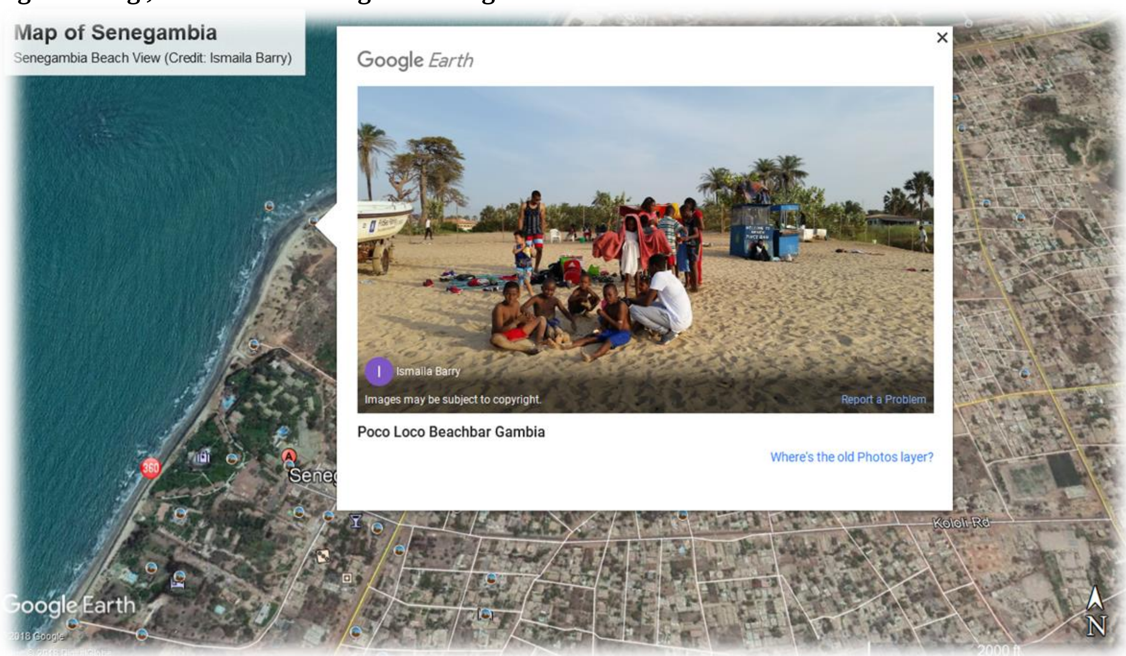
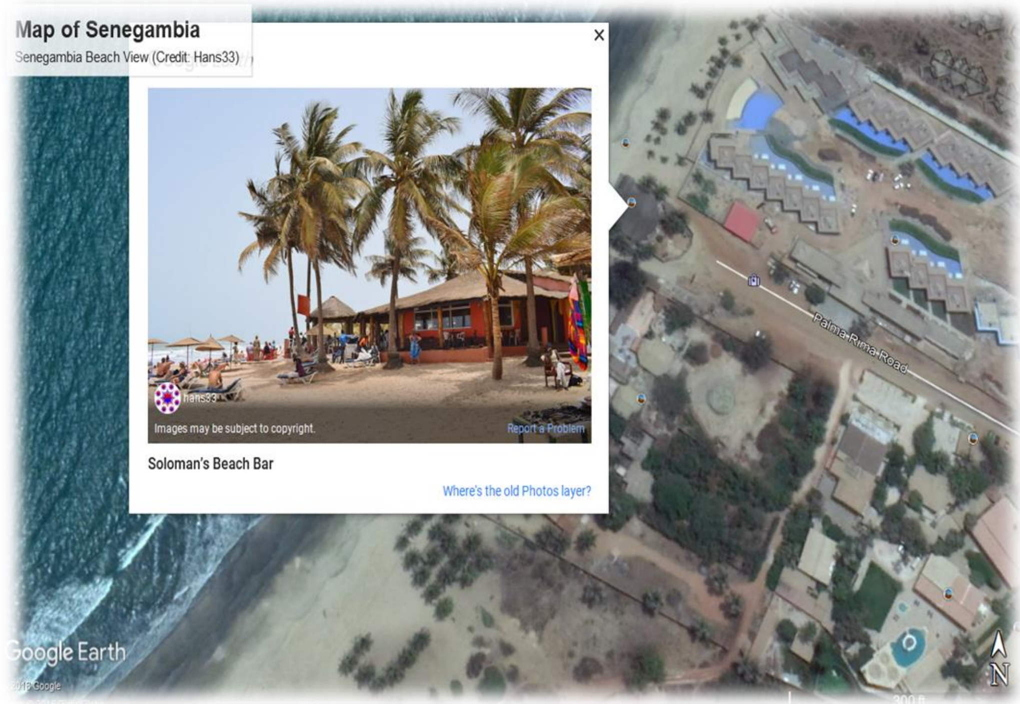
This section is designed to investigate the value of improved coastal protection against global climate change on the Senegambia beach area. **The term 'value' here means the value of only non-market goods and services,** including direct recreational and cultural uses (non-consumptive uses) and non-use values of Senegambia beach to Gambians and non-Gambians. *[Please do not include the value of your properties & the value of anything you can buy in the market (e.g., fish).]*

Figure 2. E.g., Recreational Images of Senegambia beach area





Now, I would present to you, hypothetical market scenarios in which you would be asked to make an offer (CASH) of how much a protected & preserved Senegambia beach area against climate change impacts such as SLR is worth to you

Status Quo Scenario (Business as Usual (BAU) See Visual Images below (limited beach replenishment and continued erosion)

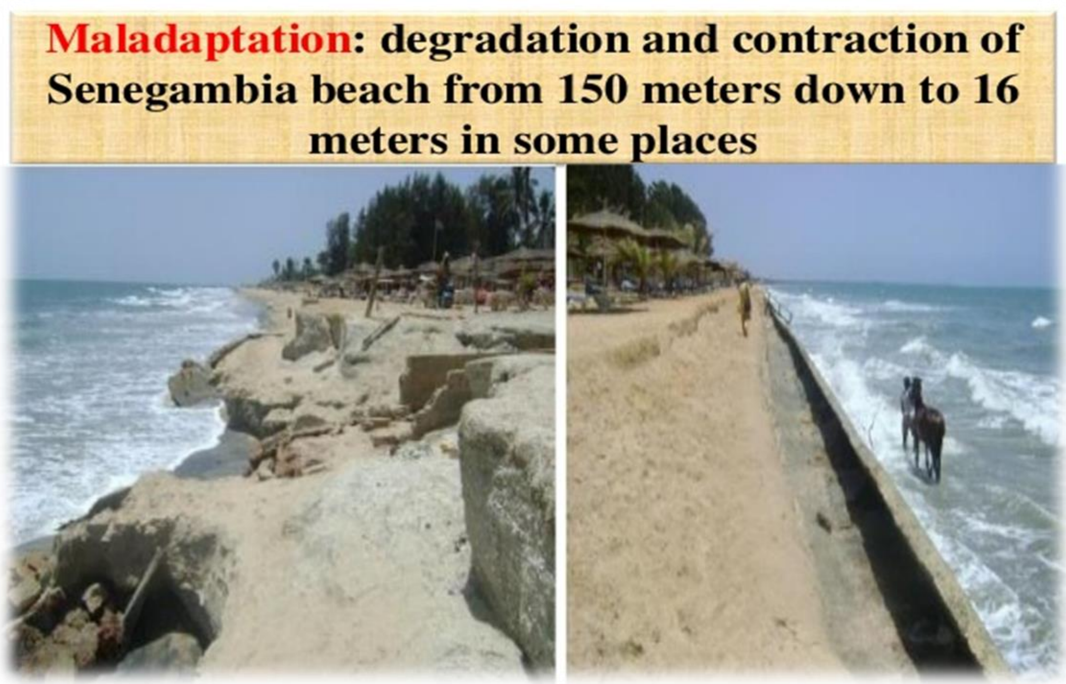
Did you know that: (Facts)?

1. Since the 1990s the area has been struggling with erosion, which has been affecting hotel guest access to the beaches (Jallow et al., 1996; Coates & Manneh, 2015).
2. In some areas, the beach has been retreating at a rate of 1-4 m per year, (NIRAS, 2015)
3. Tourism infrastructure and associated livelihoods are threatened
4. The width of the beach plain in Senegambia reduced by almost 90% since the 2003 sand nourishment (from 155.5 meters in 2003 to ~17 meters 2010) (Jallow A. 2016)
5. Currently, defense structures in some areas are failing while exposing beach users to danger from hazardous materials left on site (Coates & Manneh, 2015).
6. Without any integrated adaption strategy, significant areas used for recreation such as beach bars, gardens, and swimming pools will be lost along the shorefront (Coates & Manneh, 2015).

Figure 1. BEFORE

Source: (Jallow A. 2016)

Figure 2. NOW!!! E.g. of Lack of Necessary Adaptation for Coastal Beach Protection



Source: (Jallow A. 2016)

Figure 5. NOW

Source: TripAdvisor.com

Figure 6. NOW!! E.g. of Coastal Erosion on the Senegambia beach area

Source: (NIRAS, 2015)

Follow-up Questions on BAU

Do you understand the status quo? __ YES __ NO (If No, try to explain again)

Based on the status of Senegambia beach area areas, let's assume that the government and other stakeholders maintain present protection and preservation strategies for the beach against current and future global climate change impacts.

Project Improvement Scenario-WTP (CASH)

To change from BAU scenario, suppose a joint proposal from the National Environment Agency (NEA) and the Brikama Area Council (BAC) asked all Gambians to DONATE money for protecting Senegambia beach areas; the government would provide 60% of the project funds, and all INDIVIDUALS will be asked to contribute the remaining 40% for the project to be implemented; remember, this may be the only possible way to protect Senegambia beach area; also, we can be 100% sure that all the monies donated will be used solely for implementing the proposed project below resulting to the following expected outcomes (show visual aid image & explain project details below);

Project Description *(Coates & Manneh, 2015)*
This proposed project will continue to increase the width of the beach by building 'detached breakwaters,' 'a rock revetment,' and 'sand nourishment.' The project, when entirely funded & implemented, will move the shoreline seaward like the 2003 sand nourishment (Show image below & Explain).

Expected Outcomes/Benefits *(Coates & Manneh, 2015).*

1. *The beach width will increase by 30 m at high tide and shall last for at least 30 years*
2. *Large beach area would be available for recreational and other uses*
3. *Tourists visiting Senegambia will have access to bath in the Sand, under Sun & in Sea (the 3S)*
4. *The coastline is protected at least for one more generation to see and use*

Anticipated Drawbacks/Negative Effects *(Coates & Manneh, 2015).*

1. *Recreationists may have difficult access crossing rock revetment and possible erosion of bays back to revetment.*
2. *If the project is not fully funded & completed, then the revetment will fail, and the beach will be compromised.*
3. *Increase seawater cloudiness, alteration of sand texture in the beach, disruption of ocean-bottom habitats and burial of beach organisms which can affect turtles, fish communities, and small creatures like clams and crabs (Landry &Whitehead, 2015)*

WTP Question
Based on the above project details, would you be willing to make a onetime DONATION OF

A. *{D50} YES or NO*
B. *{D100} YES or NO*
C. *{D200} YES or NO*
D. *{D300} YES or NO*

(Systematically pick one option for each respondent starting from low to high on

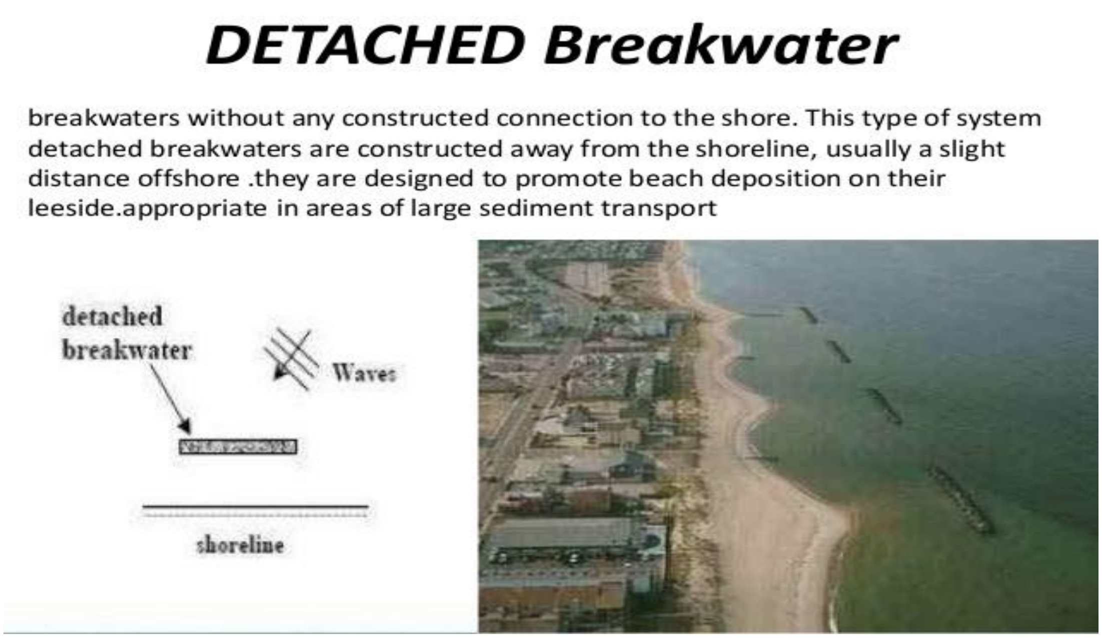
to KM for implementing this project ***within a period of one year?****?*

If the answer to the referendum question (Yes or No) above recorded zero bid (NO). Ask, did you say NO because you believe that:
____ Climate change impacts such as SLR is NOT a problem around the beach
____It is UNFAIR or IMMORAL to ask beach users to pay the costs of coastal protection
___Can't AFFORD to pay cash
___ The money would not be used accordingly
___ Gov't is NOT capable of solving the problem
___ Gov't should be RESPONSIBLE for coastal protection
___ Do not have an opinion
___ Other (specify)

Phase 1. COASTAL PROTECTION IMAGE

Source: www.zoover.se

Phase 2. E.g. of 4 detached Breakwater (design would look like the images below)



SECTION 5. ATTITUDES TOWARDS THE SCENARIO

You clearly understand the above valuation scenario presented to me.

a. Yes
b. NO

Regardless of what you offered above, would you consider visiting the beach if current conditions are improved either through this project or not

a. YES
b. NO
c. UNDECIDED

SECTION 6. DEMOGRAPHIC & SOCIOECONOMIC CHARACTERISTICS

Remind the respondent that this information is completely anonymous and would be used only for statistical purposes.

Where are you currently residing/living?

Specify place name [ ]

Are you a Gambian by nationality?

a. Yes
b. No

What is your age bracket?

a. Under 18
b. 18-24
c. 25-35
d. 36-45
e. 46-65
f. 66 or older

What is your marital status?

a. Married
b. Single
c. Divorced
d. Widowed

Do you have kids?

a. Yes
b. No

What is your current employment status?

a. Full-time
b. Part-time
c. Unemployed
d. Provide full time homecare
e. Student
f. Retired
g. Other, specify

What is your highest level of education completed? (IF Madarassa, use the equivalent to levels below)

a. None
b. Primary School (Grade 1-6)
c. Middle School (Grade 7-9)

d. High School (Grade 10-12)
e. College/Vocational Training (e.g., GTTI, Gambia College)
f. University undergraduate level
g. Graduate or Professional Degree (e.g., Masters)
h. PhD Holder

Please indicate the range of your 2017 MONTHLY personal income (after taxes):

a. BELOW 2,000
b. D2,001 –5,000
c. D5,001-10,000
d. D10,001-15,000
e. D15,001- 25,000
f. D25,001-35,000
g. D35,001-50,000
h. Over D50,000
i. Other specify……………….

Are you a member of any environmental organization?

a. YES
b. If YES, specify name: ____________________
c. NO

Which language was the interview conducted in?

a. Mandinka/Jakanka
b. Fula/Tukulor
c. Wollof
d. Jola/Koroninka
e. Serahulli
f. Serere
g. Creole& Aku
h. Manjago
i. Bambara
j. Other Gambians
k. None of the above

Was the interview conducted in the language fluently spoken and understood by both parties

a. YES
b. NO

How would you describe this survey?

a. Very Interesting
b. Interesting
c. Difficult & time consuming
d. Not credible & Boring

The information I gave is accurate, and it represents my Willingness/unwillingness to Pay for coastal protection

a. Yes
b. NO

6.9 Appendix H. Research Assistants (Interviewers)- University of The Gambia

Name	Role	Qualification	Name	Role	Qualification
Kemo Fatty	Team Leader & Interviewer	Undergrad student	Sarjo Touray	Team Leader & Interviewer	Undergrad student
Sheikh Tijan Jallow	Team Leader & Interviewer	Undergrad student	Lamin Conteh	Editor & Interviewer	Undergrad student
Mariama Danso	Interviewer	Undergrad student	Fatoumatta Jallow	Interviewer	Undergrad student
Aminata Joof	Interviewer	Undergrad student	Kawsu Barrow	Supervisor	Graduate (NDMA Staff)
Mariama Jallow	Interviewer	Undergrad student	Lamin W. Sanneh	Supervisor & Interviewer	Undergrad student
Maimuna Ceesay	Interviewer	Undergrad student	Alimatou Jammeh	Interviewer	Undergrad student
Njoba Touray	Interviewer	Undergrad student	Bintou Camara	Interviewer	Undergrad student
Ida Gaye	Interviewer	Undergrad student	Isatou Njie	Interviewer	Undergrad student
Awa Jobe	Interviewer	Undergrad student	Fatoumata Jarju	Interviewer	High School Graduate
Mabinta Trawally	Interviewer	Undergrad student	Modou L Y Jatta	Interviewer	Undergrad student
Lamin Sanneh	Team Leader & Interviewer	Advanced Diploma student	Lamin Njie	Interviewer	Undergrad student
Fatoumatta Sisawo	Interviewer	Undergrad student	Alhassan Drammeh	Interviewer	Undergrad student
Musa Dembelleh	Editor & Interviewer	Advanced Diploma student	Ebrima Sabally	Team Leader & Interviewer	Undergrad student
Fatou Fatty	Interviewer	Undergrad student	Mai O. Ceesay	Interviewer	Undergrad student
Isatou Manneh	Interviewer	Undergrad student	Ya Fatou Sarr	Interviewer	Undergrad student
Fatoumatta .S. Sanneh	Interviewer	Undergrad student	Adama O. Ceesay	Interviewer	Undergrad student
Ousman Janha	Editor & Interviewer	Undergrad student	Ousman Touray	Interviewer	Undergrad student

Abdou Jammeh	Interviewer	Undergrad student	Ebrima M. Ceesay	Interviewer	Undergrad student
Baboucarr Badjie	Team Leader & Interviewer	Undergrad student	Mariama Touray	Interviewer	Undergrad student
Isatou Baldeh	Interviewer	Undergrad student	Muhammed Ceesay	Interviewer	Undergrad student
Nyima Sawo	Interviewer	Undergrad student	Sang Mendy	Team Leader & Interviewer	Undergrad student
Dombel Jawo	Interviewer	Graduate	Masanneh Ceesay	Supervisor	Graduate (GBOS Staff)
Dawda Cham	Interviewer	Undergrad student	Alieu Jallow	Interviewer	Undergrad student
Fatou Demba	Interviewer	Undergrad student			

6.10 Appendix I. Coastal & Marine Working Group, under the NEA

Name	**Institution**
Lamin Komma	National Environment Agency (NEA)
Foday NK Fatty	National Environment Agency (NEA)
Bubacarr Jallow	Ministry of Environment, Climate Change & Natural Recourses
Jainaba Sanneh	National Environment Agency (NEA)
Malang Jatta	Department of Forestry
Masanneh Landing Ceesay	Gambia Bureau of Statistics (GBOS)
Abdoulie Camara	Kanifing Municipal Council (KMC)
Lamin B. Ceesay	Gambia Ports Authority (GPA)
Katchi Darbo	Gambia Ports Authority (GPA)
Edriss Muhammed Manneh	National Disaster Management Agency (NDMA)
Omar Kebbeh	National Environment Agency (NEA)
Omar Kanteh	National Road Authority (NRA)
Fakebba Senghore	Geological Department
Modou Lamin Sanneh	National Environment Agency (NEA)
Leese B. Mendy	Department of Water Resources