UNIVERSITY OF NAIROBI

A MULTI- STAKEHOLDER ANALYSIS OF THE INTERACTION BETWEEN WATER AVAILABILITY AND ACCESS, CLIMATE CHANGE AND LARGE-SCALE INFRASTRUCTURAL DEVELOPMENT IN LAMU, KENYA

BY

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A Thesis Submitted in Partial Fulfilment of the Requirements for Award of the Degree of Doctor of Philosophy in Climate Change and Adaptation of the University of Nairobi

2021

DECLARATION

I declare that this Thesis is my original work and has not been submitted for the award of a degree in any other university. Where other people's work has been used, this has been properly acknowledged and referenced in accordance with the University of Nairobi's requirements.

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DEDICATION

This piece of work is dedicated to my family, particularly my parents for pushing me all the way through. It is also dedicated to David, and my daughter Ysabel who motivated me to the finish line. I will always remember my time in Lamu, I pray that this work plays a part in improving access and availability of water in the area I am now so fond of.

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ABSTRACT

Climate change is altering the global water cycle and directly influencing our availability of and access to water. The threats of climate change and the relationship with large scale infrastructural development are examined for Lamu County, Kenya. The study investigated the capacity of the community in Lamu to deal with the additional impacts of climate change and large-scale infrastructural development on declining freshwater sources. In this context, climate change impacts are evaluated by examining trends in temperature and rainfall over time. This is related to changes in freshwater access and availability. The study then determines the needs of stakeholders, penultimately evaluating the capacity of Kenya's policy provisions to integrate climate change and large scale infrastructural development in local freshwater management. Finally, the study recommends participatory-based policy options for integrated water resources management under climate change. The study utilised a mixed methods research design with the specific approach being a sequential explanatory design, whereby qualitative and quantitative data were collected at different phases during the course of the study. Quantitative instruments included a household survey and climate data from the Kenya Meteorological Department, while qualitative data included focus group discussions, key informant interviews and group decision making: nominal group technique. The findings showed trends in climate variables that are consistent with global climate change predictions, confirming projections that land areas in equatorial countries including Kenya, may warm by the year 2050 by as much as 1.4^{O} C. Results from the study also indicate that climate variables are negatively impacting water access and availability in Lamu. This includes a reduction in freshwater supplies and increased salinity in reservoirs. This in turn is causing the community to make substantial changes in livelihoods. The study deduced that these impacts are not captured within the policy process informing major infrastructural development. Thus, the study recommends that the environmental impact assessment (EIA) process in Kenya is restructured to apply an integrated resources water management approach in informing the licencing of infrastructural development projects. The study further identified the potential for EIAs to mainstream climate change, recommending a mainstreaming approach in EIAs to ensure that they effectively incorporate climate change impacts in the assessment process.

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LISTS OF ABBREVIATIONS/ACRONYMS

AfDB	African Development Bank
CDM	Clean Development Mechanism
CMIP	Climate Model Intercomparison Project
CSAG	Climate Systems Analysis Group
CZM	Coastal Zone Management
EIA	Environmental Impact Assessment
EIAS	Environmental Impact Assessment Study
EMCA	Environmental Management and Coordination Act
GCM	General Circulation Model
GPS	Global Positioning System
HGFD	High Grand Falls Dam
ICZM	Integrated Coastal Zone Management
IPCC	Intergovernmental Panel on Climate Change
IPCC AR5	Intergovernmental Panel on Climate Change Fifth Assessment Report
IWRM	Integrated Water Resources Management
JPC	Japan Port Consultants
KDF	Kenya Defence Forces
KENHA	Kenya National Highways Authority
KMD	Kenya Meteorological Department
LAWASCO	Lamu Water and Sewerage Company
LAPPSET	Lamu Port South Sudan Ethiopia Transport
MOT	Ministry of Transport
NMK	National Museums of Kenya
NCCRS	National Climate Change Response Strategy Paper
NEMA	National Environmental Management Authority
NWSA	National Water Storage Authority
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SWOT	Strength Weakness Opportunities and Threat Analysis
WAG	Water Action Group

WASREB	Water Services Regulatory Board
WHO	World Health Organisation
WRA	Water Resources Authority
WRL	Static Water Level
WSP	Water Service Provider
WSTF	Water Sector Trust Fund

CHAPTER ONE

INTRODUCTION

1.1 Background

Climate and water are inextricably linked (Hosterman et al., 2012; Jeuland et al., 2013; Tabari, 2020). Water is the key to all forms of life. Its value is universally recognized and it is a powerful symbol across different cultures and religious beliefs (Gibbs, 2009). Water is essential for our survival, but on the other hand, it is also one of the most destructive elements on our planet (Tabari, 2020). Too much water in the form of floods can spell disaster, death and destruction; too little water can bring about drought, famine and economic depression (IPCC, 2021). Climate change is altering our assumptions about water resources (IPCC, 2014). Water resource planning requires us to make assumptions about future plausible hydroclimatic conditions including temperature, precipitation and river flows (Brekke, 2009; Padron et al., 2020). The choice of information supporting these assumptions is affected by a changing climate (Brekke, 2009). The need to communicate the importance of water as a resource and as an integral component of all ecosystems has never been more acute (Padron et al., 2020). Climate change is widely understood as the long term, large-scale shift in the earth's weather patterns, including changes in temperature, wind patterns and rainfall (IPCC, 2014). Our understanding of climate change is largely the result of the work by the Intergovernmental Panel on Climate Change (IPCC), the world's most authoritative voice on the issue (Castles & Henderson, 2003; IPCC, 2021). Established by the United Nations, the IPCC assesses the scientific and socio-economic information relevant to climate change. The IPCC also looks at the potential impacts of climate change, and options for slowing it down or adapting to it (Castles and Henderson, 2003; IPCC, 2021).

According to the IPCC (Bates et al., 2008; Padron et al., 2020; IPCC, 2021), the observational records and climate predictions provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change. As greenhouse gases progressively warm the atmosphere and alter the hydrological cycle, changes to the amount, timing, form and intensity of precipitation will continue (IPCC, 2014; 2021). In addition, other expected changes include the flow of water in watersheds, as well as the quality of aquatic and marine environments (IPCC, 2021). These impacts are likely to

affect the programmes designed to protect water quality, public health and safety (Arnell & Hughes, 2014; Urich et al., 2014; Tabari, 2020). This in turn will have wide ranging consequences for human societies and ecosystems. In addition, the systems used to treat and make public water supplies available require large amounts of energy, produced mainly by burning coal, natural gas, oil and other fossil fuels (Allan et al., 2020; Koutsoyiannis, 2021). Making water more available to communities uses energy and this too could contribute to climate change (Allan et al., 2020).

Arguably, coastal communities are even more vulnerable to climate change, particularly in relation to their water (Hoanh et al., 2003; Ferguson & Gleeson, 2012; Ballinger, 2015). As climate becomes warmer and sea level rises, coastal communities are at risk of salt-water intrusion into aquifers (Ferguson & Gleeson, 2012). They are also faced with flooding of coastal wetlands and marshes, lower oxygen levels in wetlands, ocean acidification due to higher concentrations of carbon dioxide in the atmosphere and the associated impacts of more severe coastal storms (Ballinger, 2015). These have significant implications on coastal water systems and as such, impact on water availability and quality. These impacts may occur in tandem with other existing stressors such as infrastructural development and coastal population growth, presenting new and different challenges to coastal communities (Hoanh et al., 2003; Massoud et al., 2018).

Coastal communities are even more at risk where current water systems are under developed (Massoud et al., 2018; Werner et al., 2012). This appears to be the case in Lamu County, one of the six coastal counties in Kenya located in the country's northern coast. With a large dependence on groundwater in the form of wells and boreholes, traditional systems of water management are proving unsustainable as the population increases (Okello et al., 2015). While in other parts of Lamu, communities rely almost solely on traditional forms of rainwater harvesting to meet their daily demands for water. This includes the use of 'djabias' or 'jabias', masonry structures for harvesting rain water that are prevalent in this area. Each 'djabia' can hold approximately 200m^3 of water and can supply around 150 -180 people with water (Biamah & Cherogony, 1994; Ignatius et al., 2018). This is becoming increasingly problematic in the face of dissimilar rainfall patterns as a likely result of climate change (Okello et al., 2015). As the county grapples with a problematic water supply and increasing water demand, Lamu is also the stage for significant infrastructural development sure to produce a surge in population. Not to mention the fact that the infrastructural development will radically change the landscape of the entire Lamu area from a rural setting to an urban

center (Okello et al., 2015). This is significant because Lamu's water needs and demands that are likely to change as a result.

As a country, Kenya is on the forefront of major global integration and investment. In 2008, Kenya adopted 'Vision 2030' – a national development plan with the aim of creating a globally competitive and prosperous nation with a high quality of life by the year 2030 (Kenya Vision 2030, 2007). The vision seeks to implement its goals through a series of predominantly large-scale development projects, one of which is the Lamu Port and Lamu-Southern Sudan-Ethiopia Transport Corridor, commonly referred to as LAPSSET. The benefits that LAPSSET will have on the national economy are well documented and understood (Enns, 2019; Chome, 2020; Aalders et al., 2021). The Kenyan Government has stated that LAPSSET will enhance competitiveness in global maritime trade, promote international trade and link the East and Central African region to the international markets (Kenya Vision 2030, 2007). However, the LAPSSET development will also have significant environmental impacts as well as place additional demands on local freshwater water systems (Okello et al., 2015). Members of 'Save Lamu', a coalition of thirty-six community-based organisations in Lamu, have raised concerns that steps to obtain technical data for analysing water current and tides for the project were skipped due to financial constraints (Save Lamu, 2013). Furthermore, the supply, access and availability aspects appear to be inadequately addressed in the environmental impact assessment informing the licensing of the LAPSSET project (Mutua, 2014; Gebreyesus et al., 2017) . As such, the impacts of LAPSSET on water in the area are not clearly understood nor fully explored. With climate change impacting supply, availability and quality of water in Lamu County as well as the anticipated impacts the LAPSSET project will have on water in the area (in terms of access and availability of water for the areas population), management of water in Lamu needs to be addressed. This is to ensure that current as well as future demand for water will be met. In addition, it is important to recognize the increased energy demands for supplying more water to more people and the impact that this will have on Kenya's contribution to global greenhouse gas emissions.

The link between climate change and development should be obvious (Birkmann & von Teichman, 2010). Climate change impacts will significantly affect national development, particularly amongst the world's poorest communities (Metz et al., 2002; Wilson & McDaniels, 2007). The IPCC (Olsson et al., 2014) suggest that climate-related hazards exacerbate other stressors, with negative outcomes for livelihoods especially for people living in poverty. Furthermore, it is suggested that climate change worsens existing poverty,

exacerbates inequalities and triggers vulnerabilities for some communities (Birkmann & von Teichman, 2010). It is predicted that climate change will create new poor between now and 2100 in developing and developed countries, jeopardising sustainable development (Olsson et al., 2014) A recent demonstration of this is in a study done on the economic impact of climate change on Ethiopian agriculture (Deressa, 2007) where it was found that increasing temperature and decreasing precipitation are both economically damaging to Ethiopian agriculture. In turn, alternative development pathways will determine future greenhouse gas emissions and influence the capacity of communities and countries to adapt to climate change (Huq et al., 2006; Olsson et al., 2014). In light of this clear connection, the integration of climate change adaptation into development planning and thinking is remarkably nuanced. It is more than a simple 'add on' policy process; it necessitates careful integration of climate change assessments on a multi-sectoral, multi-pathway and multi-stakeholder level in a way that they 'automatically' take adaptation into account (Dewulf et al., 2015). Hence, the emergence of the concept of 'mainstreaming': integrating climate change into existing decision-making and policy processes. As a result, adaptation is facilitated in tandem with development objectives and aligned with existing governance structures.

Mainstreaming climate change into national development planning is a global as much as a national necessity (Ogato, 2013). Infrastructural development projects have an impact on the environment, and in particular communities' access to and use of water. Studies show that as demand for water increases across the globe, the availability of freshwater in many regions is likely to decrease because of climate change (Jimenez Cisneros et al., 2014; Emelko et al., 2011; Kundzewicz et al., 2009; Vorosmarty et al., 2000; and Arnell, 2004). Without factoring the impacts of climate change on freshwater illustrated in the above-mentioned studies, water demands and needs in response to infrastructural development will significantly increase in Lamu. Lamu will experience population growth at an unprecedented rate, which will increase the demand on the already overexploited freshwater sources. To illustrate this, the LAPSSET feasibility study carried out in 2011 concludes that a fully industrialized port will result in population figures of between 450,000 and 1.25 million in 2030 and 2050 respectively. The study also concludes that in the long term, a supply of 181,550 – 296,750 m^3 of water/ month is anticipated. It is assumed that this covers industrial as well as household water use. The current water demand for Lamu town (Island) is estimated at about 3,000 m^3 /day, with a population of just under 150,000 people (LAPSSET Feasibility Study, 2011). Currently the Lamu Water and Sewerage Company (LAWASCO) is the water service provider tasked with providing water services to the Lamu area. It serves approximately 124km^2, with a population

mandate of 150,000. However, the actual population served through LAWASCO is 50,000 and as such, the current water demands are not met by the WSP charged with servicing the area (Coast Water Services Board, 2018). If you factor the impact of climate change on freshwater resources, Lamu is bound to experience significant water problems with the infrastructural development planned.

With the worlds continuing massive population growth, urbanization and the observed changes in climate persisting, the potential impacts on freshwater resources are likely to increase in magnitude, diversity and severity (Vorosmarty et al., 2000). The goal of this research endeavour is to explore the interaction of two distinct factors: climate change and large-scale infrastructural development, in as far as they have an impact on water in Lamu. In looking at how these distinct factors interact and impact water availability and accessibility in Lamu, it will be possible to make recommendations as to how communities can cope. It will also be possible to make suggestions as to what water policies will support the continued survival and adaptation of these communities.

1.2 Problem Statement

The problem can be characterised into three factors namely: supply, demand and policy. On the supply side, Lamu is experiencing a critical shortage in freshwater (Ochiewo, 2001; Biamah, 2016). Current water service provision is inadequate in serving all Lamu residents and is also overly dependent on declining groundwater sources in the region. Over dependence on groundwater sources is unsustainable (Srivastava et al., 2015). Further, Lamu is dependent on poor and outdated water infrastructure, with limited access to piped water (Okello et al., 2015). Supply of water in the region is further impacted by climate change. While on the demand side, Lamu is experiencing an increase in demand for freshwater. Lamu is the site for large scale infrastructural development in the form of the Lamu Port and Lamu-Southern- Sudan- Ethiopia Transport Corridor (LAPSSET) project. As the site for major infrastructural development, Lamu's population and as such freshwater demands and needs are increasing. This is putting additional strain on current freshwater sources that are already under significant stress. The Kenyan Government has proposed certain measures to combat this including creating a desalination plant in the region, however this is a long-term measure that is yet to be operationalised. Ideally, these supply and demand issues should be addressed Lamu remains on the verge of a freshwater crisis. Ideally any water supply and demand issues should be addressed before a large scale infrastructural development project such as

LAPSSET is approved. This leads to the third problem around policy. The policy process informing development projects of this nature is not sufficiently accounting for climate change impacts on water availability and access.

The Intergovernmental Panel on Climate Change (Jimenez Cisneros et al., 2014; IPCC, 2021) predicts that by 2030, there will be an increase in average global temperatures ranging from 0.5 to 1.5°C. Understanding how this relates to Lamu's freshwater availability and accessibility will enable local communities whose livelihoods may be inevitably affected to adapt to the negative effects of climate change. In addition, large-scale infrastructural development will also have an impact on water availability and access for different stakeholders. With the development of the LAPSSET project as well as other large-scale infrastructural projects in the area, the details of this impact and how they interact with the effects of climate change on water in the area are not known. While the impacts of the development of LAPSSET in Lamu County may be captured within the context of an environmental impact assessment mandated by Kenyan law, these impacts were not looked at in relation to the impact climate change is likely to have on access to and use of water. When both impacts are not looked at in tandem, any adaptation plans or strategies are incomplete. The problem is exacerbated, perhaps, by a range of gaps in our knowledge on mainstreaming climate change into national development, and within local contexts. Understanding the relationship between development and climate change adaptation in Lamu County necessitates localizing the impacts of climate change. Localised impacts in the backdrop of local conditions – societal, economic and developmental; promotes adaptation that is sustainable.

Currently, existing research globally tends to focus on the physical aspects of climate change or discuss the social ones (Schilling et al., 2020; Uexkull & Buhaug, 2021). The role that water plays in influencing the indirect causal pathways between climatic conditions and a wide set of conflict related outcomes needs greater consideration by the academic community (Abrahams, 2020; Schilling et al., 2020; Uexkull & Buhaug, 2021). This study reviews the nature of adaptation in Lamu County as well as the scale of adaptation required as a result of continued infrastructural development. The study also does so within the goals of cooperative problem solving, encouraging multi-stakeholder involvement. Multi-stakeholder engagement was a key part of this research in order to not only have a better understanding of the extent of the problem, but also to allow stakeholders to be a part of the problem solving. Stakeholders are more likely to support the implementation of integrated water resources

management (IWRM), which they can take ownership of and as such ensure sustainability and continuity. As such, it will be argued that elements of effectiveness, efficiency, equity, and legitimacy are incorporated into the decision-making process surrounding water in the County.

Furthermore, the theme will weigh the pertinent issues around water decision making in the County, prioritizing them and revealing the new and challenging institutional processes necessary to manage water in the face of climate change and infrastructural development. The recommendations will look at the different technological innovations available, their applicability within Lamu and explore means of wider significance. The results of this study will shed light on the key ways communities can adapt to the joint impact of large infrastructural development and climate change on water, and that may be adoptable in other regions of the world.

1.3 Research Questions

1. Are the current trends in climate variables having an impact on freshwater sources in Lamu?
2. Who are the key stakeholders in Lamu with regard to the demand for and use of freshwater?
3. What are the anticipated impacts of the development of LAPSSET on freshwater in Lamu?
4. How can stakeholders adapt to the climate change impacts on freshwater in light of LAPSSET's additional demands on water?
5. Is 'mainstreaming' sufficiently considered in Kenya's current policy on development?

1.4 Hypothesis

The null hypothesis for this study is that the capacity of Lamu's community to deal with declining freshwater is not affected by climate change impacts or large scale infrastructural development. The specific questions raised and corresponding hypotheses are as follows:

- Who are the key stakeholders in Lamu with regard to the demand for and use of freshwater?
    - There is a significant relationship between stakeholders with the greatest demand for freshwater and relative power of stakeholders in freshwater management
    - Stakeholders with the greatest demand for freshwater have in effect less power in freshwater management than local and national Government

- What are the anticipated impacts of the development of LAPSSET on freshwater in Lamu?
    - Large infrastructural development has a negative impact on freshwater availability and accessibility for local residents
    - LAPSSET development will increase freshwater supply to Lamu
- Are the current trends in climate variables having an impact on freshwater sources in Lamu?
    - Current trends in climate variables for Lamu agree with regional predictions for Africa of rising temperatures and reduction in rainfall
    - There is a relationship between negative trends in climate variables and declining freshwater sources in Lamu
- How can stakeholders adapt to the climate change impacts on freshwater in light of LAPSSET's additional demands on water?
    - Active engagement and participation of all stakeholders is key in coping with declining freshwater
    - Key stakeholders (with power to effect change and make decisions) determine adaptation actions
- Is 'mainstreaming' sufficiently considered in Kenya's current policy on development?
    - Environmental considerations within the basic structure of development policy in Kenya is mainly a response to environmental movements and is not inherently intuitive to future environmental problems
    - Development policy is biased towards decisions perceived to generate more income for the national economy at the expense of those decisions which are beneficial to local communities

1.5 Objectives

Overall Objective:

Investigate the capacity of the Lamu community to deal with the additional impacts of climate change and large-scale infrastructural development on declining freshwater sources.

Specific Objectives:

1. Determine perceived and actual trends in temperature and rainfall to establish the occurrence of climate change.

2. Evaluate the impact of rainfall and temperature trends on freshwater availability to establish relationship between climate change and freshwater.
3. Assess the needs of stakeholders in relation to freshwater access and use
4. Using LAPSSET as an example, evaluate the capacity of Kenya's policy provisions to integrate climate change and large-scale infrastructural development in local freshwater management.
5. Recommend participatory-based policy options for integrated water resources management under climate change.

1.6 Justification and Significance of the Study

1.6.1 Justification of the Study

This study considers the gaps in existing development policies in as far as their capacity to manage freshwater in Lamu. In particular, it examines the ability of these policies to address the additional impacts of climate change and large-scale infrastructural development. This research has practical as well as societal relevance. Firstly, LAPSSET – a Vision 2030 flagship project – is underway without a clear understanding or consideration for the wide-ranging impacts that the large-scale infrastructural projects will have on water sourcing and use within Lamu County, or how these impacts will interact with climate change. This is a concern for the thousands of residents whose livelihoods and standards of living will likely be affected. Existing studies (Nembrini, 2013; Okello et al., 2015) into the current sources of water that residents are dependent on in Lamu County have concluded that additional investigations would need to be carried out in order to assess the capacity of current sources to handle any additional population. Bearing in mind that the Shela aquifer's status as a viable freshwater reservoir is in danger as it is at risk of being exploited to its full capacity. Furthermore, currently there is no clear understanding or detailed information on how any large infrastructural development (including LAPSSET, with all of its different components) will interact with the present and future water needs of Lamu.

Secondly, research argues that conventional approaches to groundwater management in developing countries need to be reassessed, as most of them presume the existence of institutional, legal and technical frameworks that are simply not in place (Pietersen, 2006; Morris et al., 2003). As in Lamu, the existing policies were based on insufficient knowledge of freshwater sources and how different stakeholders interact with these sources. This research study will provide much needed baseline data to inform freshwater management policies that are holistic and participative. Another rationale to consider is the fact that Lamu

is of particular interest to coastal groundwater managers because it is the site of major infrastructural development (Okello et al., 2015) as well as having a unique geographical location. Lamu was declared a 'UNESCO World Heritage Site', rendering it a major tourist attraction as well as special global environmental reserve site. As the oldest and best-preserved Swahili settlement in East Africa, there is a clear need to maintain the landscape for the benefit of Lamu residents, the Kenyan cultural economy and as a global common.

Finally, studies have shown that serious water shortages are more likely to marginalize already disenfranchised members of the affected community (Denton, 2002; Zwarteveen & Meinzen-Dick, 2001) as well as cause violent conflict (Reuveny, 2007; Gleick, 2011; Homer-Dixon, 1994). It is necessary to address the additional pressures that large-scale infrastructural development and climate change will have on freshwater supplies as this allows us to circumvent the potential negative implications of heightened decline in freshwater access.

1.6.2 Significance of the Study

Freshwater is indeed a scarce resource. Only 2.5% of the total water volume on earth is freshwater, with the largest portion of it lying underground. Fresh groundwater is an important source of water supply in coastal areas such as Lamu, however coastal areas have very fragile freshwater supplies due to saline intrusion and land surface inundation of seawater. These happen for a number of reasons including excessive and heavy withdrawal of ground water from coastal plain aquifers, seawater ingress, tidal water ingress, relatively less recharge and poor land and water management (Okello et al., 2015; Werner et al., 2013). As a result, there is a reduction in drinking and irrigation water supplies of usable qualities in coastal zones.

In addition, the demand for freshwater in coastal zones is rising with factors such as population growth, water pollution and economic, as well as technological progress. It is expected that communities' increasing demand for water would result in increased efficiency in water management, however, as demonstrated by Jevon's paradox, increased water use efficiency does not necessarily lead to decreased consumption (Polimeni & Polimeni, 2006). Jevon's paradox occurs when technological progress increases the efficiency with which a resource is used but the rate of consumption of that resource rises because of increasing demand. Thus, freshwater resources are declining at an alarming rate all around the world in spite of technological advancements improving water use efficiency (Okello et al., 2015). The decline is exasperated by climate change.

The overall outcome of the research is an investigation into the capacity of the Lamu community to cope with the additional impacts of climate change and large-scale infrastructural development on declining freshwater sources. The provision of water should epitomize tenets of integrated water resources management, to ensure that all Lamu stakeholders are actively involved in their water management processes. This is entirely significant for the local community who have been largely left out of the process. While the Government of Kenya has commissioned studies including the LAPSSET Feasibility Study (2011), there have been serious concerns with the lack of stakeholder participation and engagement (Laher, 2011) throughout the entire LAPSSET development process. Significant concerns were raised on the feasibility study's lack of investigation into the environmental issues that would emanate as a result of the project. Furthermore, recommendations from the feasibility study focused on improving access to water in Lamu County in light of LAPSSET's development without taking into consideration the impacts climate change will also have on water in the same area.

1.7 Operational Definitions of Key Terms

For the purposes of the discussion presented in this thesis, the following are operational definitions of key terms:

Water availability – refers solely to the amount of water physically available nearby, not accounting for issues of water quality and delivery (McDonald et al., 2015)

Water access- refers to the proportion of the population using any piped water, public tap, borehole with a pump, protected well, springs and rainwater (Aiga & Umenai, 2003)

Water quality – the degree to which water is clean and suitable for drinking

Water sources- a place from which water issues or can be obtained for example rivers, streams, wells and boreholes.

Climate change – long term shifts in temperature and rainfall

Climate change adaptation – process of adjusting to or responding to current or expected climate change and its effects.

Large infrastructural development project – identified within the context Kenya's national development agenda - Vision 2030. Globally, these are typically projects that cost over $100 million.

Mainstreaming- refers to the integration of policies and measures to address climate change in on going sectorial and development planning and decision making (Klein & Huq, 2003)

Stakeholder – individual or group with an interest in any decision or activity of an organisation.

Traditional well – shallow sunk by hand digging and draw water from a natural or man-made aquifer.

1.8 Scope and Limitations of the Research

Using the LAPSSET project as an example of large-scale infrastructural development, this research aims to evaluate from the point of competing demands, the influence of LAPSSET on multiple stakeholders' ability to adapt to the impacts of climate change on water availability and access. The scope of this study is restricted to the multi-faceted consequences of climate change and large-scale infrastructural development on water. Thus, it will address issues such as sourcing of water, distribution of water, trends in climate variables and their impact on water and changes in access to water in light of infrastructural development in Lamu County. This study will only cover climate change trends in the form of temperature and rainfall variables over time as this is the only secondary data available for at least thirty years. It will evaluate these issues within the context of multi-stakeholder perspectives, in order to ensure that key recommendations to abate the problems associated with water distribution, are established through active participation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Water resources are important to both society and ecosystems. We depend on a reliable, clean supply of drinking water to sustain our health. We also need water for agriculture, energy production, navigation, recreation and manufacturing (Gibbs, 2009). Global projections show that by 2050, between 350-600 million people will be exposed to increased water stress due to climate change (Arnell, 2004). Development practitioners agree that climate change is likely to impose additional pressures on water availability, water accessibility and water demand in Africa. Given the pivotal role that water plays in communities, it is important to establish the extent of climate change impacts on local water supplies (Klein & Huq, 2003; Boholm & Prutzer, 2017).

In addition, scientists also argue that the impacts of climate change are experienced locally. Therefore, geographic variability in climate impacts emphasizes the need for 'place-based' approaches to climate vulnerability analysis and adaptation (Adger and Kelly, 1999; Cutter et al., 2000; Turner et al., 2003). Consequently, there is a growing field of research in determining climate change impacts within local conditions (Patrick, 2020; Zubaidi et al., 2020). The current thesis examines a place-based and resource specific approach to climate vulnerability analysis and adaptation, focusing on climate change impacts on water in Lamu. Lamu is of special concern as it is a coastal community that is undertaking large infrastructural development projects that will introduce new demands on local water supplies. Incorporating these additional demands on local water supplies with the impacts of climate change is therefore a significant concern for future planning and adaptation. This review examines the current knowledge on climate, the impacts of changes in climate on freshwater, the impact of large-scale infrastructural development on water, policies around integrated water resources management and finally mainstreaming as a method of improving current policy on development.

2.1 Current and Future Climate

Scientists have high confidence that global temperatures will continue to rise for decades to come, largely due to greenhouse gases produced by human activities. The IPCC (IPCC, 2021), projects global surface temperature change for the end of the 21st century to likely exceed 1.5°C. They argue that the extent of climate change effects on individual regions will vary over time and with the ability of different societal and environmental systems to mitigate or adapt to change. Taken as a whole, the IPCC (IPCC, 2014; IPCC, 2021) states "climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development". Some groups of people will likely face greater challenges than others; thus, the extent of climate change impact depends on vulnerability. As defined by the report (IPCC, 2014), climate vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. The IPCC recognises vulnerability as a function of three elements: the magnitude of climatic changes affecting a particular system (exposure), the characteristics of the system (sensitivity), and the ability of people and ecosystems to deal with the resulting effects (adaptive capacity) (Noble et al., 2014; McCarthy et al., 2001). Assessing vulnerability of a system to climate change based on these three factors is important for defining the risks posed by climate change and provides information for identifying measures to adapt to climate change impacts.

It is argued that Sub-Saharan Africa is the most vulnerable region to the impacts of climate change (Njang et al., 2014). This is due to its reliance on agriculture, which is highly sensitive to climate variables such as temperature and precipitation, and low capacity for adaptation (Kotir, 2011). Research has shown that climate in Africa is already exhibiting significant shifts evident by changes in average temperature, change in amount of and distribution of rainfall, and the prevalence of increasing frequency and intensity of weather extremes (Kotir, 2011; Ozor et al., 2012; Nicholls & Cazenave, 2010). While uncertainties exist with regards to the magnitude of impacts, climate will negatively affect numerous processes in Africa including access to freshwater and agricultural production.

For most of the east African region the latest General Circulation Model (GCM) projections largely agree on wetter conditions for the area (Njang et al., 2014; Shongwe et al., 2011). One study (Shongwe et al., 2011) concludes that there is substantial evidence in support of a positive shift of the whole rainfall distribution in East Africa during the wet seasons. Models used indicated an increase in mean precipitation rates and intensity of high

rainfall events as well as less severe droughts. Given their global focus, however, GCMs can overlook critical regional dynamics, which may change local level climate (KULIMA Report, 2014). The projected climate change scenarios for the Lamu land/ seascape have been downscaled to the weather station at Lamu by the Climate Systems Analysis Group (CSAG) at the University of Cape Town (KULIMA Report, 2014). The downscaled results generally project an increase in rain day frequency from November through to April, with most positive change in extreme rainfall occurring in October and November, with a decrease between June to September for all types of rainfall frequency. It is worth noting, that while promising research initiatives are under way, there is still a long way to go for Kenya in terms of undertaking the substantive research needed to build a rich national climate database (Okello et al., 2015; Ochieng et al., 2016). Having noted this, studies also suggest it is impossible to determine the extent of climate change effects on individual regions without an understanding of the ability of that region's societal and environmental systems to mitigate or adapt to change (Adger 1999; Dolan & Walker, 2003).

2.2 Impacts of Climate on Freshwater Availability

It is unproductive to look at climate change impacts on water, without understanding to some extent the vulnerability of water first. The concept of 'vulnerability' is not straightforward as there is no universally accepted approach for assessing vulnerability (Gain et al., 2012). Beside climate change, economic development, current demographic trends and related land use changes have direct impacts on increasing the demand for freshwater resources (Pielke et al., 2009). In tandem, the net effect of these supply and demand changes is affecting the vulnerability of water resources (Gain et al., 2012). The IPCC characterises vulnerability as a function of a systems exposure, sensitivity and the adaptive capacity of the system (IPCC, 2014; 2021). Similarly, climate change impacts on water can be viewed in terms of the three functions.

2.2.1 Exposure to Climate Change

Rising temperatures, irregular and unpredictable rainfall, increased frequency of intense rainfall and increasing frequency of ENSO events are examples of climate change impacts that are directly related to water systems (Jimenez Cisneros et al., 2014; Wong et al., 2014; Okello, 2015). This exposure can be explained in terms of changes in distribution to the river flows and groundwater recharge over space and time that are determined by changes in temperature, evaporation and crucially, precipitation (Jimenez Cisneros et al., 2014; IPCC, 2021). An IPCC Technical Paper on climate change and water (Bates et al., 2008) adds snow

and land ice, sea level, evapotranspiration, soil moisture, runoff and river discharge and patterns of large-scale variability as changes in climate as they relate to water. Changes have already been observed globally and further changes are projected (Chiew, 2007; Kundzewicz et al., 2008). However, at the same time, the use of such hydrological models to study changes is challenging. Many of the hydrological studies (Chiew, 2007; Kundzewicz et al., 2008; Vorosmarty et al., 2000; Kundzewicz et al., 2018) utilise global scale data (model outputs) and therefore are not useful for planning at the local scale.

Additionally, sea level rise is also another climate change impact that is a threat to water supplies, particularly in low-lying coastal areas with large populations. One quarter of the global population live in coastal areas that have less than 10% of the global renewable water supply. Many coastal communities are already considered vulnerable to ongoing climate variability (Wong et al., 2014; Dolan & Walker, 2003; Cinner et al., 2012). IPCC defines vulnerability of coastal zones by the degree of incapability to cope with the impacts of climate change and accelerated sea level rise. Vulnerability is assessed on susceptibility of coastal zone to physical change resulting from climate change, impacts on social economic and ecological systems and available adaptation options (Gilbert and Vellinga, 2005; Wong et al., 2014).

In terms of climate change impacts on coastal zones, one major concern is the threat to coral reefs. Coral reefs are particularly important for fisheries, tourism, and coastal protection but also have high aesthetic and spiritual values (Cinner & Aswani, 2007). Coral reefs are highly vulnerable to climate change induced stresses that have led to substantial coral mortality over large spatial areas. Such climate change impacts have the potential to lead to declines in marine fish production and compromise the livelihoods of fisheries dependent communities (Cinner & Aswani, 2007). Cinner et al. (2012) examined social vulnerability in the context of changes specific to coral reef ecosystems based on different scales: exposure, sensitivity and adaptive capacity. It concluded that Kenya was one of the highest ranked countries in terms of sensitivity, in addition to having the overall highest vulnerability out of all the countries sampled. They argued that in looking at coastal vulnerability, distinctions in underlying sources of vulnerability are important because specific policy tools may be required to address different dimensions of vulnerability. However, the study did not look at other drivers of change in marine ecosystems such as overfishing and pollution. The disadvantage of a specific vulnerability focus is that it only captures one of potentially many impact pathways and there is no guarantee that the one (focused on) will be significant compared to the other (Cinner et al., 2012).

But perhaps, the biggest threat to coastal zones as a result of climate change is sea level rise. Sea level rise is essentially the "encroachment of saline water into fresh ground water regions in coastal aquifer settings" (Werner & Simmons, 2009). It is mainly caused by thermal expansion of sea water due to ocean warming, water mass input from land ice melt and land water reservoirs (Nicholls & Cazenave, 2010). The IPCC (IPCC, 2014) predicts that by 2100, global warming will lead to sea level rise of between 110-880 mm. Accelerated sea level rise may entail elevated tidal inundation, increased flood frequency, accelerated erosion, rising water tables, increased salt-water intrusion and a host of other ecological changes. Such biophysical changes are expected to cause various socio-economic impacts including loss of land, infrastructure and coastal resources and the decline in associated economic, ecological, cultural and subsistence values (Klein & Nicholls, 1999).

Few quantitative studies have looked at the impact of sea level rise on seawater intrusion. Werner & Simmons (2009) suggest that the impact of sea level rise is dependent on whether or not the system is flux controlled or head controlled. A flux-controlled system is one where groundwater discharge to the sea is maintained to control the position of the sea water/fresh water interface despite a rise in sea level. While a head controlled system is one whereby groundwater abstractions or surface features maintain the head condition in the aquifer despite sea level changes hence minimising seawater intrusion.

Nicholls & Cazenave (2010) further this argument, summarizing the main physical impact as a decline in coastal wetlands such as salt marshes and mangroves, unless they have a sufficient sediment supply to keep pace with sea level rise. This has overwhelmingly negative socio-economic impacts. They state that there is a difference between climate induced sea level rise and other coastal impacts that are not necessarily related to climate change. Other coastal impacts include human induced changes in coastal areas (such as devastation of coastal defences, destruction of wetlands, port & harbour works and reduced sediment supply due to dams). These human induced changes make it difficult to identify sea level rise as a direct result of the negative impacts of climate change. In addition, the non-climate components receive much less attention because they are considered a local issue. They also suggest that Africa in particular appears highly threatened owing to the low levels of development combined with expectations of rapid population growth in coastal areas. However, the extent of future sea level rise remains highly uncertain. Improved understanding of adaptation is fundamental because it is one of the biggest determinants of actual rather than potential impacts (Nicholls & Cazenave, 2010).

One study (Nicholls et al., 1999) looked at the increasing risk of flood and wetland loss as a result of sea level rise. Using 'dynamic analysis' methodology, they concluded that the areas most vulnerable to flooding are the Southern Mediterranean, Africa, South Asia and South East Asia; with the Indian Ocean islands in danger of the largest relative increase in flood risk. By 2080 sea level rise could cause loss of up to 22% of coastal wetlands. When combined with other losses due to direct human action, up to 70% of the worlds' coastal wetlands could be lost by 2080. Results also showed that without an adaptive response, a global sea level rise of only 37-38cm by the 2080's could greatly enhance the occurrence of coastal flooding and increase in the decline of coastal wetlands. While it is important to note that this study raised the question of considerable uncertainty in their projections, it is prudent to begin proactive planning for the potential impacts of sea level rise now. Sea level rise will only exacerbate existing problems. Twenty one percent of the world's populations already live within 30 km of the coast and these populations are growing at twice the global average; as such, planning could have immediate benefits (Nicholls et al., 1999).

A rise in sea levels can reduce the quality of water and can damage the infrastructure that is used to transport and deliver water. Rising sea levels and the concurrent occurrence of drought can increase the salinity of both surface water and ground water through saltwater intrusion (Field et al., 2014). Some studies have concluded that saline intrusion due to excessive water withdrawals from aquifers is expected to increase due to sea level rise – leading to even further reduction in freshwater availability (Kundzewicz et al., 2009). The methods used to study sea level rise can be classified into two groups: (1) approaches based on the analysis of trends and variability in shoreline change observations and (2) approaches based on the comparison of shoreline observations with a coastal model outcome (Le Cozannet et al., 2014). Both approaches however are challenged by the fact that shoreline data are often lacking or insufficiently resolved temporally to capture the dynamics of coastlines. As well as this, relative sea level along the coast is generally only known in a limited number of areas where tide gauges are available. Both are challenges pertinent to Lamu, and perhaps, there is a great opportunity to rely on stakeholder engagement and participation to provide observational evidence to examine sea level rise and the consequences of it on water, as is suggested in one key study on sea level rise (Le Cozannet et al., 2014).

2.2.2 Sensitivity to Climate Change

The second element to consider in determining the extent of climate change impacts on water is sensitivity – the characteristics of water systems that would determine vulnerability to climate change. According to Doerfliger et al. (1999) vulnerability is defined as the "intrinsic geological and hydrogeological characteristics, which determine the sensitivity of groundwater to contamination by human activities". This is incredibly difficult to study as it entails setting aside groundwater reserves as protected areas for further study. Many presently water stressed arid and semi arid areas are likely to suffer from decreasing water resource availability due to climate change, river flow and ground water recharge decline. The rise in temperatures as a result of climate change alters the rate of operation of key chemical processes in water, while changes in precipitation impact the rate at which materials are flushed into rivers and groundwater. Furthermore, changes in flow volumes affect dilution of loads, which has a direct impact on water supply. Declining water quality because of climate change, results in rising water withdrawals from low quality sources, greater pollutant loads due to heavy precipitation, water infrastructure malfunctioning during floods as well as over flooding capacity of water and wastewater treatment plants during extreme rainfall (Kundzewicz et al., 2008). But again, as pointed out by Hinkel (2011), these studies (Kundzewicz et al., 2008;2018; Doerfliger et al., 1999) on climate change impacts as they relate to water tend to assume a linear relationship between climate changes and hydrological responses, which may not necessarily be the case. Experiences in assessing vulnerability suggest that vulnerability is a complex subject that has many dimensions including social, economic, political and geographic. These often have overlapping effects that make it difficult to tease out the precise cause-effect relationship (Hinkel, 2011). This implies that vulnerability is bound to a specific location and context (Cutter et al., 2003).

It is espoused that vulnerability should be considered within local contexts (Chang et al., 2017). Geographic location for one plays a part in community livelihood decisions, for example agriculture versus forestry, or agriculture versus fisheries (Ghosh & Ghosal, 2020). Different livelihoods express their vulnerabilities to climate change in different ways, requiring us to consistently consider vulnerability within specific contexts and possibly household to household (Ghosh & Ghosal, 2020). In addition, some studies (McCullough et al., 2019; Ghosh & Ghosal, 2020) have found strong evidence for different climate-water relationships across different regions. For example local to regional drivers may combine to influence the sensitivity of lake ecosystems to climate change, and that sensitivities among lakes are highly variable within and across the regions (McCullough et al., 2019).

2.2.3 Adaptive Capacity to Climate Change

The third element of vulnerability addresses the adaptive capacity of systems to the impacts of climate change. Climate change is an addition to the already existing threats to freshwater ecosystem and their services (Woodward et al., 2010; Azhoni et al., 2018). Water availability and quality is already threatened by environmental degradation, loss of biodiversity, increased extent of arid and semi arid areas, alteration of water availability (spatial and temporal), spread of diseases, droughts, reduced river flows and human & wildlife conflict as a result of widespread development (Bates et al., 2008). Not to mention the fact that a large proportion of the world population is already experiencing water stress. People in these areas will be even more exposed to water related diseases, damage to aquatic ecosystems and services they provide, damaging weather events and a reduction in availability of water for industrial and cooling purposes. According to Vorosmarty (2000), by the year 2025, rising water demands will greatly outweigh greenhouse warming in defining the state of global water systems. In addition, the effect of direct human impact on global water supply remains poorly articulated but potentially important facet (Vorosmarty et al., 2000). Furthermore, water related vulnerability is a threat to the pursuit of sustainable development (Kundzewicz et al., 2008).

In order to adequately deal with some of these impacts, water management personnel need to understand potential climate change impacts on stream flows, groundwater levels and ecosystems. Aldous et al. (2011) suggest that one way of doing this is to regionally downscale global circulation models, link downscaled climate parameters such as temperature and precipitation to a hydrological model and develop future hydrological projections including water flow and ground water recharge. The same study (2011) also suggests a methodology to understand climate effects on freshwater ecosystems whereby modelled hydrological output can be paired with ecological data or models to determine ecological impacts of changes in hydrology. However, in doing so, there is still a need for a basin specific response that accounts for an understanding of water use, infrastructure, socio-economic and political landscape, hydrological regime and sensitivity to climate change impacts. While little can be done to halt climatic changes over the next 50 years at the river basin level, Aldous et al. (2011) suggest that the focus should be on how climatic changes manifest in river basins worldwide as it is possible to do a lot within this context.

It is perhaps for this reason that the discussion on climate change impacts as they relate to water (and especially freshwater) has shifted to a conversation on “multiple stressors”. Stressors are environmental changes that place stress on the health and functioning

of an ecosystem. While there is increasing evidence that multiple stressors may interact to produce unexpected effects on aquatic ecosystems, there is a pressing need to better understand the ecological surprises causes by multiple stressors in freshwater ecosystems (Ormerod et al., 2010). Some indicators of water resource stress include hydrological based measures of resources available per person. Additionally, one can also look at population living in stressed categories (Arnell, 2004). It is also pertinent to address the question of how to offset multiple stressors in future and manage them sustainably, as the impact of climate change is dependent on how water resources are managed in the future. Ormerod (2010) argues that is very much a local question and should also consider the complex interaction between ecology and socio-economics that engender such effects as it is difficult to manage individual stressors without the unexpected and as yet, largely unpredictable interactions and effects these stressors might have. In addition, climate impacts not only depend on the changes in water resources, but also on the present-day pressure on water and the degree of adaptation that can be accommodated within the water management system (Arnell, 1996, 1998).

Accordingly, adaptive capacity for coastal zones becomes a key issue for consideration. One study (Adger, 1999) concluded that the point in enhancing a coastal zones adaptive capacity is two fold; identify existing local social vulnerability, and focus on community-based research so that outcomes of climate models and scenarios are not too broad for useful planning and adaptation at local scales. The study (Adger, 1999) based this on a framework in Vietnam that showed that baseline social vulnerability is enhanced by some institutional and economic factors associated with Vietnam's economic transition from central planning. The study (Adger, 1999) defined social vulnerability as "the exposure of groups or individuals to stress as a result of social and environmental change where stress refers to unexpected changes and disruption to livelihoods".

The IPCC (Gilbert and Vellinga, 2005) came up with technical guidelines, a seven-step analysis of vulnerability in coastal zones. Klein & Nicholls (1999), state that local change of sea level rise (relative or observed) is what matters, not global or regional level. It is for this reason that the discussion has somewhat moved from vulnerability assessment towards integrated coastal zone management (ICZM). It is widely argued that ICZM is the most economically efficient way to manage the coastal zone. It recognizes multiple and growing problems in coastal zone and their multiple and interacting causes, and is increasingly becoming about making trade offs aimed at resolving competing sectorial demands rather than optimizing the output of a single resource (Klein & Nicholls, 1999).

Building on this, Dolan & Walker (2003) suggest that any framework for enhancing coastal zones adaptive capacity should be at the local scale situated within larger national, regional and international settings. They proffer that the determinants of such a framework should include access and distribution of resources, technology, information and wealth, risk perceptions, social capital and community structure, institutional frameworks that address climate change hazards and a bottom up approach. They recognize that community adaptive capacity involves complex relationships among political, socio-economic and cultural elements that vary across a range of temporal and spatial scales. Thus, research needs to be grounded at the community level and involve local knowledge systems (Dolan & Walker, 2003).

Vulnerability varies according to individual countries, geographical positioning and the capacity to mitigate or adapt to the changes (Ozor et al., 2012). According to the IPCC (Jimenez Cisneros et al., 2014) and in particular relevance to Lamu County, global mean sea level will continue to rise during the 21st Century. In fact, under all the current findings the rate of sea level rise will very likely exceed that observed during 1971-2010 due to increased ocean warming and increased loss of mass from glaciers and ice sheets (Jimenez Cisneros et al., 2014). This puts coastal zones including Lamu County at a risk of water shortages as a result of saline intrusion and changes in precipitation and droughts. Intrusion of saltwater into freshwater in the region could result in less water available to drink and to grow plants and food.

Adaptive capacity is hard to measure and successful adaptation is difficult to define. As the literature on adaptive capacity grows, a general consensus emerges on the determinants of adaptive capacity. Variations exist on how it is to be evaluated, enhanced and applied to policy making due to its "dynamic, contextual and latent nature" (Azhoni et al., 2018). The studies reporting successful adaptation are minimal and barriers of adaptation are being discovered as adaptation research transitions into implementation. However, the root causes of these barriers are often overlooked and the interconnectedness of the barriers is poorly addressed (Azhoni et al., 2018). Freshwater is expected to become increasingly scarce in the future, particularly as a result of climate change. In understanding the problem of freshwater scarcity and planning future water supplies, the global picture is less important than the effect of warming on freshwater availability in individual regions and seasons. This is a much more complicated thing to predict than global trends. Thus, stakeholders and communities will have a role to play in climate related hydrological studies. At the same time, water sourcing and distribution remains a serious current and future concern of the

region. Unsustainable water use and unequal natural geographical distribution and accessibility are characteristic water concerns in Africa (Ozor et al., 2012). With the already standing water concerns plaguing the region, climate change has the potential to impose additional pressures on water availability and accessibility.

Water scarcity has been an issue in Kenya for many decades (Ogendi & Ong'oa, 2009; Marshall, 2011; Gedo & Morshed, 2013; Mwihaki, 2018; Wakhungu, 2019). This is for a number of reasons including inequitable delivery of water to various regions in the country (Ogendi & Ong'oa, 2009; Marshall, 2011) and poor distribution of freshwater basins (Marshall, 2011). Climate change will only serve to exacerbate Kenya's current water problems (Ngaira, 2009).

2.3 Impacts of Large Scale Development Projects and the Policy Processes Informing them in Kenya

2.3.1 Overview of the Policy Process

The LAPSSET project is Eastern Africa's "largest and most ambitious" infrastructure project bringing together Kenya, South Sudan and Ethiopia (Auma, 2018; LAPSSET Authority, 2018; Murithi, 2019; Chome, 2020; Aalders et al., 2021). The project is part of the Kenya Vision 2030 Strategy, a long-term development policy that aims to transform Kenya into an industrialising, middle-income country in a clean and secure environment (LAPSSET Authority, 2018). With this in mind, any kind of economic and industrial activity has a certain impact on natural resources (Arshad et al., 2021). Roads for instance, have ecological effects spread throughout the landscape. Road ecology and its application to planning, conservation, management, designs and policies are great challenges for science and society (Trozzi & Vaccaro, 2000; Arshad et al., 2021). As far as water is concerned, roads accelerate water flows and sediment transport, which raise flood levels and degrade aquatic ecosystems (Forman & Alexander, 1998). This in turn, has an impact on local freshwater supplies (Sahoo et al., 2021). Ports too, have impacts on local water supplies (Jahan & Strezov, 2017). According to Trozzi & Vaccaro (2000), ports may cause different forms of water pollution including oil/ fuel leakages and leakages of chemical substances, not to mention the constant demand for water for operations.

These impacts are often captured within the ambit of an Environmental Impact Assessment (EIA). In Kenya, the Environmental Management and Coordination Act (EMCA) provides the legal basis for conducting an EIA on specific types of projects before their commencement (Environmental Management and Coordination Act, 1999; Ngetich &

Ndiema, 2020). The EMCA read together with the EIA and Audit Regulations give provisions on the procedure of carrying out an EIA, the principles governing EIA's and also provides for the rules governing the National Environmental Management Authority (NEMA). It is a legal requirement that any Government or private project undertake an EIA. In the case of a group of projects, policies or program with environmental impact – a strategic environmental assessment is required in addition to an EIA. Both assessments are similar in process (Musyoka & Field, 2018).

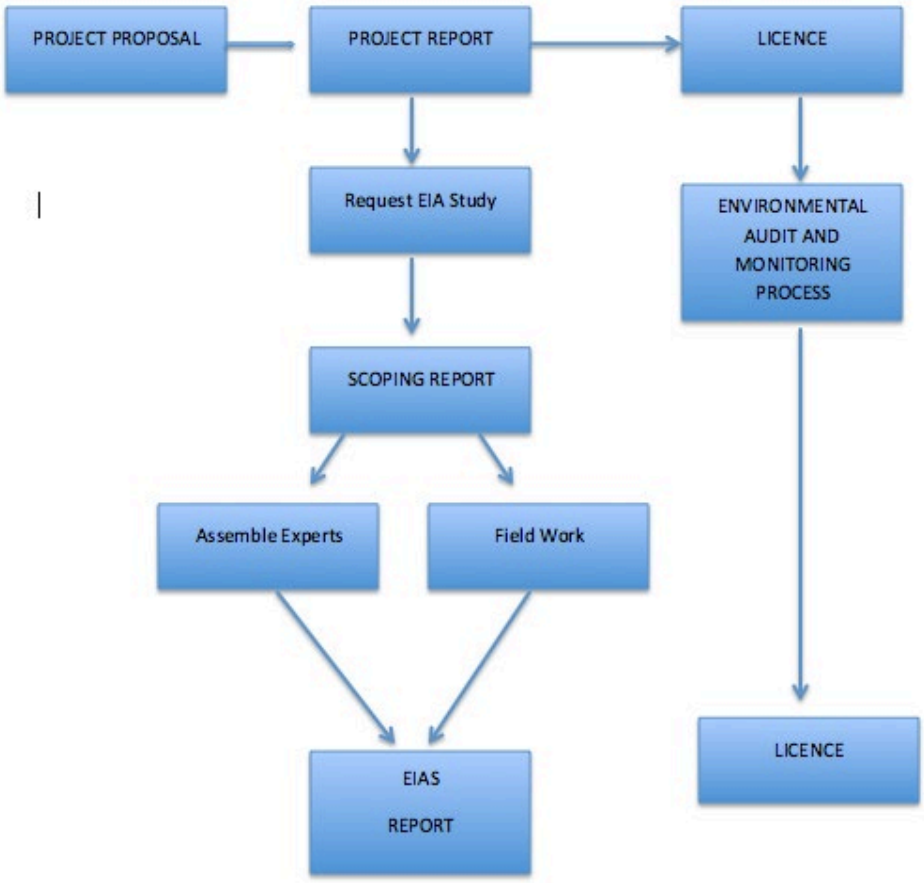


Figure 2.1 EIA Process

It is worth mentioning that at each level of the process, NEMA and other lead authorities are directly involved (Fig. 2.1). In developing and reviewing the project report, NEMA screens the project to determine whether or not an EIA study is required for the development activity. The screening exercise assesses public participation as a key element of the project-reporting phase. A licence may be issued if the authority is satisfied that the project will not have significant environmental impacts, or that the proposed mitigation measures are adequate to address the identified impacts. Where the project has significant

environmental impacts and the project report does not disclose adequate mitigation measures, an environmental impact assessment study (EIAS) is then required (Environmental Management and Coordination Act, 1999; NEMA, 2002; Ngetich & Ndiema, 2020). The development of the EIAS involves a scoping process and report – whereby NEMA ensures that the EIA is focused on the key issues, while ensuring that indirect and secondary effects are not overlooked and eliminating irrelevant impacts. Scoping identifies the key concerns, evaluates them, organizes and presents them to aid decision-making (NEMA, 2002). Again, consultation and public participation are key elements in the scoping process. It ensures that the project assessment is focused on the affected persons (Environmental Management and Coordination Act, 1999; Gebreyesus et al., 2017; Omenge et al., 2019; Okoth et al., 2019). The EIAS is undertaken and upon submission of the final EIAS Report, the authority conducts a review to determine if the project measures to mitigate against environmental impacts are sufficient. If this is the case, a licence is issued with conditions for approval. If not, it is denied with opportunities available for the project proponents to seek legal recourse.

Ultimately, even if a licence is issued, the project is still subject to environmental audit and monitoring process (Fig. 2.1). According to NEMA (2002), "environmental auditing is a management tool comprising of a systematic, periodic and objective evaluation of how effective environmental management is performing in safeguarding the environment", while the monitoring process is "an activity undertaken to provide specific information on the characteristics and functioning of environmental and social variables in space and time. Environmental monitoring compares impacts predicted in an EIA with those that actually occur during and after implementation, in order to assess whether the impact prediction process performs satisfactorily (Environmental Management and Coordination Act, 1999; NEMA, 2002). Finally, NEMA also makes provisions for evaluating projects, policies and programmes that have transboundary implications. The EIA on such initiatives require avenues for consultations between and among affected states. NEMA facilitates the consultations in accordance with provisions of an enabling instrument.

2.3.2 Commentary on EIA Policy Process in Kenya

In theory, an EIA should consider all aspects of a project's impact, including the implications for local freshwater supplies. Practically this is often not the case. The steps required to obtain technical data for analysing water and hydrological processes are complex and expensive and as a result, firms tasked with carrying out EIA's tend to overlook detailed

water analysis. Unfortunately, the environmental impact of a project is often evaluated without sufficient detail (Barczewski, 2013; Gebreyesus et al., 2017; Okoth et al., 2019

From a study done in Malawi (Kosamu, 2011), some of the characteristic limitations to successful EIA's in infrastructural projects include: (1) limited experience and practice of EIA practitioners; (2) cost of EIA process; (3) limited links between EIA and urban planning procedures; (4) a lack of political will by relevant institutions and authorities; (5) project delays; (6) lack of effective monitoring and auditing, (7) lack of data, especially those to be used in predictive models. It is recommended that active environmental management should actively involve the interests of all stakeholders, and that follow up, of predicted environmental impacts resulting from any project should entail monitoring, auditing and reporting (Kosamu, 2011). In addition, EIA's do not explicitly consider the impacts of climate change in tandem with a project's environmental impact. Arguably, this renders EIAs incomplete in their valuations and complicates climate change adaptation efforts. Okello et al. (2015) looked at the potential impact of population growth and climate change on freshwater in Lamu. The research (2015) concluded that there is a need for a better risk assessment of freshwater degradation that encompasses water stress analysis using an indicator that combines the effects of climate change, sea level rise and the anthropogenic contribution (population growth and urbanisation), thereby providing policymakers with a clearer analysis of the situation. Additionally, the research suggested that population growth exacerbated by land use change will be a more significant driving force that will affect the availability of freshwater than climate change.

In the pursuit of infrastructure development, implementation of environmental regulations is facing a number of serious problems in Kenya. Currently, implementation of the regulatory process suffers from inadequate funding, corruption, gaps or duplications of regulations, a lack of engagement with important community stakeholders and a misunderstanding by society at-large of the benefits of a sustainable project (Barczewski, 2013; Gebreyesus et al., 2017; Okoth et al., 2019). These serious issues result in oversight of the significant impacts of large infrastructural development projects.

2.4 Existing Models of Participatory Approaches to Freshwater Management

Water management, in general, is facing major challenges due to increasing uncertainties caused by climate and global environmental change and by fast changing socio-economic boundary conditions (Pahl-Wostl, 2006). To address this, it is important to first

contextualise the development of water management approaches to identify gaps in current models of water management. Initially, the major concern for freshwater management was the integration of science effectively into community-based decision making. Rhoades et al. (1999) argued that the formalization of the process of community-based management was insufficient to guarantee that local people would meaningfully consider scientific information and opinion when making decisions about watersheds. In addition, they also argued that genuine social interaction between scientists and non-scientists requires a considerable investment of time and energy on the part of the scientist to develop personal relationships with non-scientist based on trust and mutual exchange of information. The case for 'stream naturalization' emerged. This entails revising existing concepts of integration to accommodate place-based contexts (Rhoades et al., 1999).

In the past decades, freshwater management has been advanced as a significant concern for international peace and security. The international community predicted that wars in the 21st century would be over water (Pearce, 2012). Several international agreements governing global freshwater have been concluded with the most common, effective strategy to reach agreement being the desire to develop or maintain good relations (Kranz and Mostert, 2010). This follows the fundamental of international agreement and problem solving – the need to maintain national sovereignty (Kranz and Mostert, 2010). But, there is no 'one size fits all' solution to water management, despite efforts to find universal, often simplistic answers. Gleick et al. (2011), argue that every basin is different and therefore the solutions will vary according to what is hydrologically, economically, socially and politically possible. An integrated basin-specific approach to sustainable water management that allows all solutions to water challenges to be analysed and compared in a systematic way is the only way forward (Gleick et al., 2011). The emerging prevailing theme in international initiatives is a commitment to 'soft-path' water solutions. The 'soft-path' approach is defined as a new strategy for more sustainable water management and use that recognises the limits to traditional approaches (Cohen et al., 2013). 'Soft-path' solutions rely less on traditional hard infrastructure that transports water over long distances and focuses more on local water supply options, greater water conservation and efficiency. In essence, the soft path seeks to improve the overall productivity of water use and deliver water services matched to the needs of users, in contrast to seek sources of new supply (Gleick, 2018). The impetus for these reforms include the perception that soft-path solutions will be less expensive, less energy intensive, produce fewer greenhouse gas emissions and are more likely to be acceptable to local communities if public involvement is encouraged (Cohen et al., 2013). However, in

cases where water supply is completely exhausted, the soft approach is not necessarily ideal. Thus, Gerlack et al., (2018) argue for the importance of understanding community context in deciding the appropriate response.

Concurrently, international practitioners agree that more attention has to be devoted to understanding and managing the transition from current management (traditional management approaches) regimes to more adaptive regimes that take into account environmental, technological, economic, institutional and cultural characteristics of freshwater sources. This implies a paradigm shift in water management from a prediction and control approach, to a management as learning approach (Pahl-Wostl, 2006). As such, strategies evolved to include local governments, NGOs, and individual water users through a hybrid, holistic approach to freshwater management. The old water management paradigm that focused on national water resources development is gradually being replaced by a new paradigm that is focused on integrated water resources management across all levels (national, international and subnational) (Mostert, 2010). But even this paradigm has been severely criticised: the most common criticism is that the gap between theory and practice remains wide. While there is still a long way to go to achieve a common understanding of integrated water resource management (IWRM), national governments have by and large failed to sustain truly integrative programs (Jeffrey & Gearey, 2006).

Integrated water resources management is viewed from a participatory approach, where key individuals concerned with freshwater use and access are actively engaged in the process of freshwater policy development and management. For example, one study done in Tanzania (Kashaigili et al., 2005) evaluated the joint challenges resulting from natural resource use and existing levels of climate variability. It adopted a case study approach and looked at the changes in water resource management approaches over a three-year period. The study found that using participative methods in water management produced a number of positive results: rural livelihoods became more profitable, sustainable water approaches as well as local livelihood strategies diversified, regional ecosystems improved as a result of restoring river flows in some rivers, conservation of riparian vegetation occurred, and tree felling for charcoal production was halted (Kashaigili et al., 2005). Similarly, another study in Turkey (Yavuz & Baycan, 2013) looked at the feasibility of strength, weakness, opportunities and threats (SWOT) analysis and Analytic Hierarchy Process Integration to incorporate stakeholder preferences in the decision-making process in the largest freshwater lake in Turkey. They found that conflicting views of participatory approaches must fully respect knowledge, experiences, values and interests of various stakeholder groups. Critical

to the success of the decision-making process is the active involvement of a range of stakeholder groups in the process to provide support for the implementation of water management strategies. A decision-making process that is transparent leads to a more sustainable water shed plan as well as better management decisions as the acceptability of policy decisions by inhabitants is increased (Yavuz & Baycan, 2013).

Management of freshwater in Kenya is rather different both in terms of development and approaches. All water resources in Kenya remain under the control of the state. The Ministry of Water and Sanitation is tasked with the responsibility of creating institutions to manage water resources and provide water services. In 2002, the water sector reforms in Kenya culminated in the passing of the Water Act, gazetted in October 2002. The Water Act introduced new water management institutions to govern water and sanitation. The water reforms saw the introduction of the commercialization of water resources as part of the decentralization process and the participation of stakeholders in the management of national water resources. The 2002 Water Act provided a legal framework for the creation of water institutions and limited the Ministry's role to policy formulation. As a result of the provisions in the Water Act of 2002, the Water Resources Management Authority was created. Its mission is to manage, regulate and conserve all water resources in an effective and efficient manner by involving the stakeholders, guaranteeing sustained access to water and equitable allocation of water while ensuring environmental sustainability. When it comes to water issues affecting the various communities in Kenya, the approach taken has ranged from water companies partnering with residents in the low-income areas to the use of community groups to address water-related problems. Water Action Groups (WAGs) - an initiative of the Water Services Regulatory Board (WASREB) Kenya are being used to solve the water issues (Moraa et al., 2012; Wakhungu, 2019).

In 2010, passage of Kenya's Constitution resulted in 47 newly established counties (Constitution of Kenya, 2010). This led to the need to devolve water management responsibilities and in 2016, a new Water Act was enacted, repealing the 2002 Act. The devolution of responsibilities to local level functions has been the principal mechanism for improving accountability and transparency in the water and sanitation sector (Moraa et al., 2012; Wakhungu, 2019). The purpose of the 2016 Water Act is to align the water sector developments with the 's primary objective of devolution. The 2016 Act gives County Governments the mandate for water and sanitation service provision. However, water service, water resource regulation and management of national public water works remain the responsibility of the National Government (Water Act, 2016). The Act recognizes that water

related functions are a shared responsibility between the national government and the County government.

As part of the implementation of the act, 47 water works development were created. Section 70 (1) of the Water Act 2016 restructured WASREB with the main objective to protect the interests and rights of consumers in the provision of water services, while ensuring other stakeholders interests are also safeguarded. Accordingly, WASREB sets standards and enforces regulations that guide the sector in not only ensuring that consumers are protected and have access to efficient, affordable and sustainable services, but also, provide for financial sustainability of Water Service Providers (WSPs) (WASREB, 2018). The Water Sector Trust Fund (WSTF) was also created under the Act and was restructured from the Water Services Trust Fund to the Water Sector Trust Fund (WSTF). The mandate of WSTF is financing water and sanitation services in the country. The 2016 Water Act also introduced additional institutions of management including the Water Tribunal to deal with disputes, the Water Sector Trust Fund (WTSF) to source funds, and the National Water Storage Authority (NWSA) responsible for development. These institutions were established in the effort to organize the water sector in the country and to ensure that the anticipated universal access to water is achieved.

In spite of this, a major criticism of the current water policy process is that citizens have limited information on the services available and how they can interact with the Government to get better water services. A key issue in water management before the 2016 Act was that management of water in local communities was largely an imposition of national policy rather than integrated, stakeholder participation in policy and day-to-day decision-making. While the new Water Act 2016 attempts to address this, there are still gaps in implementation. Also, in relation to development projects, water-related concerns are reviewed from the view of an environmental impact assessment. While EIA's take into account stakeholder perspectives, project development stakeholders are not necessarily the same as water management stakeholder groups. The lack of cohesion in processes, results in gaps in decision making as well as water management. These are just some of the issues that require further investigation to ensure effective, participative water management in local communities such as Lamu.

2.5 Mainstreaming: Climate Change Adaptation and the Role of Multiple Stakeholders

Adaptation is an issue relevant at local, national, regional and international levels. It is defined as the process of adjustment to actual or expected climate and its effects. It seeks to

moderate or avoid harm or exploit beneficial opportunities (Noble et al., 2014). Historically, climate change adaptation and development have been managed in different arenas (Ayers et al., 2014). As developing countries endeavour to further their growth agenda, they are burdened with the need for adaptation to the negative impacts of climate change, which is the direct result of unsustainable development pathways by developed countries. Developing countries are the least responsible yet most vulnerable to the impacts of climate change and as such, developed countries have a direct responsibility to assist the most vulnerable countries in adaptation.

The argument for a strong response to climate change from those responsible for development policy is becoming clearer and more urgent, and is now widely supported (Noble et al., 2014). Originally the IPCC limited its study to the scientific, technical and economic aspects of climate change, but gradually the IPCC has brought attention to the increasingly important climate-development nexus. The Third Assessment Report first addressed development linkages by including discussions about alternative development pathways and global sustainability (IPCC, 2001). However, the Fourth Assessment Report (IPCC, 2007) devoted more attention to specifically addressing the nexus between adaptation and sustainable development. The report highlighted the fact that both the threats and the opportunities that climate change poses for the development agenda are still under-appreciated. The Fifth Assessment Report (Noble et al., 2014) strongly draws on the climate-development nexus stating that "climate change calls for new approaches to sustainable development that take into account complex interactions between climate and social and ecological systems". The report (Noble et al., 2014) also pointed out the need for strategies and actions that will move toward climate-resilient pathways while at the same time helping to improve livelihoods, social and economic well-being and responsible environmental management. In light of the relationship between climate change adaptation and development, scholars widely agree that the required policy response needs to be better, quicker and more coherent than anything that has been seen so far (Boyd et al., 2009; Najam et al., 2003; Sietz et al., 2011). Perhaps the greatest challenge at this point is designing holistic and workable plans that can be integrated into existing policy and processes to ensure that these threats and opportunities are responded to. Furthermore, the challenge is also to ensure that these plans are specific to local conditions and include the perspectives of local stakeholders.

Thus, the emergence of the concept of mainstreaming which refers to the integration of policies and measures to address climate change in on going sectorial and development planning and decision-making. The process of mainstreaming ensures the long-term sustainability of investments as well as reducing the sensitivity of development activities to both today's and tomorrow's climate (Klein & Huq, 2003; Huq et al., 2006). The term 'mainstreaming' is not unique to climate change and has been used within the context of gender equality since 1995 (Beijing Platform for Action, 1995). What is unique about 'mainstreaming' as a concept is that it goes beyond integration within structures, it is not a simple add on process, but rather a system of continuous checks and balances to ensure that integration is reflected in daily practice. Large infrastructural developments have an impact on the availability of natural resources, particularly local fresh water supplies because they place a competing demand on the resource. Furthermore, large infrastructural developments are also susceptible to the negative impacts of climate change. It is therefore important that large infrastructural development projects incorporate climate change adaptation throughout their planning and implementation.

Mainstreaming climate change adaptation into development will be no easy ride. Development is already highly complex: its aims, goals and processes are dynamic and dependent on numerous factors. People and places across the developing world have different needs and will therefore experience the impacts of climate change and climate change responses in different ways (Pasquini et al., 2013). Development futures are already unclear and difficult to plan; this is even before adding the issues climate change is likely to introduce into the mix. Bringing the two together coherently is an unprecedented challenge (Boyd et al., 2009; Schipper, 2007). It is also important to note the importance of the sustainable development agenda through the sustainable development goals (SDGs). The agenda recognises that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development (UN Sustainable Development Goals, 2016). SDG 6 in specific aims to achieve universal and equitable access to safe and affordable drinking water for all by the year 2030 as key in achieving sustainable development agenda.

Mainstreaming in Kenya and indeed Africa is key. One area where this is apparent is with road infrastructure. Repairing and maintaining roads damaged from temperature and precipitation changes (directly related to predicted climate change) could potentially cost

Africa upwards of $183.6 billion (Chinowsky et al., 2013), or $300 billion by 2030 (Mungai et al., 2021). This cost is strictly to retain the current roads and does not include costs associated with impacts to critically needed new roads (Chinowsky et al., 2013). Identifying and responding to these threats is pivotal for Kenyan infrastructural development, however, there is currently no mainstreaming plan or framework that enables infrastructural development in Kenya to integrate adaptation to climate change. Another point to consider is Africa's access to climate finance. While there are opportunities to access financing for adaption through the clean development mechanism (CDM), the CDM is designed to deal with energy and industrial mitigation, rather than climate mitigation from the agricultural and forestry sectors common within the African context (Capoor and Ambrosi, 2006). Also, access to technology, management and know-how are very often constraints to participating in the CDM. Most African countries cannot access the global capital markets directly. As such, large institutions such as the Aga Khan Foundation and the Emerging Africa Infrastructure Fund are pioneering innovative financing arrangements on the continent to encourage investment (Capoor and Ambrosi, 2006).

The Africa Development Bank amongst other global entities have made various commitments to scaling up climate finance in the continent to support mainstreaming (Mungai et al., 2020). However, given the scale of the problem and corresponding finance needed, are current financing commitments sufficient? An analysis of four major climate and development funds (the Global Environment Facility, the Green Climate Fund, the Adaptation Fund and the International Climate Initiative) suggested that while support for green initiatives has risen over the last two decades, cumulative investment for climate change mitigation and adaptation projects under the four funds stood at USD 94 billion (Fonta et al., 2018). A UNEP Adaptation Gap Report (Neufeldt et al., 2018) shows that most developing countries are preparing National Adaptation Plans, however, the finance needed to implement these plans is not growing fast enough. The pace of adaptation financing is indeed rising, but it continues to be outpaced by rapidly increasing adaptation costs.

It is important that policy and decision makers understand the impacts of climate change on a very local level in order to determine the best way forward for mainstreaming, particularly in terms of cost implications. Arguably it is for this reason that portfolio screening is now being considered as the ideal mechanism for mainstreaming. Portfolio screening occurs when development agencies screen their project portfolios with two goals in

mind. The first goal is to ascertain the extent to which existing development projects already consider climate risks or address vulnerability to climate variability and change. The second is to identify opportunities for incorporating climate change explicitly into future projects (Klein et al., 2007). However, owing to the fact that portfolio screenings are conducted independently, the broader lessons emerging from the screenings have not been systematically analysed.

The policy implications of mainstreaming are exceptionally dynamic. Do we need to create new policies for effective mainstreaming? Or do we integrate into existing policies? How do we associate policy, mainstreaming and the participation of multiple stakeholders? Gupta and Thompson (2010) argue that the policy discussions cannot be isolated and need to be approached holistically. They argue that the evolution of policy in mainstreaming is rooted in the sectorial approach taken to green house gas emissions. Thus, the motivation for mainstreaming was to ensure that specific sectors responsible for green house gas emissions integrated climate change as a strategy for mitigation. However, the discussion around policy is shifting to mainstreaming as 'good development practice' by development agencies (Gupta and Thompson, 2010). Countries are taking on mainstreaming as a national obligation, as climate change impacts will threaten development as much as development contributes to the climate change problem.

Arguably one of the most pertinent challenges for mainstreaming is the complex interplay between decision makers, the political economy and identifying where mainstreaming ideally fits in. This is exemplified by the national and international debates that emerged when Bangladesh formulated the Bangladesh Climate Change Strategy and Action Plan in 2007. The debates centred on the financing and integration of climate change into development planning. Using a political economic lens, research into the formulation of the 2007 Action Plan illustrated how major national initiatives around international problems must be understood in terms of the interplay of actors, their ideas and power relations (Alam et al., 2011). Alam et al. (2011), argue that power relations among actors significantly influenced the selection of ideas and implementation activities. In addition, the study also concluded that "donor concerns around aid effectiveness and consequent creation of parallel mechanisms of planning and implementation may run counter to both the mainstreaming process and the alignment of assistance with country priorities and systems" (Alam et al., 2011). The study (2011) suggests that climate change planning processes must be opened up to include actors from across sectors, population groups and geographical areas (Alam et al.,

2011). Similarly for Kenya, the Kenya National Climate Action Plan (2013) and the National Climate Change Response Strategy Paper (NCCRS) (2010) attempt to integrate climate change into national planning. One criticism of the policy responses thus far, is that Kenya's adaptation discourse is driven by "particular imaginaries" (Symons, 2014). Symons (2014) cites these 'imaginaries' as the view of adaptation as a 'universal apocalypse' and the view of adaptation as a technical-economic problem. The argument is that adaptation in Kenya is largely a matter of reducing the perceived risks to economic growth as well as enhancing opportunities to gain revenue from international funding sources. It is important that Kenya takes on a critical interpretation of the NCCRS in order to keep equity and justice at the centre of the climate debate (Symons, 2014).

Furthermore, it is also important that we begin to map out and understand the role of different stakeholders within the process. Tanner and Allouche (2011) argue that we need a new political economy of climate change and development. One in which explicit attention is given to the means by which ideas, power and resources are conceptualized, negotiated and implemented by different groups at different scales. The climate change and development interface warrants such attention because of its importance in achieving sustainable poverty reduction outcomes. There is an opportunity for policy-makers and planners to build on their years of experience in development initiatives, to tailor climate- change activities in support of positive development outcomes, and to reshape on-going development activities in the light of considerations of climate-change mitigation and adaptation (Anderson et al., 2008). But it is essential that this process looks at a wide range of stakeholders and is locally applicable.

2.6 Summary

The literature on this topic identifies that on a global, regional as well as national level the climate is changing. Resultantly, global water systems are at risk. Developing countries, and in particular coastal communities are especially vulnerable to changes in water distribution and availability. Coupled with widespread infrastructural development that fails to integrate climate change impacts, these communities may face severe water shortages. This might result in increased conflict, heightened poverty and food insecurity. Unfortunately, there is a gap in our knowledge on localised climate change impacts, and how these impacts relate to local water systems within local conditions (societal and economic). This knowledge would be useful in supporting development initiatives within these regions, while promoting adaptation to the negative impacts of climate change. The research sought to fill this gap, by

highlighting the experience in a small coastal community in Kenya. The quantitative and qualitative data collected, provide knowledge that will contribute to enhancing the capacity of the community to adapt to the negative impacts of climate change. This knowledge will also help them contextualise infrastructural development within the scope of mainstreaming.

CHAPTER THREE

MATERIALS AND METHODS

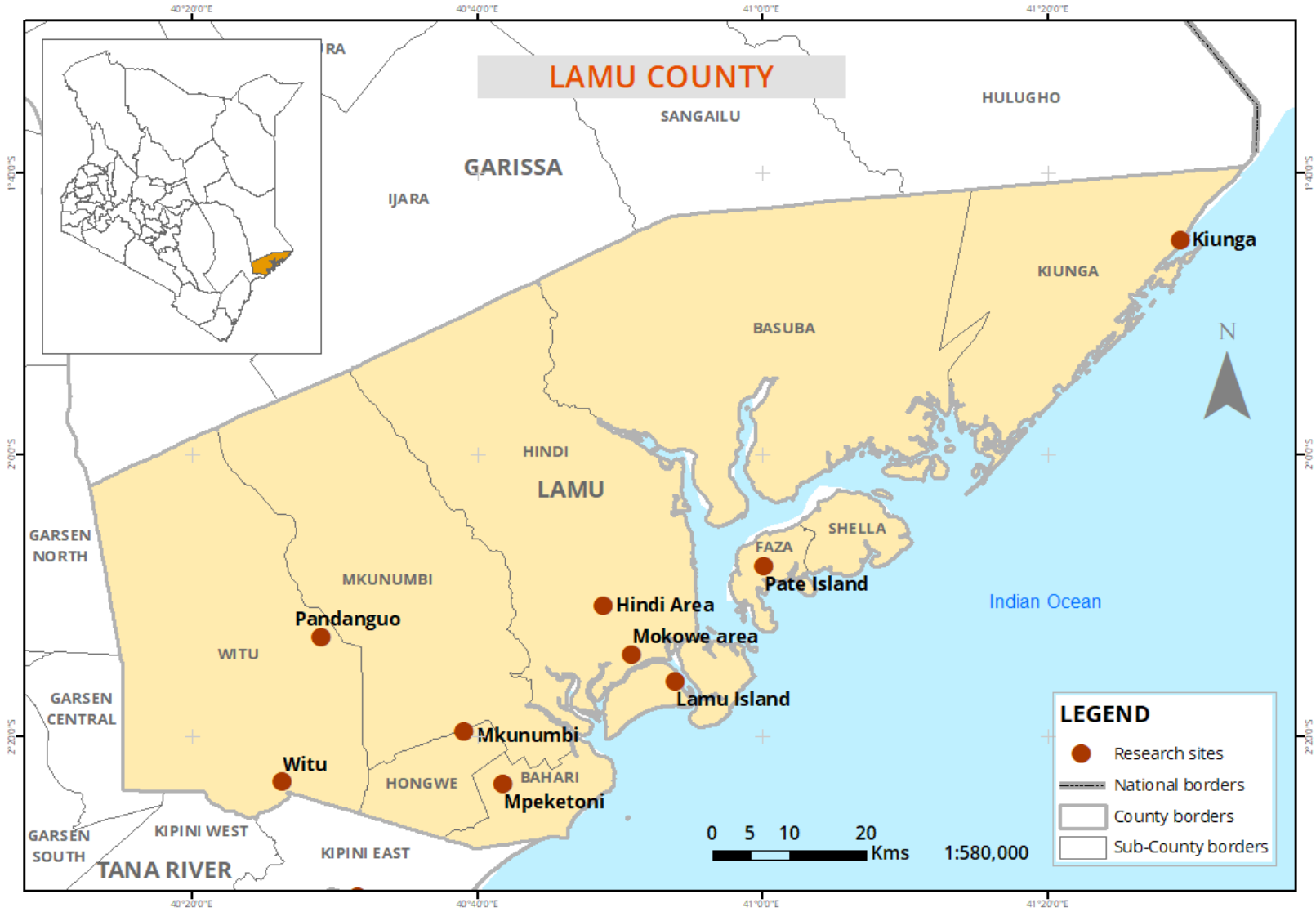
3.1 Introduction

This chapter will provide detailed overview of the methods used to accomplish the overall objective of this study. First it situates the study, describing the location, climatic, hydrological, societal and economic conditions of Lamu. Then, the chapter explains the mixed methods research design utilised. The chapter will also discuss the conceptual framework that guided methodology design and overall data collection. Methods of sampling are then discussed, setting the stage for an overview of the primary and secondary methods of data collection. Finally the methods of data analysis are discussed, with an overview of the ethical considerations applied throughout the study.

3.2 Study Area

3.2.1 Location and Description

The study area is Lamu, one of the 47 counties of Kenya. The promulgation of the Constitution of Kenya, 2010 introduced devolution (Constitution of Kenya, 2010). This saw the creation of 47 counties that vested substantial authority of governance to the County Government. This includes some power and control over county development planning and investment. The study was not limited to one particular area in Lamu County; rather it was determined by the location of the research sites identified (Map 3.1). The possible research sites are households in densely populated parts of Lamu (as identified in the Lamu County Integrated Development Plan, 2013). Households are specifically targeted, as household water use is a significant use of freshwater in the region. Lamu County is located in north-eastern coast of Kenya. It consists of a mainland and the Lamu Archipelago. It covers a total land surface area of 6273.1 sq. km, bordering Garissa County to the North, the Indian Ocean to the South and South East, and Tana River to the South West and West (Lamu County Integrated Development Plan, 2013). The total length of the coastline is 130km while the water mass stands at 308km (County Government of Lamu, 2015). The County has two parliamentary constituencies - Lamu East and Lamu West. Division in the County is detailed in table 3.1.



Map 3.1 Research Sites in Lamu County

Table 3.1 Division in Lamu County

#	**Division**	**Location**
1	AMU	MKOMANI
		LANGONI
		SHELLA-MANDA
		MATONDONI
2	HINDI	HINDI/MAGOGONI
		MOKOWE
3	MPEKETONI	MPEKETONI
		MKUNUMBI
		NDAMBWE
		BAHARI
		HONGWE
		MAPENYA
4	WITU	WITU
		DIDE WARIDE
5	FAZA	FAZA
		PATE
		SIYU
		TCHUNDWA
6	KIZINGITINI	KIZINGITINI
		NDAU
		MBWAJUMALI
7	KIUNGA	KIUNGA
		BASUBA

3.2.2 Target Population

According to the Kenya Population and Housing Census (2019), the population of Lamu was 143,920 with a population density of 16 people per km^2. In terms of age, 41.7% of the population is between the ages of 0-14 years, 54.8% are between 15-64 years and 3.5% are over 65 years. Of economic significance is that the population is predominantly young, with a high rate of unemployment and a growing demand for freshwater. The LAPSSET project is expected to attract huge migrant population estimated to be over one million. This will certainly overstretch the County's water supply services necessitating commensurate development planning for adequate service provision (Lamu County Integrated Development Plan, 2013). The population in the study comprised of participants from Lamu East and Lamu West constituencies. The study mainly targeted households located in Shella-Manda, Mokowe, Hindi, Mpeketoni, Mkunumbi, Pate and Lamu town. Although not all locations in Lamu were chosen for this study, the physical, economic and environmental profiles of the chosen locations is typical of what is happening in the whole of Lamu County.

3.2.3 Climatic Zone in Lamu

Based on the Köppen-Geiger climate classification, Lamu County can be said to be between the Tropical Monsoon and Arid Steppe Hot climate (Kulima Report, 2014). The area is characterized by bimodal rainfall distribution of ca. 540mm per year and a mean temperature of 28°C. The tides are semidiurnal, with a mean range of 2.5m to 3m and a maximum range of approximately 4m (Kulima Report, 2014; Church & Palin, 2003). The climate and weather patterns on the Kenyan coastline are dominated by large-scale pressure systems of the western Indian Ocean (El Nino, Indian Ocean Dipole and the Madden Julian Oscillation) and two distinct monsoon seasons. During March and April, the wind blows in an east-to-southerly direction with strong incursions of maritime air from the Indian Ocean bringing heavy rains (the "long rains") from mid-April to the end of June. In the months of May to August, the South-Easterly Monsoon (SEM or Kusi) influence sets in and the weather becomes stable with cooler temperatures. Between September and December, the northeast monsoon, dominates again, bringing "short rains" from November to December. The range of temperature is from 23ºC to 32ºC throughout the country. The coldest months are May to July while the hottest months are December to April. As climate change is altering rainfall patterns worldwide and consequently impacting water supply, trends in rainfall observed over the past 40 years in Lamu will give some indication on the impact on society and the natural environment.

Lamu County is generally flat and lies between altitude 0 and 50m above sea level. This makes it susceptible to flooding during the rainy seasons and periods of high tides. Due to the physiographic climate and other natural conditions, the County is made of two broad economic zones: mainland for agriculture and livestock keeping and islands for marine activities. The main topographical features include coastal island and dudol plains, sand dunes and the Indian Ocean. The County has four major catchment areas categorized as Dodori Coastal zone, Duldul, Lamu Bay Drainage and Tana River Delta (Lamu County Integrated Development Plan, 2013).

3.2.4 Main Sources of Domestic Water in Lamu

Lamu is Kenya's oldest inhabited town (founded in 1370) and was one of the original Swahili settlements along the coast of East Africa (County Government of Lamu, 2015). Water infrastructure in Lamu has largely remained unchanged since the original settlement and the main source of domestic water in Lamu is still wells. While no study has been undertaken to document all the wells in Lamu, there is some information on Lamu Island (see Map 3.1) Nembrini (2013) estimates that there are roughly 300 wells in Lamu Island, these are all predominantly dependent on the Shella Aquifer. This includes 30 wells in Shella (part of Lamu Island). Many households were and are still depending on traditional wells to source their daily water. This includes households who source water from traditional wells for other domestic water uses other than drinking. These households supplement water from traditional wells with water from the water service providers (WSPs). The study by Nembrini (2013), noted that in Lamu Island, 155 of these wells are equipped with electrical pumps providing water to about 6500 people.

Few hydrogeological studies and geophysical investigations have been undertaken in order to assess the capacity of the aquifers and to locate the areas where water could be tapped. It was concluded by Nembrini (2013) that the potential fresh water resources available for exploitation were estimated around 3,400 m^3/day over an area of 21 km^2. The recommended harvesting for the existing 30 wells in Shella was 750 m^3/day. Any groundwater development would have to be done in a way to avoid seawater intrusion, in order to protect the fragile fresh water lenses lying beneath the dune. At Mokowe, the mainland harbour of Lamu, a well field could be supplied from the depression of Bele Bele, with a potential of 250 m^3/day over an area of 4 km^2 (Nembrini, 2013). Considering the daily water requirements of the Lamu population (current water demand for Lamu Island alone is

estimated at about 3,000 m^3 / day), water sourced from traditional wells is nowhere near sufficient (Lamu County Integrated Development Plan, 2013).

In addition to wells, local communities in Lamu have for a long time depended on traditional 'djabias' or 'jabias'. These are mason, cylindrical shaped structures used to harness rainwater for domestic water use (Fig. 3.1). It consists of an induced sloping catchment area and a tank to store water. The catchment area is usually a continuous concrete slab with garlands on the side to direct run off water into the reservoir and also minimize rainwater losses through splashing (Biamah, 2016; Gould & Nissen-Petersen, 1999). Although the average distance to access clean water is approximately 5km, most areas within the interior of Lamu County cover longer distances in search of clean water. Access to piped water is limited to within the urban centres of the County (Lamu County Integrated Development Plan, 2013).

Figure 3.1 Djabia located on Lamu Island

More recently, development partners such as the World Bank and the Lamu County Government have initiated projects to bring piped water into the remote divisions of Lamu. Villagers of the remote Kiwayu Island for instance, now have access to piped water after the Lamu County Government expended Ksh. 9 million to enable island dwellers to have access

to clean drinking water (County Government of Lamu, 2015). Otherwise limited piped water is available on the island. In line with the 2002 and 2016 Water Act, Lamu is supplied with piped water through the Coast Water Services Board (Water Act, 2016). The Board however, does not provide the services directly but rather through contracted agents known as Water Service Providers (WSPs). Lamu in specific is supplied directly by the Lamu Water and Sewerage Company (LAWASCO), Lake Kenyatta Water Association, Hindu Water Association and Witu Water Association. LAWASCO supplies piped water to around 50,000 Lamu residents, while the population under their mandate is well over 100,000. In a recent study (Okello et al., 2015) it was concluded that new water management policies that take into consideration climate change as well as population increase and LAPSSET development should be formulated and implemented in order to conserve Shella aquifer's status as a viable freshwater reservoir.

3.2.5 Economic Infrastructure

Coastal communities within the region mostly rely on agriculture and tourism, which together contributes close to 50% of the Lamu's gross domestic product. Tourism specifically is a main earner of foreign exchange in Lamu. With increasing population, the pressure on social amenities including potable water, has become very high (Okello et al., 2015). The County has a total road network of 688.6km, and only 6km of this is tarmacked. This makes travelling by road a nightmare and impassable during the rainy season (Lamu County Integrated Development Plan, 2013). There are two main roads, Mokowe-Garsen Road, which connects the County to the rest of the coast Counties, and Mokowe –Kiunga Road that connects the County to Somalia. There are eight main jetties that link the mainland to surrounding islands. While some of these jetties are in fair condition, most of them are in a deplorable state and need urgent rehabilitation. Dhows and speedboats are the major transport route linking the far-flung islands to the rest of the County. This presents several challenges to residents including risk of accidents and huge fuel costs. There are 13 airstrips (11 public and 2 private) with three airlines providing daily passenger flights. The County has no rail transport (Lamu County Integrated Development Plan, 2013). The LAPSSET project is envisioned to greatly transform the County's transport infrastructure, bringing essential services into the 21st century.

3.3 Conceptual Framework

The research contends that community water access and availability can be understood in terms of:

i. Supply of water
ii. Demand for water
iii. Participation of stakeholders in decision making around water

In the context of Lamu, there is a reduction in the supply of water (Ignatius et al., 2018). This reduction is attributed to the negative impacts of climate change (Okello et al., 2015) and the poor water infrastructure in the region (Ignatius et al., 2018; Okello et al., 2015). Secondly, there is a corresponding increase in the demand for water (Okello et al., 2015). The surge in population in the region, as a result of large infrastructural development is responsible for this increase in demand (Okello et al., 2015).

Integrated Water Resources Management (IWRM) is used as a conceptual model in this study. With the pressure of a water crisis occurring all over the world, the development and implementation of alternative water resource projects is needed now more than ever. This is however, a complex and difficult task due to the different disciplines that are involved in water management (Thomas and Durham, 2003). The concept of integrated water resources management attempts to address these complexities. “Integrated water resources management (IWRM), is a process, a change, and an approach that mainstream water resource use and management into the national economy in an equitable manner without compromising the sustainability of vital ecosystems” (Dungumaro and Madulu, 2003). Following from this definition, IWRM draws on an understanding of water use and management, equitable considerations (participation of all relevant stakeholders) and principles of sustainability. The basic tenets of IWRM require an assessment of the impact of an action or decision on water access for other users or the benefits from its use. Secondly, IWRM looks at the result of an action or decision and if the result will be the most efficient use of the available financial and water resources. Thirdly, IWRM assesses how the decision or action will affect the functioning of natural systems (Mitchell, 2005). These inclusions lead to mainstreaming of water use and management into development.

However, at the same time, IWRM in the coastal zone of Lamu will be affected by a number of factors including climate change. Climate change negatively impacts water availability in coastal zones, thus exacerbating existing water problems in an already water stressed area (Kundzewicz et al., 2009; Nicholls and Cazenave, 2010; Werner and Simmons, 2009). The present study argues that current water constraints in Lamu are worsening as a

result of climate change impacts. Understanding water use and management in Lamu necessitate an understanding of how climate variables (temperature and rainfall) interact with and impact water. This will support a more holistic, sustainable approach to IWRM. Another factor to consider is the impact of large infrastructural development on water availability and access. Studies (Trozzi and Vaccaro, 2000; Forman and Alexander, 1998; Okello et al., 2015) show that infrastructural development has an impact on local freshwater supplies (this impact is detailed in subsection 2.3). Existing policy on development purports to incorporate and mitigate against such impacts, however the extent to which this is the case is a factor to consider in successful IWRM for Lamu.

A final factor to consider in IWRM is the actual involvement of stakeholders. IWRM ought to be equitable, in that it seeks to consider the participation of all relevant stakeholders in the process. However, the study questions the relative power and influence of these stakeholders to actually implement IWRM. It is one thing to elicit participation, but is the participation of stakeholders meaningful in that it translates to relative action? Do stakeholders who have less stakes in water use in the area, have more power in making decisions? This is significant to the process of IWRM, as stakeholders have to own the process in order to be more likely to sustain it. The study also addresses some ancillary issues that might also have an influence on the factors affecting IWRM. These include conflict and migration. Studies have shown that serious water shortages are more likely to marginalize already disenfranchised members of the affected community (Denton, 2010; Zwarteveen & Meinzen-Dick, 2001) as well as cause violent conflict (Barnett & Adger, 2007). Lamu is likely to suffer intensified water shortages as a result of climate change and LAPSSET development. This could potentially result in a rise in conflict in the area, as well as migration out of the County. Alternatively, residents of Lamu County could migrate to parts of the County that are more 'water rich' than others, potentially causing strife within the County.

To address these factors, the study suggests a response that focuses on integration within existing policy arrangements. This includes integrating climate change through mainstreaming (Ogato et al., 2017; Vincent & Colenbrander, 2018) and applying an IWRM approach in decisions around Lamu's water (Fig. 3.2). This will ensure that the climate change impacts and large infrastructure development impacts on water are reflected in County development planning. The study conceptualized that any water management strategies used to solve water constraints in Lamu could only succeed if they were geared towards mainstreaming climate change adaptation and integrating the impacts of large

infrastructural development on local water (Fig. 3.2). It builds on the IWRM model proffered by Badham et al., (2019) within the context of Lamu.

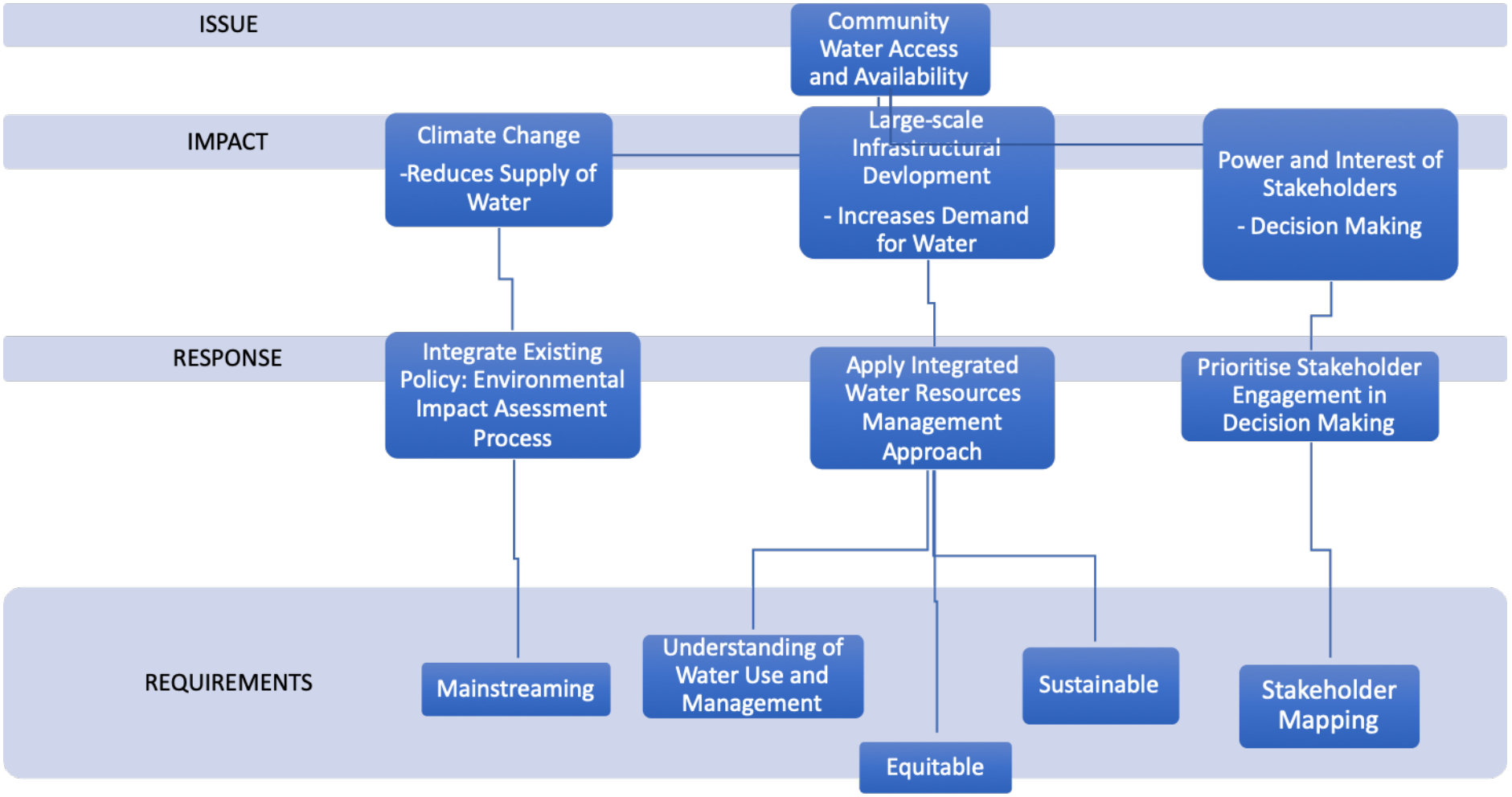


Figure 3.2 Conceptual Framework

3.3 Research Design

The research design used in this study is mixed method research using the sequential explanatory design approach (Creswell et al., 2003, Creswell & Clark, 2007). This refers to empirical research that involves the collection and analysis of both qualitative and quantitative data (Johnson & Onwuegbzic, 2004) in different phases. For this study, the first phase involved the collection and analysis of quantitative data and the second phases involved the collection and analysis of qualitative data (Fig. 3.3). During the first phase, both primary and secondary methods were utilised and during the second phase, primary methods were utilised (Fig. 3.3). The benefit of this research design is it allowed for triangulation, whereby different aspects of a phenomenon could be more accurately identified by approaching it from different vantage points using different methods and techniques (Creswell & Clark, 2007). Climate change is complex in nature and viewed as a "threat, environmental stressor, risk domain, and impacting process with dramatic environmental and human consequences" (Reser & Swim, 2011). Due to this, the research required a synthesis of perspectives and experiences to adequately address the overall research objective. The intention was to work with community members and practitioners to formulate important principles of knowledge and develop solutions to a significant problem. Furthermore, Creswell & Clark (2007) argue that the triangulation approach obtains complementary quantitative and qualitative data on the same topic, bringing together the strengths of the two methods. The triangulation design involved the collection and analysis of two types of data, which were then merged at the interpretation of results stage (Creswell & Clark, 2007).

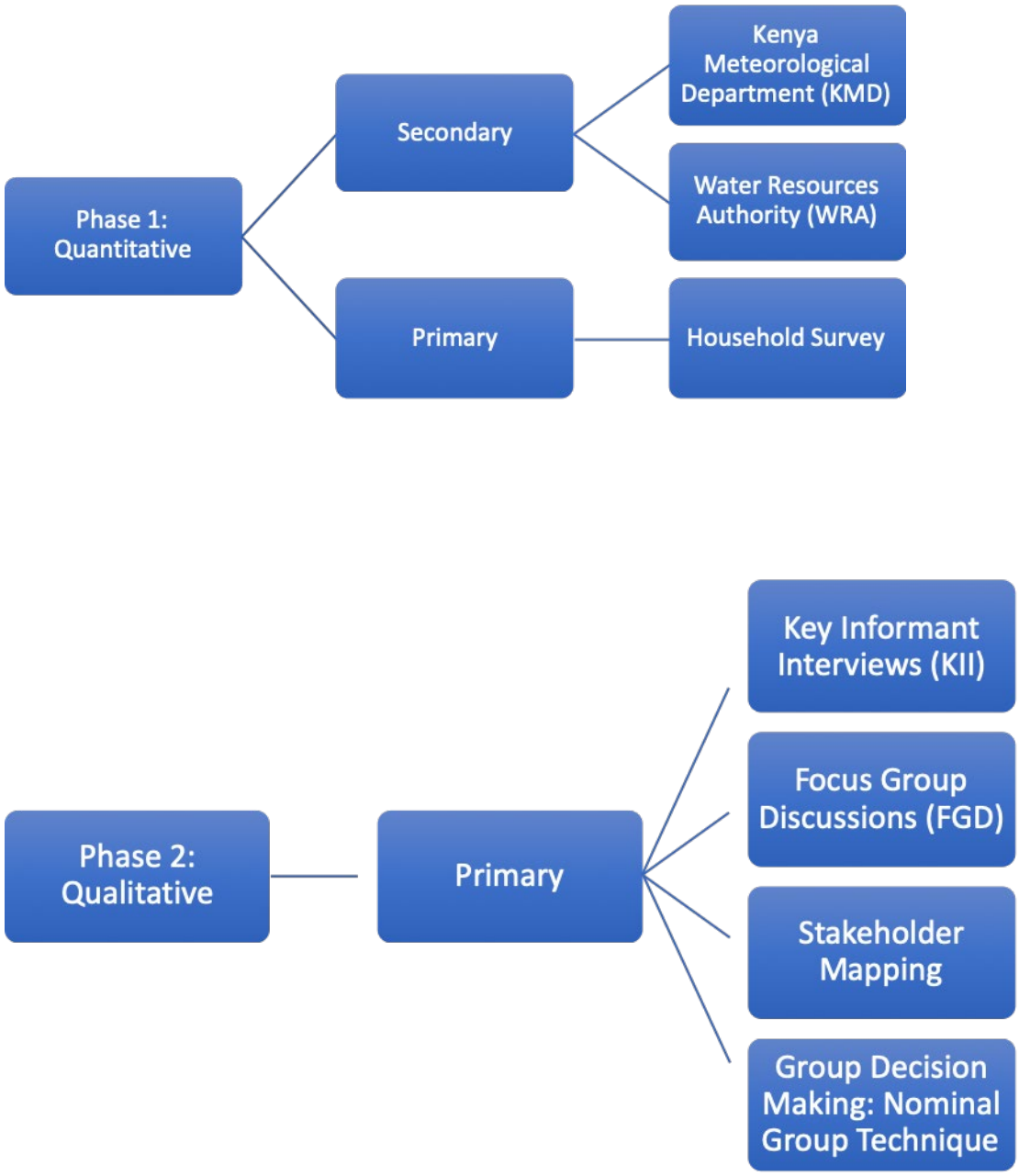


Figure 3.3 Overview of Phase 1 and Phase 2 of Data Collection: Mixed Method Research with Sequential Explanatory Design Approach

The quantitative data enabled the researcher to trace rainfall and temperature trends and relationships. It allowed for comparisons to be made between empirical rainfall and temperature statistics for the past 40 years, and stakeholder observations in Lamu County. It also enabled the collection of data on the accessibility, availability and use of water in Lamu County, drawing parallels to the changing climate patterns in the region over time. The qualitative component of the research design helped to

elucidate the processes underlying the quantitative outcomes. It also supported the development of a stakeholder map, to support the practical application of integrated water resource management (IWRM). Studies (Lang et al., 2012; Miller et al., 2014) suggest that sustainability challenges require new ways of knowledge production and decision-making. The involvement of a wide range of actors allows the research process to integrate the best available knowledge, reconcile values and preferences, as well as create ownership for problems and solution options (Lang et al., 2012). Community-based, interactive, or participatory research approaches are often suggested as an appropriate means to meet both the requirements posed by real-world problems as well as the goals of sustainability science as a transformational scientific field (Lang et al., 2012).

3.4 Primary Data Collection Methods

3.4.1 Household Survey

Sampling:

According to the Lamu County Integrated Development Plan (2013), the County population as projected in 2012 to 2017 stands at 112,551 persons. The study sample size (number of participants in the study) was determined by the Yamane (1967) equation:

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size and e is the allowable error (5%). For this study:

$$n = \frac{112551}{1 + 112551(0.05)^2}$$

A sample size of 399 individuals was generated for a statistically significant representation of the population. The Yamane equation was used to avoid bias in interpreting the results. If too few participants were included in the study, the results could not be generalised to the population, as the sample would not represent the size of the target population. The study targeted a total of 552 respondents to ensure a confidence level of 99% and confidence interval of 5.76.

The household survey was conducted during the first phase of the study and it informed objective one through to four. The survey was presented and managed via

KoboToolbox –an android enabled application. The survey was structured to cover five areas. These included: demographics, changes observed in rainfall and temperature, water sourcing and access changes in water sourcing and LAPSSET impact on water. The final part of the household survey used Google Maps to record a Geo-tag for each respondent. The household survey is attached in Appendix A. The household survey was distributed within the selected research sites (see Map 3.1) with the help of four trained enumerators (research assistants). Each research assistant collected data from a given number of respondents within the administrative district. The number of respondent per district is weighted to the population size within the district. Through the household survey, it was possible to identify segments (for example farming, fishing, domestic use, pastoralism) with significant linkages to freshwater use in Lamu County. The farming, domestic, pastoralism and fishing segments were earmarked for further investigation.

3.4.2 Key Informant Interviews

Sampling

Following the household survey, a stratified random sampling technique was used to select the farmers, housewives, fishermen and pastoralists to be subjected to further analysis. Key informant interviews were then conducted with Government officials, NGO workers, LAPSSET authority members, community elders and experts concerned with water availability and access. They provided contextual explanations of water history, development agenda and process as well as personal narratives relevant to climate variables.

The key informant interviews were conducted during the second phase of the study (4th May – 17th June, 2017). The interviews took on a semi-structured format (Kombo & Tromp, 2006) whereby an interview guide was utilized (attached in Appendix B and Appendix C). The interviews sought to gain a more complete, in-depth understanding of the issues under study informing objectives two through to four. The interviews also gained more detailed information including personal experiences, contextual and historical background.

3.4.3 Stakeholder Mapping

Sampling

Specifically, objective three concerned with stakeholder needs used the snowball sampling technique. This is where research participants recruited were asked

to suggest other participants to be included in the study. It was useful in identifying additional stakeholders who are not easily recognisable.

Stakeholder mapping occurred during the second phase of the study (4th May to 17th June, 2017). It is a widely used method (Bryson, 2004; Bryson et al., 2011; Wester et al., 2003) and was used to achieve the third objective of the study (section 1.5). The mapping exercise identified stakeholders and their interests, clarified stakeholders' views of a focal organization (or other entity) and identified some key strategic issues. This study followed the example of Wester et al. (2003) that used stakeholder mapping to make the argument for a move from stakeholder participation to substantive stakeholder representation in river basin management in order to achieve equitable water management.

As the key informant interviews were concluded, the researcher posed the following questions in order to determine additional informants as well paint a picture of key stakeholders in relation to the research topics:

"Do you think there is anything I should be asking about these topics that I'm not already asking?"

"Is there anyone else you recommend I talk to?"

Through this, the researcher was able to identify a range of key stakeholders in the Lamu region in relation to freshwater access.

Following this, the following steps were carried out:

1. Brainstormed the list of potential stakeholders based on baseline findings (Lamu County Integrated Development Plan, 2013)
2. Added any additional stakeholders as identified through snowball sampling
3. Developed a Power versus Interest Matrix as per Eden and Ackermann (1998) (Fig. 3.4)whereby stakeholders are arranged on a two-by-two matrix where the dimensions are the stakeholder's interest in the issue at hand, and the stakeholder's power to affect the issue's future.
4. Four categories of stakeholders result: Players who have both an interest and significant power; participants who have an interest but little power; context setters who have power but little direct interest; and the crowd which consists of stakeholders with little interest or power. Power versus Interest Matrix typically helps determine which players' interests and power bases must be taken into account in order to address the problem or issue at hand. They also help highlight coalitions to be encouraged or discouraged, what behaviour

should be fostered, and whose "buy in" should be sought or who should be "co-opted." Finally, they provide some information on how to convince stakeholders to change their views (Bryson, 2004).

5. Developed a stakeholder influence diagram, indicating how the stakeholders on the power versus interest matrix influence one another.

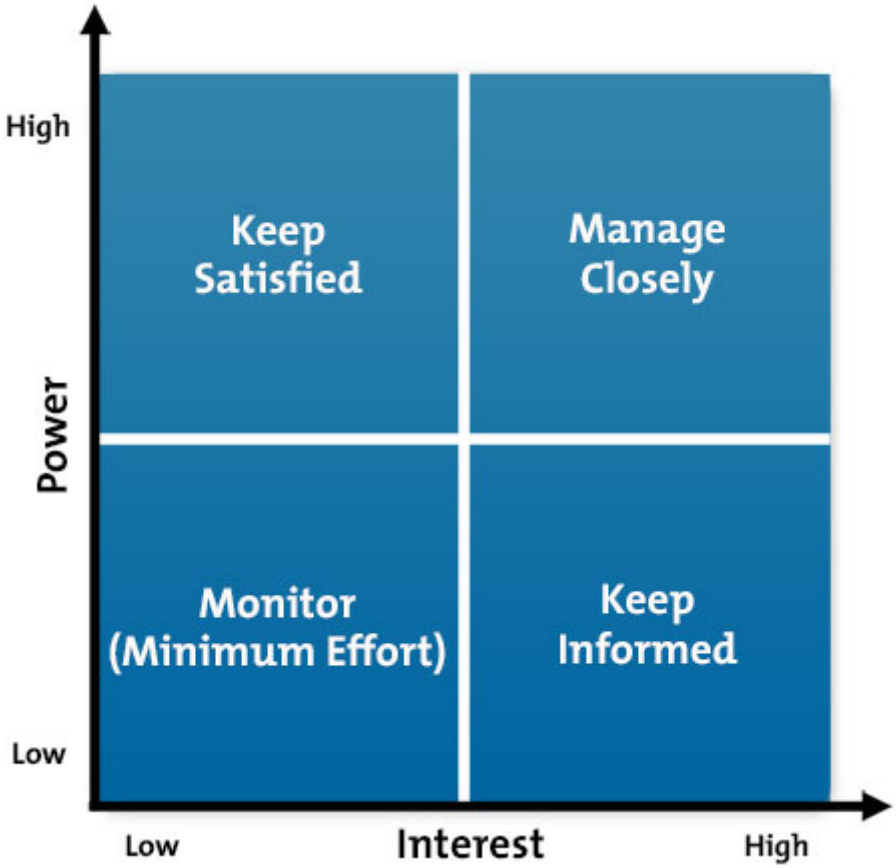


Figure 3.4 Power Versus Interest Matrix
Source: (Eden and Ackermann, 1998)

3.4.4 Focus Group Discussion

Sampling

The purposive sampling technique was utilized. This involved selecting members of the community that were viewed to provide the best information and inviting them to be a part of the focus group discussion or the group decision making session. The two focus groups comprising six individuals each were women and youth. The women were from the Amu District, within the Shella region and between the ages of 34 and 45. Women rather than men were viewed as having the best

information, as they were more involved in household water use than the men. Participants selected to be a part of the focus groups had answered 'yes' to the household survey question on knowledge of climate change (page 5/8, Appendix A) and yes to the household survey question on knowledge of the LAPSSET project (page 8/8, Appendix A). This was to ensure that the focus groups selected would be able to give the best information. The youth were members of Save Lamu – a coalition of numerous NGO's in the Lamu area interested in protecting Lamu from environmental damage. They represented two smaller NGOs' that were involved in youth advocacy work in the region. They were between the ages of 22 and 30. They were invited to participate in the focus group discussion after key informant interviews were conducted with members of Save Lamu Coalition.

The focus group discussions occurred during the second phase of the study in line with meeting objective five of the study (section 1.5). The first focus group involving Women (see section 3.4.2) was conducted on the 11th of May 2017 in Shella (public square). The second focus group discussion with the youth (see section 3.4.2) occurred on the 12th of May 2017 in the headquarters of Save Lamu, Lamu town. The discussion was planned and designed to obtain information on the participant's beliefs and perceptions on a defined area of interest: freshwater use and access in Lamu and how to make it better. The discussion was guided by a pre-determined list of open-ended questions (see Appendix D for focus group guide). The researcher facilitated the discussion, while two research assistants were present to take notes. Both discussions were set in a location suggested by the participants and lasted approximately 45 minutes.

3.4.5 Group Decision Making: Nominal Group Technique

Sampling

The purposive sampling technique was utilized similarly to the focus group discussion. For the nominal group technique, participants from key informant interviews were selected to be a part of a wider group discussion. The group was made up of ten individuals (men and women) representing NGO/ civil society, youth, women, hoteliers, fishermen, farmers and community elders. The group selection was informed by the need to accumulate more detailed knowledge and facts around the subject area, as well as generate additional alternatives. Given that one of the objectives is to suggest policy recommendations for IWRM in Lamu, the study

followed the argument that the involvement of a wide range of stakeholders in decision-making leads to a higher level of acceptance and satisfaction.

The nominal group technique occurred during the second phase of the study, on the 8th of May 2017. The discussion was organised in a residence located in Shella. The discussion was organised to compliment findings from the focus group discussions, and also supported achieving objective five of the study (section 1.5). Nominal grouping is a highly structured technique designed to keep personal interaction at a minimum level during the process. De Ruyter (1996) found that nominal groups could produce a significant amount of interventions as the individual contribution of each participant is emphasized.

The nominal group discussion was characterized by participatory engagement to chart the way forward. Participants were presented with a problem and solution tree (Snowdon et al., 2008; Hesse-Biber & Leavy, 2011; Greenwood, Whyte & Harkavy, 1993; De Ruyter, 1996; Delp et al., 1977) in order to identify and define the problem and then engaged to develop workable solutions to the problem. The problem tree was structured like any other tree, with three parts: trunk, roots and branches. The trunk represented the main problem being discussed, the roots represented the causes of the problem and the branches represented the effects (The researcher served as the group moderator while three research assistants were present to assist with note taking and audio recording of the session. The session took roughly 120 minutes, including introductions. Images captured during the discussion are attached in Appendix E. The method involved the following steps:

1. Problem Solution Tree: presentation of the problem within an illustration of a tree. Participants were asked to list what they believed was the cause of the problem on pieces of paper that were handed to them. Problem was presented as: “Limited Freshwater Availability in Lamu”. Researcher then invited participants to mention items they had written down and wrote out the causes on the flip chart. Each participant had the opportunity to present at least one response. If there was any confusion with the response mentioned, the moderator gave the participant a chance to explain their contribution before recording it on the flip chart. Group interaction was limited, and clarifications on the process were cleared up before the discussion began.

2. During the collection of items, additional ideas and views stimulated by the input from others were also expressed and recorded. However, no verbal interaction occurred between group members.

3. The relative importance or priority of each item is established by a voting procedure. This was done by asking each participant to select five items that they consider to be the most important.

4. The same methodology (1-3) was applied for the second part of the session, where participants were invited to give ideas on 'How to improve freshwater availability in Lamu'.

3.5 Secondary Data Collection Methods

Temperature and rainfall data was obtained from the Kenya Meteorological Department (KMD) for the Lamu Meteorological Station (Station ID: 9240001) over the period 1974-2014, the total period of time the Lamu Meteorological Station has been operational. The traditional definition of climate change is the 30-year average of weather. KMD has collected rainfall and temperature data from 1974 for the Lamu station and in order to give a more detailed picture of the trend, temperature and rainfall data was examined for the entire period 1974-2014. Rainfall data was in the form of average daily totals, monthly average precipitation and total amount of rainfall received per year. While temperature data was in the form of monthly maximum and minimum average, annual maximum and minimum average. For the missing data sets, 4 data points on either side of the missing values were taken and their average used to fill in the data gaps.

Additionally, the study reviewed secondary data (the most recent overview done) from the WRA. The data included the latest status of wells taken in Amu, Kipungani and Matondoni in 2010. The data covered location (latitude and longitude), depth, WRL(m) (static water level) and whether or not the wells were operational. In addition, Lamu borehole water quality analysis data was also reviewed. This data was also from the year 2010, and included GPS location of boreholes, pH levels and salinity levels. The study also included an on-going review of water quality tests on boreholes under the LAPSSET project being undertaken by Charles Mudunyi (MSc. Candidate). NEMA also provided the initial feasibility study commissioned for the LAPSSET project and relevant EIAs for the different aspects of the LAPSSET project

including the recently released draft Strategic Environmental Assessment (SEA) for the LAPSSET project. EIAs were reviewed in order to determine if the EIA stated impacts on water (or lack thereof) are an accurate representation of what is happening on the ground.

3.6 Techniques of Data Analysis

All the quantitative data for this study has been analysed using SPSS for Windows, version 21.0 and Microsoft Excel. The statistical techniques utilised in the data analysis are descriptive including mean, mode, percentages, frequencies, maximum and minimum values. Inferential statistics were used to examine the differences and relationships between samples of the population. This included correlation and regression analysis. For the rainfall and temperature data, SPSS chart builder was used to create the line graphs plus their trends. The nature of the chart determined the kind of trend line that was used. The type of regression analysis chosen depended on the trend line. For instance, for polynomial trends, a polynomial regression analysis model was set to analyze them, and the linear regression model was set for graphs with linear trends. The findings from regression analysis revealed whether the independent variable (time) was a significant predictor of the dependent variables (rainfall/temperature). Independent sample t-test was used to compare whether there was a significant difference in mean rainfall between the short and long term rains period.

Qualitative data for this study was first transcribed and then analysed using framework analysis (Krueger, 2014; Rabiee, 2004), which uses a thematic approach to develop themes both from the research questions and the narratives of research participants. The five key stages of framework analysis included: familiarization; identifying a thematic framework; indexing; charting; mapping and interpretation. Finally, data gathered was synthesized using triangulation (Carter et al., 2014). Triangulation involved the conscious combination of quantitative and qualitative data from methodologies listed under objective one through to five, as a mechanism to integrate multiple data sources to improve the understanding of how water can be affected by both infrastructural development as well as climate change.

3.7 Data Management and Ethical Considerations

A paragraph soliciting consent was presented to each participant (as shown in the KII, FGD and Group Nominal Technique Guides Appendix A, B, C) before engaging their participation. Following assent, respondents were assured of the confidentiality of the information given and of the fact that all information collected would be strictly used for academic purposes only. The study ensured respondents anonymity by not requiring their names to be recorded on the household surveys. For all methods of data collection, respondent's express permission was attained before recording any material with the option to decline to be recorded during any of the proceedings. The researcher and the enumerators personally administered the questionnaires to all participants. The NACOSTI research permit was also obtained (APPENDIX F) and an additional letter from the university (APPENDIX F) as requested by Government key informants.

CHAPTER FOUR

RAINFALL AND TEMPERATURE TRENDS IN LAMU COUNTY

4.1 Introduction

The purpose of this chapter is to present an analysis of the temperature and rainfall trends in Lamu, informing the first objective of this study. Examining the trends in rainfall and temperature is vital to assess the extent of climate-induced changes and suggest feasible adaptation strategies. It is important to understand local stakeholders attitudes and perceptions regarding climate change as they must first perceive and have knowledge of the causes for the change in climate and the impact on local water in order to effectively adapt and have the motivation to do so. With this in mind, the accuracy of local stakeholders perceptions of climate is critically important to implement appropriate adaptation. To this end, the chapter presents results from an analysis of the trends in temperature and rainfall over a forty-year period (1974-2014). Then, stakeholder observations on changes in temperature and rainfall are presented. The relationship between these findings is discussed in the final section.

4.2 Results

4.2.1 Observations in Temperature and Rainfall for Lamu

During the 40-year period (1974 – 2014), a maximum and a minimum annual average temperature of 30.9°C and 24.0°C was observed in Lamu respectively. A nearly stable monthly average of 27.4°C was recorded over the same period. The coolest year was 1990, with an annual average temperature of 25.1°C, while the hottest year was 1988, with an annual average of 29.5°C. Monthly minimum and maximum temperatures over Lamu are highest from March to May and lowest from June to August. The month with the highest maximum temperature is March while the month with the highest minimum temperature is April. The lowest maximum temperature is in July while the lowest minimum temperature is in August (Figure 4.1 and 4.2).

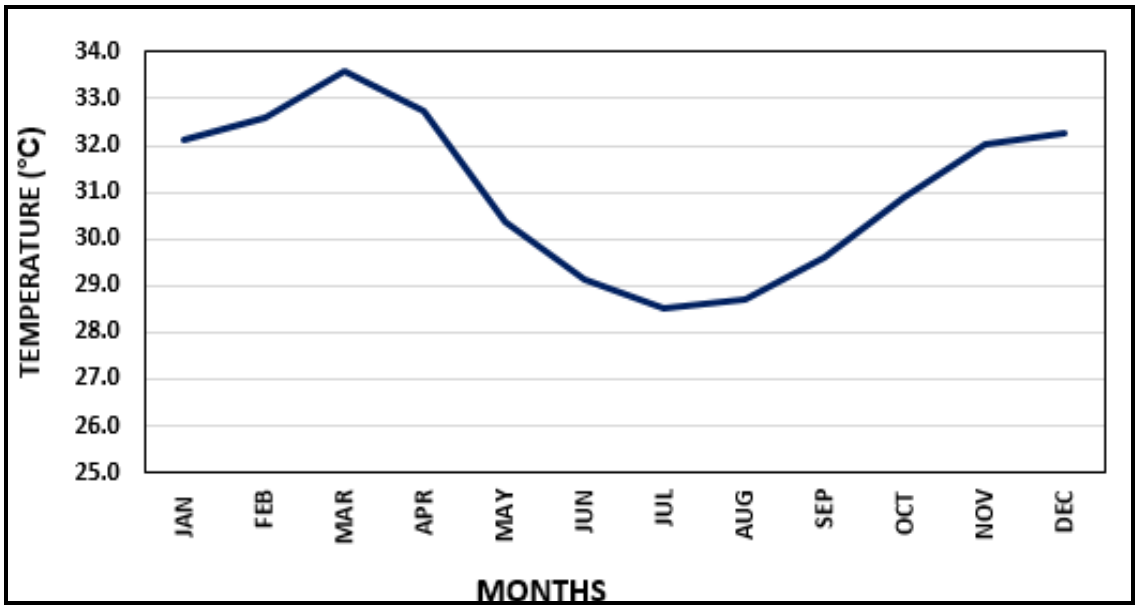


Figure 4.1 Mean monthly maximum temperature over Lamu (1974 - 2014)

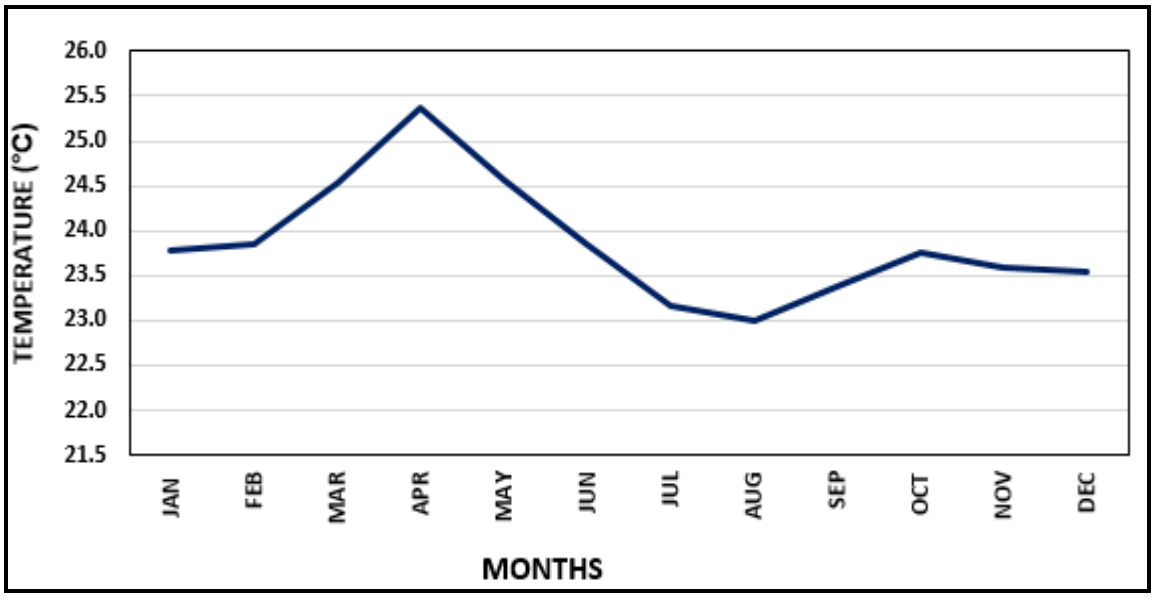


Figure 4.2 Mean monthly minimum temperature over Lamu (1974 - 2014)

Lamu County received an average of 1022 mm of rainfall annually. The lowest amount of rainfall was observed in 1980 while the highest was in 1997 (Figure 4.3). It is worth noting that significant spikes in the amount of rainfall received are most likely associated with the El Niño and La Niña events that occurred between 1980 and 1999. The sharp spike in rainfall received in 1997 could be attributed to the El Niño phenomena. The years 1988 to 1989 were relatively dry compared to the annual average and this could be explained by the La Niña phenomenon that occurred during that time frame. In addition, the years 1980 and 1992 (538 mm and 561 mm, respectively) were extremely dry relative to the annual average of 1022 mm of

rainfall. It was during this time that the most severe, continental droughts (as they spanned over may sub-regions and covered wide areas of the African continent) were reported affecting 1.5 million people in the arid and semi-arid districts of Kenya including the coastal regions (Verschuren and Laird, 2000).

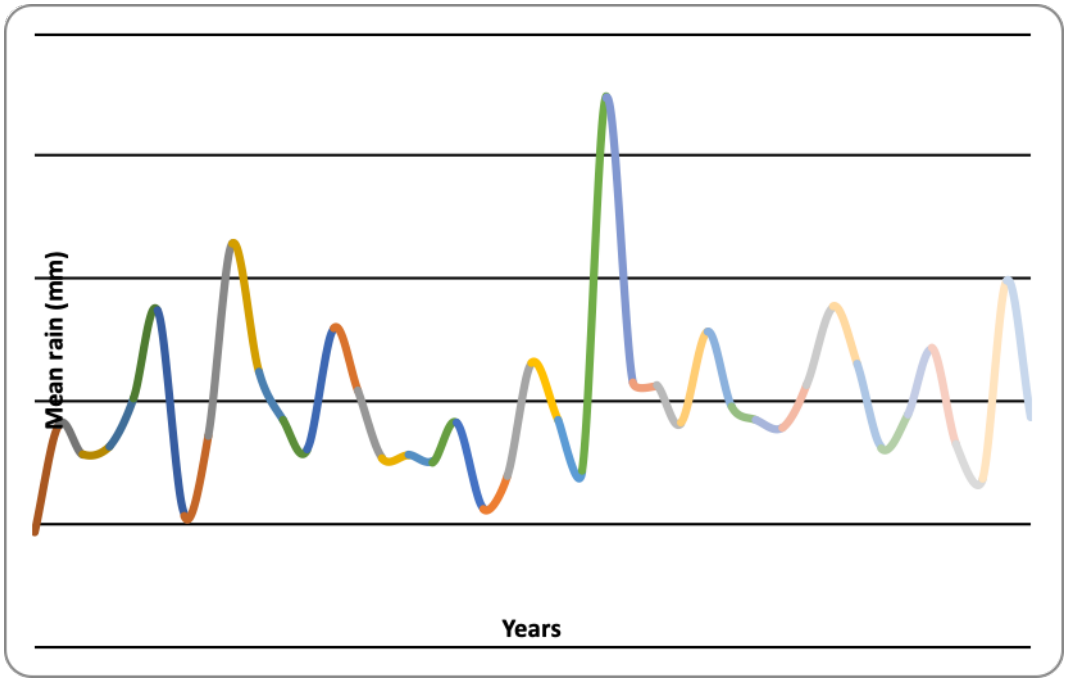


Figure 4.3 Average annual rainfall received in Lamu (1974-2014)

The mean monthly rainfall for the period 1974-2014 for Lamu is shown in figure 4.4, with the long rains occuring between March and June, and the short rains between October and December.

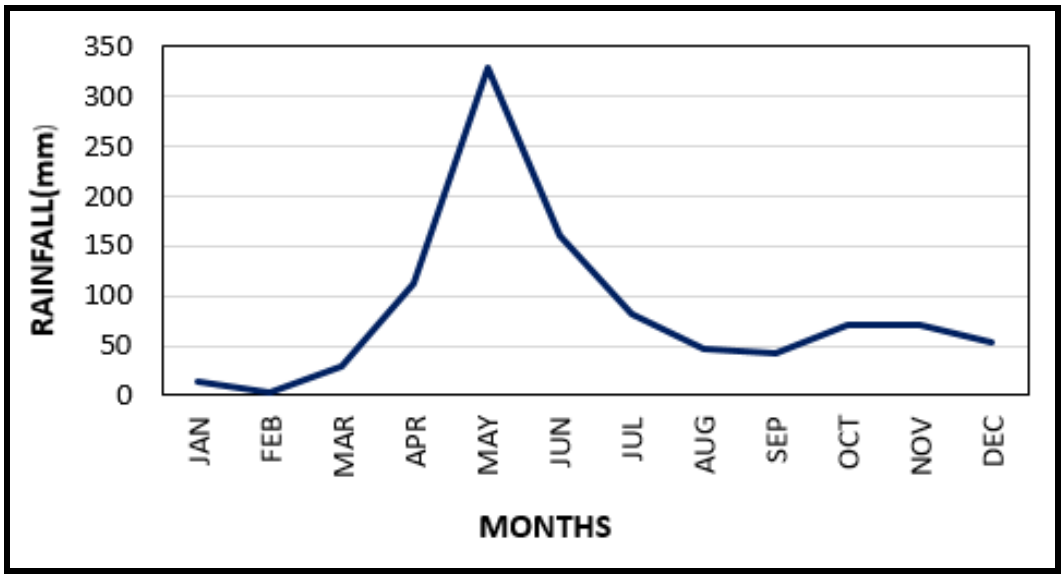


Figure 4.4 Mean monthly rainfall (1974-2014)

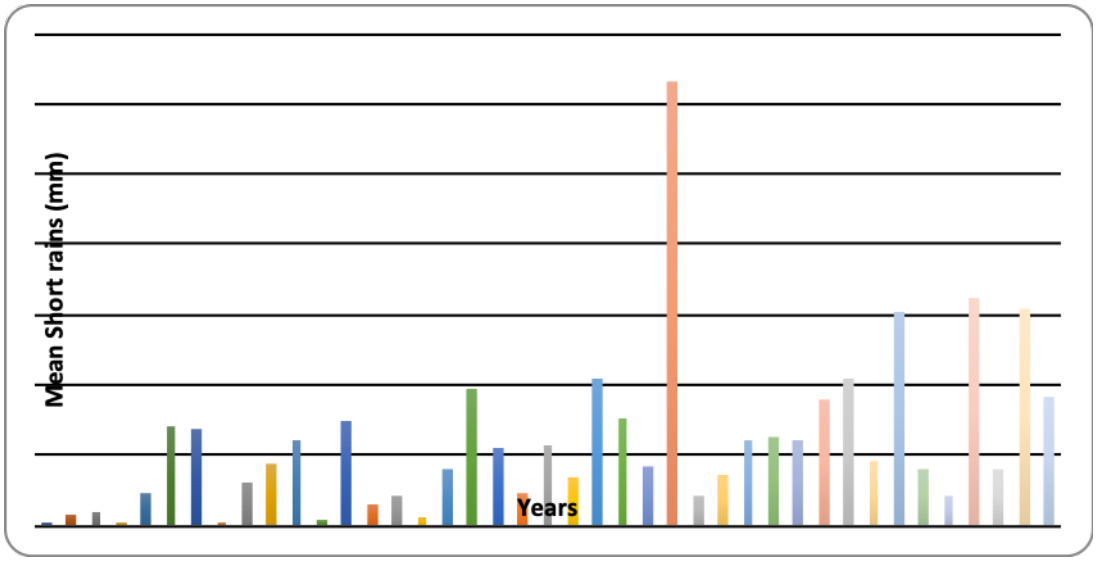


Figure 4.5a Amount of rainfall received during the short rains (October – November) 1974-2014

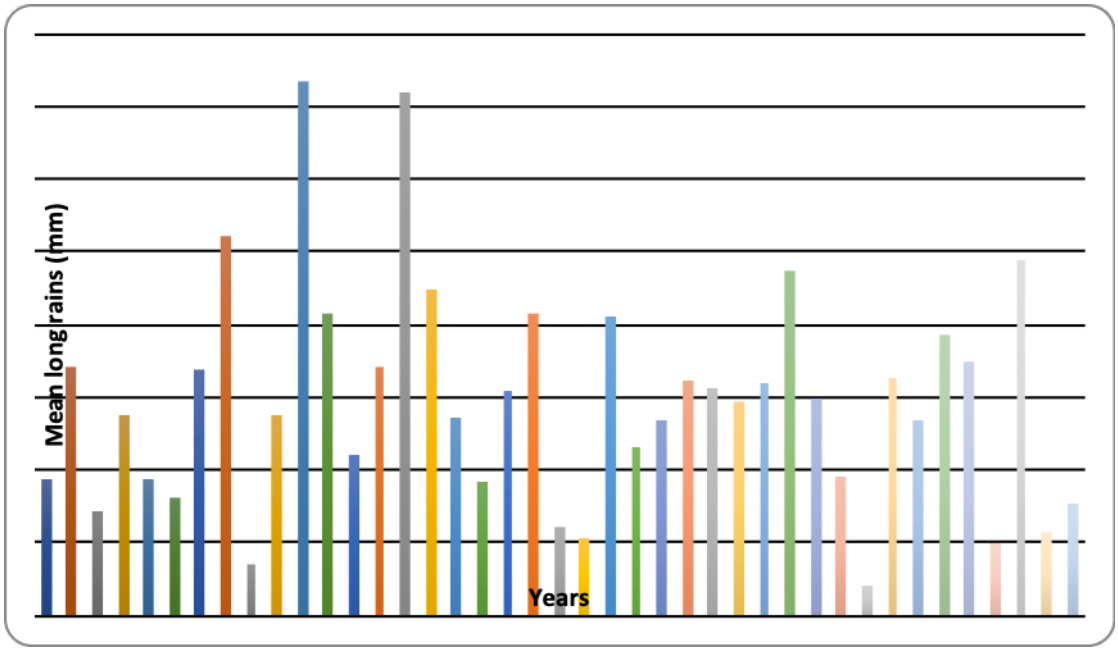


Figure 4.5b Amount of rainfall received during the long rains (March to June) 1974-2014

Rainfall in Lamu peaks during the long rains in May. Cumulatively, more rainfall is received in the long rain season as shown in figure 4.5b.

4.2.2 Trends in Temperature for Lamu

Results for the one station in the area considered in the study show that annually there is a notable increasing trend of the maximum temperature over Lamu. (Figure 4.6). This was noted specifically during the months March to August.

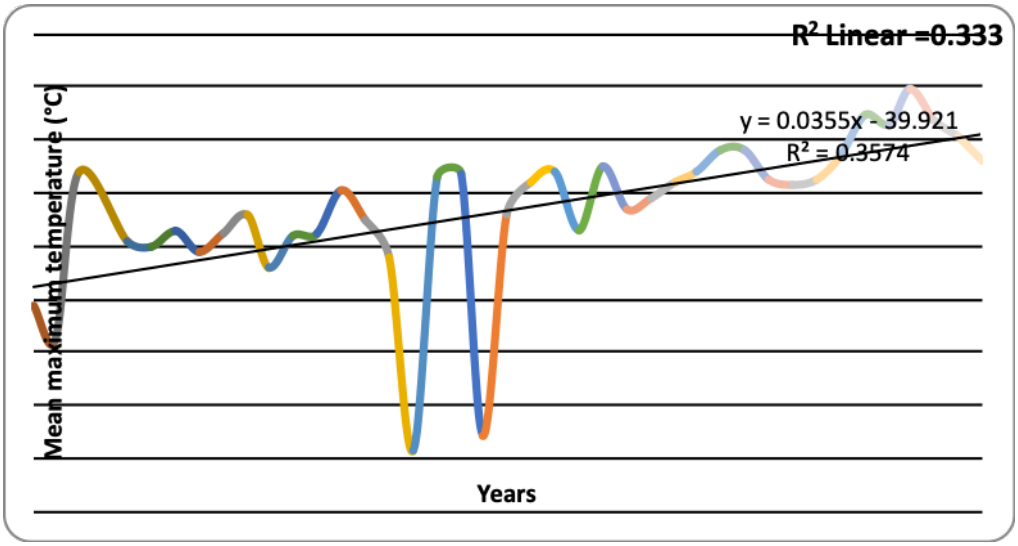


Figure 4.6 Trend Analysis for MaximumTemperature (1974-2014)

The results of the regression analysis based on the equation $Y = \beta + \beta_1 X_1 + \varepsilon_i$ are shown in Table 4.1

Table 4.1 Regression Coefficients Maximum Temperature

Model	Unstandardised Coefficients		Standardised Coefficients	t.	Sig.
	B	Std. Error	Beta		
(Constant)	30.151	.182		165.439	.000
Year	.033	.008	.577	4.410	.000

The regression equation becomes:

$Y = 30.151 + 0.033\ X_1$

Thus, time (in years) was a significant predictor of mean maximum temperature (p=0.000). The equation implies that one unit increase in time (years) leads to 0.033 units increase in average maximum temperature.

Table 4.2 Descriptive Statistics for Maximum Temperature

	N	Minimum	Maximum	Mean	Std. Deviation
Temperature	40	28.6	32.0	30.851	.7012
Valid N (listwise)	40				

At the same time, the model showed a non-significant decreasing trend of the minimum temperature over Lamu annually (Figure 4.7).

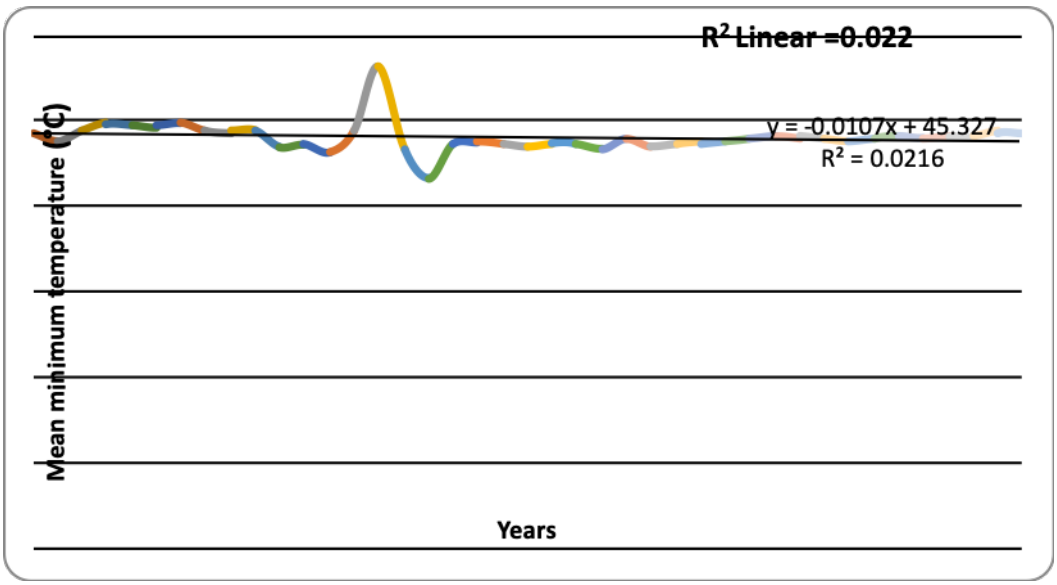


Figure 4.7 Trend Analysis Minimum Temperature (1974-2014)

Regression model set as: $Y = \beta + \beta_1 X_1 + \varepsilon_i$

Regression equation: $Y = 24.281 - 0.011\ X_1$

Regression analysis results (table 4.3)

Table 4.3 Regression Coefficients Minimum Temperature

Model	Unstandardised Coefficients	Standardised Coefficients	t.	Sig.

	B	Std. Error	Beta		
(Constant)	24.281	.277		87.746	.000
Year	-.011	.011	-.147	-.927	.359

Thus, time (in years) was not a significant predictor of mean minimum temperature (p=0.359).

4.2.3 Trends in Rainfall for Lamu

Results from the annual rainfall analysis show a fluctuating trend over Lamu, with rainfall increasing and decreasing over time.

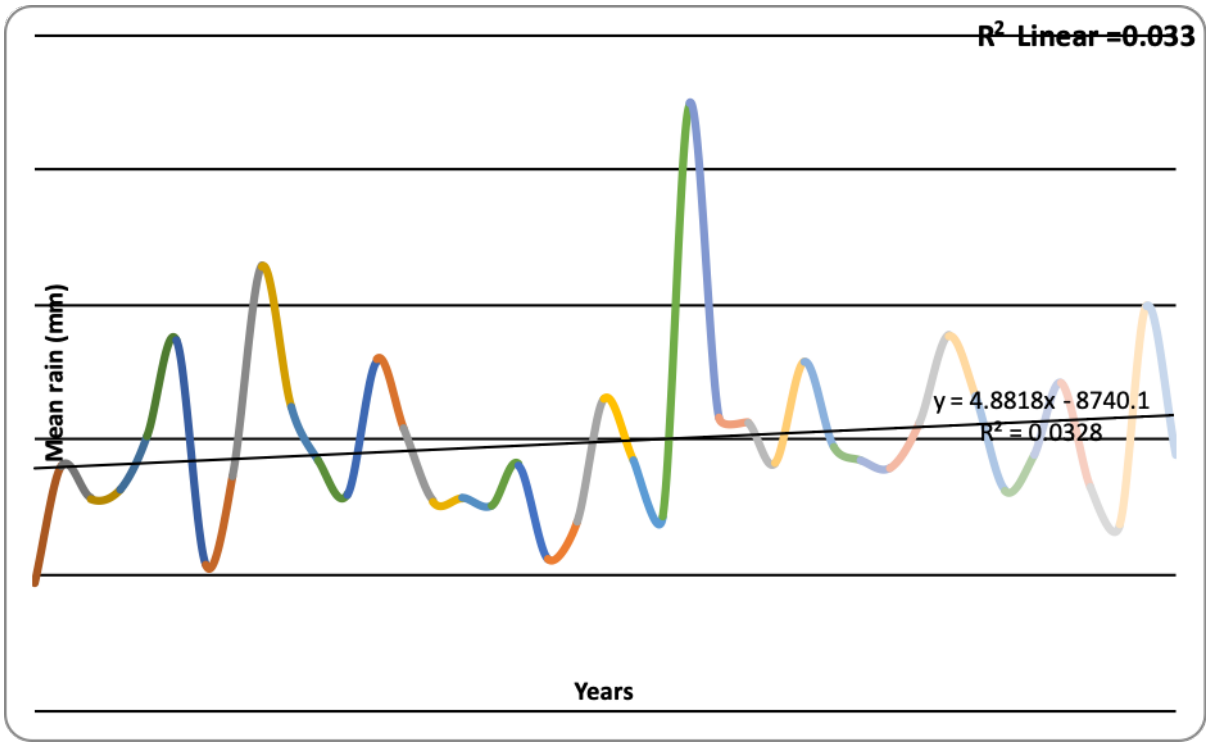


Figure 4.8 Trend Analysis for Rainfall (1974-2014)

A linear regression analysis was conducted to fit the data with the right model

$Y = \beta + \beta_1 X_1 + \varepsilon_i$,

Where:

Y = Average annual rainfall (mm)

X_1 = Time in years

β_j = The coefficient for the independent variable to the j^{th} power

ε_i= random errors.

Table 4.4 Regression Coefficients Annual Rainfall

Model	Unstandardised Coefficients		Standardised Coefficients	t.	Sig.
	B	Std. Error	Beta		
(Constant)	891.719	102.345		8.713	.000
Year	4.882	4.246	.181	1.150	.257

From Table 4.4, the regression equation is:
$Y = 891.719 + 4.882\ X_1$
From the findings, $p > .05$ hence time (in years) was not a significant predictor of rainfall.

Table 4.5 Descriptive Statistics Rainfall

	N	Minimum	Maximum	Mean	Std. Deviation
Rain	41	466.8	2242.0	994.237	322.9799
Valid N (listwise)	41				

Looking at the trend over the seasons, there is a fluctuating trend during the long (Figure 4.9) and short rains (Figure 4.10).

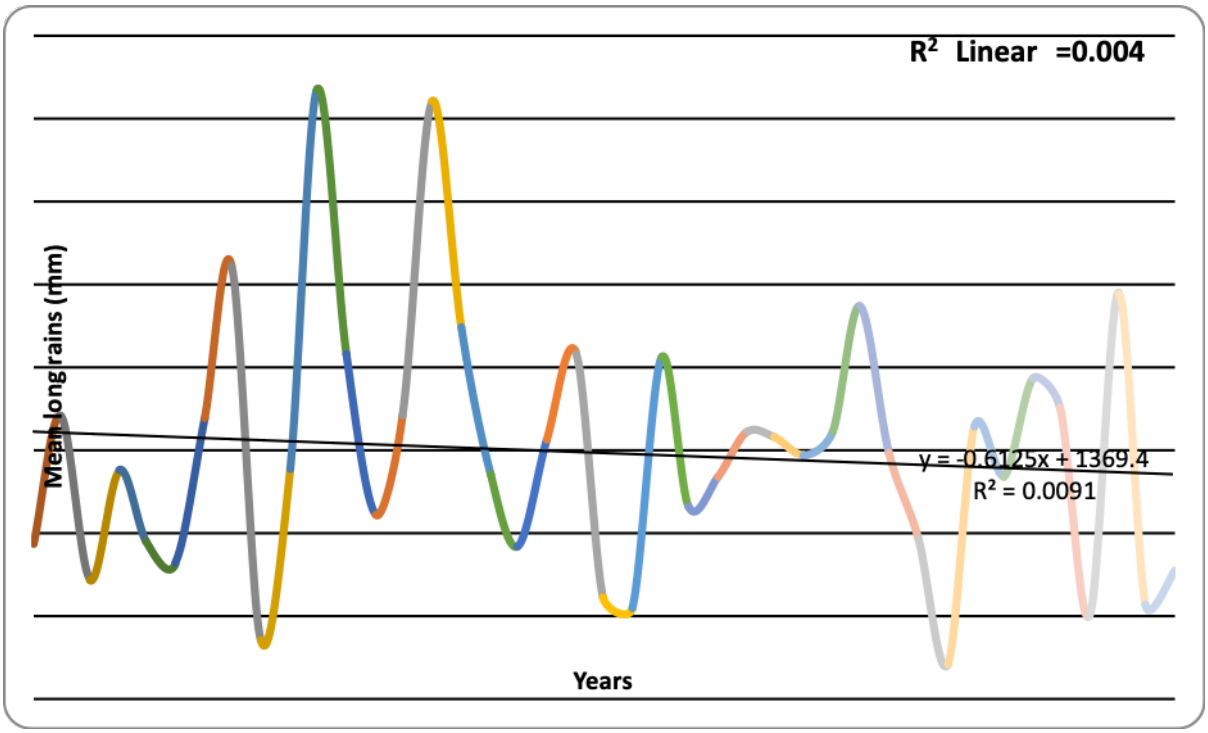


Figure 4.9 Trend analysis for the long rains March – May (1974-2014)

From the results (Figure 4.9), a fluctuating trend is shown whereby the amount of rainfall during the long rains season rises and falls over time. The regression model was devised to determine trend.

$Y = \beta + \beta_1 X_1 + \varepsilon_i,$

A linear regression analysis was performed using the long rains (mm) as dependent variable and time in years as independent variable. Table 4.6 shows the regression coefficients.

Table 4.6 Regression Coefficients for Long Rains

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	160.119	24.910		6.428	.000
Year	-.421	1.033	-.065	-.407	.686

By using the Unstandardized Coefficients (Table 4.6), the regression equation becomes:
$Y = 160.119 - 0.421X_1$
Showing that time was not a significant predictor of rainfall during the long rains ($p > .05$).

Table 4.7 Descriptive Statistics for the Long Rains

	N	Minimum	Maximum	Mean	Std. Deviation
Long Rain	41	20.2	367.1	151.277	77.4757
Valid N (listwise)	41				

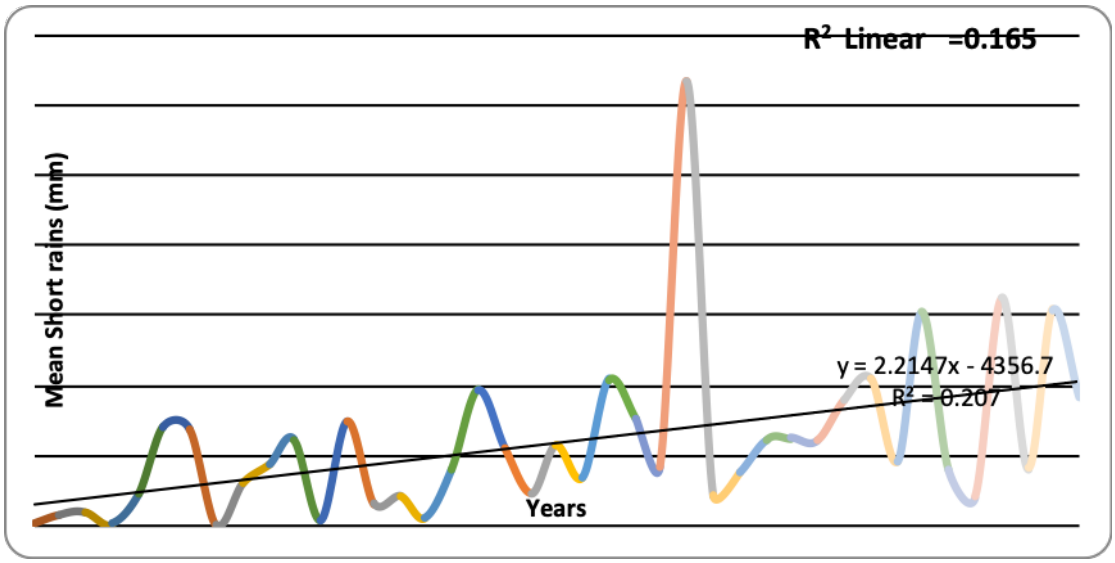


Figure 4.10 Trend analysis during the short rain season October – December (1974-2014)

A rising and falling trend is exhibited. The Regression model was used to determine the trend:
$Y = \beta + \beta_1 X_1 + \varepsilon_i$,
Regression analysis was conducted as indicated in Table 4.8.

Table 4.8 Regression Coefficients for Short Rains

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	19.693	18.569		1.061	.295
Year	2.142	.770	.407	2.780	.008

The regression equation becomes:

$Y = 19.693 + 2.142\ X_1$

The result revealed that time (in years) was a significant predictor of the short rains ($p < .05$). There is an increasing trend of rainfall, during the short rains.

Table 4.9 Descriptive Statistics for Short Rains

	N	Minimum	Maximum	Mean	Std. Deviation
Short Rains	41	.0	316.1	64.672	63.0838
Valid N (listwise)	41				

The study sought to know whether there was a significant difference in the mean rainfall for the long rains and the short rains over time. The results (Table 4.10) show the Levene's Test for Equality of Variance to be 0.037; hence the variances for the two groups are not the same. Therefore, information was selected from the second line of the t-test table – equal variances not assumed. The findings revealed that there was no significant difference in the mean rainfall for the short rains and long rains periods (p=0.436) (Table 4.10) over time.

Table 4.10 Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
									Lower	Upper
Rainfall	Equal variances assumed	9.394	.037	.967	4	.388	84.4100	87.3197	-158.0283	326.8483
	Equal variances not assumed			.967	2.001	.436	84.4100	87.3197	-291.1028	459.9228

Thus there is a non-discernable trend in average rainfall over Lamu during the period 1974-2014. This is also the case for rainfall received during the long rain season. However, the short rains season show an increasing trend over the same time period.

4.2.4 Community Observations of Trends in Temperature and Rainfall

Majority of the respondents (96%) reported having observed changes in temperature over the last ten years (2006 to 2016). Only 4% of respondents observed no changes during the same period. Of those who observed changes (532), 60.2% reported that temperatures have risen while 17.3% observed that it has become cooler over the same time. Out of the total respondents 22.6% reported that even though temperatures have changed in Lamu County, they could not quantify the change. Overall more men than women observed that there were changes in temperature over the last ten years.

Table 4.11 Observation of changes in temperature by gender

		Gender of the respondent		
		Female	Male	Total
Observed changes in Temperature	Cooler	8.8%	8.5%	17.3%
	Warmer	29%	31.2%	60.2%
	Don't know if cooler or warmer	11.1%	11.4%	22.5%
	Total (%)	48.9%	51.1%	100%
	Total	270	282	552

Majority of the respondents who observed that temperatures have risen included watchmen (78.1%), fisherman/woman (73.9%) and pastoralists (72.7%) (table 4.12). These disparities were considered in order to see if certain livelihoods were more sensitive to perception of changes in temperature than others.

Table 4.12 Changes in temperature by source of livelihood

SOURCE OF LIVELIHOOD	'Cooler'	'Warmer'	'Don't Know'
Unemployed	18.6%	58.7%	22.7%
Other Workers[1]	10.0%	60.0%	30.0%
County Government Worker	17.2%	56.9%	25.9%
SME Owner	9.5%	69.0%	21.4%
Jua-Kali (Fundi)	30.3%	45.5%	24.2%
Watchman/ Messenger	15.6%	78.1%	6.3%
Farmer	26.7%	53.3%	20.0%
National Government Worker	25.0%	58.3%	16.7%
Fisherman/ Woman	13.0%	73.9%	13.0%
Domestic Worker	25.0%	60.0%	15.0%
Pastoralist	0.0%	72.7%	27.3%
Mangrove Harvester	28.6%	57.1%	14.3%
Civil Society Worker - NGOs, CSOs and Churches	0.0%	40.0%	60.0%
Rancher	0.0%	33.3%	66.7%
Sand/Ballast Miner	0.0%	50.0%	50.0%
Total %	17.3%	60.2%	22.5%
Total	95	332	125

Out of the sample of 532, 511 (96%) respondents reported having observed changes in the amount of annual rainfall in the last ten years (2006-2016). Out of the respondents who observed changes, 89.4% were of the opinion that rainfall has reduced during this period while 5.9% opined that rainfall has increased over the same duration. The remaining 4.7% who observed changes in rainfall could not say if rainfall had increased or reduced. Similarly, the changes observed in rainfall were examined by livelihood to see if certain livelihoods were more perceptive to changes in rainfall than others. The study showed that on average, a large majority (95.2%) of the sample (511) who noted changes in rainfall were from rainfall dependent sectors –

[1] 'Other workers' denotes casual labourers that are not on long or short contracts – i.e. hired by the hour or the day for specific tasks. For example grass cutters.

this included miners, fishermen, pastoralists, farmers, ranchers and mangrove harvesters (Table 4.13). Out of the total sample (532), 54.5% noted that the amounts of rainfall received have over the years failed to meet their required needs. Further, they opined that the rains received were not enough to last them until the next rainy season.

Table 4.13 Changes in rainfall by source of livelihood

SOURCE OF LIVELIHOOD	Rainfall has Increased	Rainfall has Reduced
Unemployed	6.8%	88.9%
County Government Worker	14.8%	79.6%
SME Owner	9.3%	83.7%
Jua Kali (Fundi)	2.8%	91.7%
Farmer	0.0%	96.6%
Watchman/ Messenger	3.6%	96.4%
National Government Worker	0.0%	87.0%
Fisherman/woman	4.5%	95.5%
Domestic Worker	0.0%	100.0%
Pastoralist	9.1%	90.9%
Mangrove Harvesting	0.0%	83.3%
Civil Society Worker - NGOs, CSOs and Churches	0.0%	80.0%
Rancher	0.0%	100.0%
Sand/Ballast Miner	0.0%	50.0%
Other Workers	4.3%	92.8%
Total	5.9%	89.4%

4.2.4 Knowledge of the term 'Climate Change'

Of those who reported changes in temperatures (532), 16.4% are aware of the term 'climate change'. Similarly, of those who reported changes in the amount of rainfall received (511), 15.8% are aware of the term 'climate change'. All respondents who are SME owners, pastoralists and miners expressed complete lack of awareness of the term climate change. Furthermore, volunteers in CSOs/Churches also showed complete lack of awareness of the term climate change. This was of particular interest

as it was expected that civil society/NGO's would have some awareness on the term climate change. Civil servants (in County and National government) are the most aware of the term climate change at 54.2% and 32.8%, respectively. This is also of particular interest as it was expected that government workers would be much more aware of the term 'climate change'. In terms of livelihoods and awareness of the term climate change, 20% of farmers knew what the term meant. While 14.3% of mangrove harvesters and 17.4% of fishermen knew what the term climate change is (Table 4.14). The observations of these specific livelihoods were examined, as they are perceived to be especially vulnerable to the impacts of climate change due to their dependence on natural resources.

In addition, 11.6% of the total sample (532) noted that in the past they were able to tell when the rains will come (predict the rainy season) but now are unable to, while 8.3% observed that it is still easy for them to tell when the rains will come. Majority of the sample (80.1%) opined that they have never been able to predict the rainy seasons.

Table 4.14 Knowledge of the term 'climate change' by livelihood

		Do you know what climate change is?	
		No	**Yes**
Source of Livelihood	Unemployed	92.1%	7.9%
	County Government Worker	67.2%	32.8%
	SME Owner	100%	0%
	Jua Kali (Fundi)	87.2%	12.8%
	Watchman/ Messenger	88.2%	11.8%
	Farmer	80.0%	20.0%
	National Government Worker	45.8%	54.2%
	Fisherman/ Woman	82.6%	17.4%
	Domestic Worker	68.2%	31.8%
	Pastoralist	100%	0%
	Mangrove Harvesting	85.7%	14.3%
	Civil Society Worker - NGOs, CSOs and Churches	100%	0%
	Ranching	66.7%	33.3%
	Sand/Ballast Miner	100%	0%
	Other Workers	81.7%	18.3%
	Total (%)	84.2%	15.8%
	Total	465	87

4.3 Discussion

The trend analysis showed evidence for an increasing trend of maximum temperatures in Lamu. The results are consistent with Collins (2011), which indicated that rapid warming from 1979 onward was witnessed in Kenya. On a regional level, Issahaku et al. (2016) and Safari (2012) recorded similar results (significant warming) of temperature trends in Ghana and Rwanda respectively. Also King'uyu et al. (2000) investigated the trends in the mean monthly minimum and maximum temperature records over eastern Africa and similarly found evidence of significant warming in the region. Furthermore, the results also show consistency with the IPCC (Watson et

al. 1997) projections for the African continent, whereby land areas in equatorial countries including Kenya, may warm by the year 2050 by as much as 1.4°C. This projection represents a rate of warming of about 0.2°C per decade.

The minimum temperatures showed a non-significant decreasing trend for Lamu. This decreasing trend was also only present during the March to May season. Similarly, King'uyu et al. (2000) found that there were large geographical and temporal variations in observed trends, with some neighbouring locations at times indicating opposite trends. This was particularly the case for many coastal locations and those near large water bodies showing significant opposite trends to the overall warming trends observed around the continent. The possible explanation for this is the potential for temperature variability, occurring as the result of the recurrence of extreme values. King'uyu et al., (2000) concluded that these recurrences were significantly correlated with the patterns of convective activities, especially ENSO, cloudiness, and above/below normal rainfall. This could explain the difference between maximum and minimum temperature trends in Lamu as a sharp spike in rainfall was recorded in 1997, while the years 1988-1989 were relatively dry compared to the annual average. The overall increase in annual temperature observed in the study area is attributed to an increase in the maximum temperature.

The present study sought to compare findings with stakeholder's views and perceptions in order to determine if they concurred with the instrumental datasets. Majority (60.2%) of views of respondents from the household survey (particularly farmers, fishermen/women and pastoralists) agree with instrumental datasets showing an increasing trend in temperature through time. The results give some understanding of the annual changes in temperature at a local level and confirm that global warming can be revealed even at local scales. The general pattern in the trends indicated increased warming in Lamu, which could have severe implications for water availability in the area. If the current trends in temperature continue in the future, the magnitude and timings of water availability in Lamu could be significantly impacted, putting access to drinking water for the thousands of residents in Lamu at risk. Not to mention the additional pressure on water as a result of the expected population increase when LAPSSET is completed.

Further, there were disparities observed in relation to temperature increase between livelihoods. A higher percentage of farmers (53.3%), fishermen/women

(73.9%) and pastoralists (72.7%) noted that temperature had become warmer. These are livelihoods that are especially sensitive to any changes in temperature and are high on the livelihood vulnerability index (Gerlitz et al., 2017). The index uses multiple indicators to assess exposure to natural disasters and climate variability including social and economic characteristics. In this case, the highest levels of exposure and sensitivity combined with low levels of adaptive capacity increase certain livelihoods vulnerability (Gerlitz et al., 2017). Owing to their higher vulnerability to any changes in temperature, they are livelihoods that are more likely to perceive a shift in temperature.

The study findings showed fluctuating trends for mean annual rainfall. The same is observed for the long (March – June) rains. There was however evidence of an increasing trend during the short (October to December) rain season. It is difficult to ascertain consistency with other studies as rainfall trends in Kenya show varying results. For around the same period (1970's into 2009) one study (Githui et al., 2009) identified increasing amounts of annual rainfall within the range of 2.4% to 23.2% in the Western part of Kenya. While another study (Rao et al., 2011) found no discernable increasing or decreasing trend either in annual or seasonal rainfall in the Eastern region of Kenya. According to an assessment of 12 Climate Model Intercomparison Project 3 (CMIP) General Circulation Models (GCMs) over Eastern Africa done by the IPCC (Niang et al., 2014), by the end of the 21st century there will be a wetter climate with more intense wet seasons and less severe droughts during October-November and March-April-May. An earlier report by the IPCC (Watson et al. 1997) projected that equatorial Africa could experience a small increase (of about 5%) in rainfall by the end of the 21st century. However the same report (Watson et al., 1997) also recognised that rainfall results around the region are not consistent. This is due to the challenge of "determining the character of the climate change signal on African rainfall against a background of large natural variability compounded by the use of imperfect climate models" (Watson et al., pg. 4, 1997). Further, as argued by the IPCC (Niang et al., 2014), there is also the challenge of insufficient observational data in Africa. Most areas of the African continent lack sufficient observational data to draw conclusions about trends in annual precipitation over the past century. The observations from one station in Lamu are not enough to draw substantial conclusions. This is due to both spatial distribution and the lack of long-term (more than 40 years) data. But the IPCC (Niang et al., 2014) does conclude from areas

where there is sufficient data, that there are very likely increases in rainfall over parts of Eastern and Southern Africa.

This points to the importance of stakeholder observations and perspectives on changes observed over time. In the study by Rao et al. (2011), researchers looked at farmers' perceptions of short and long-term variability in climate, their ability to discern trends in climate and how the perceived trends converged with actual weather observations by the Kenya Meteorological Department (KMD). They found this method of analysis useful where the climate showed high intra- and inter-annual variability. Similarly, the present study sought to compare the results of the trend analysis with first hand stakeholder observations. A majority of the respondents (89.4%) opined that rainfall has reduced over the past ten years (1996-2016). Additionally, 54.5% of respondents expressed the inadequacy of rainfall during the rainy seasons to meet their everyday needs. They stated that the rainfall received was insufficient to last until the next rainy season. The changes described in rainfall were examined by livelihood to see if certain livelihoods were more perceptive to changes in rainfall than others. The study showed that on average, a large majority (95.2%) of the sample that noted changes in rainfall were from rainfall dependent sectors – this included fishermen, pastoralists, farmers, ranchers and mangrove harvesters. Community members from these livelihoods noted that the amounts of rainfall received over the years have failed to meet their required needs.

Community perceptions do not necessarily agree or disagree with the trend analysis, as there was no discernable trend from the dataset, with the exception of the increasing trend during the short rains. However, community perceptions do differ from global predictions for Africa, whereby it is projected that equatorial Africa could experience a small increase in rainfall by the end of the 21st century (Watson et al., 1997). Understanding the trends is complex and variable phenomena such as rainfall are not as straightforward (Ballew et al., 2019; Wiest et al., 2015). Despite models predicting increased rainfall in East Africa with climate change, the region is frequently experiencing droughts. This has come to be referred to as the 'East African paradox'. It is argued (Lyon and Vigaud, 2017) that the models are accurate but extreme weather events such as El Niño experienced in 2015 could cloud the overall picture. Scientists (Lyon and Vigaud, 2017; Giannini et al., 2008) have offered a number of explanations for the paradox ranging from natural variability of climate that models struggle to capture, to patchy observational data due to poor infrastructure

and records in the region. It is also possible that the underlying wet trend has not yet emerged (Giannini et al., 2008). The frequency and intensity of rain are expected to change due to global warming and they are also indications that they change on shorter timescales (Trenberth, 1999).

It is worth discussing the potential reasons for the results on community observations on rainfall in the Lamu region. On the one hand, it is possible that respondents equated warmer temperatures over the years to a corresponding decrease in rainfall based on their understanding of the correlation between temperature and rainfall. And on the other hand, it is possible that their responses were influenced to a greater degree by variability in rainfall rather than long-term trends. Another likelihood worth noting is the possibility that the findings could point to a problem of storage capacities rather than inadequate rainfall. Residents could be receiving sufficient rainfall but due to poor and outdated storage facilities (discussed further in chapter five and six), they were unable to hold the extra water. As a result, they perceived that rainfall was insufficient.

The trend analysis for temperature and rainfall used in this study demonstrated the use of linear trend as a semi-effective method for studying variations of temperature and rainfall data. While it identified strong trends in temperature that concurred with stakeholder observations, trends in rainfall were not as perceptible and as such, inconclusive. As suggested by the IPCC (Watson et al., 1997) and Sun et al. (2018), historical data may not always give a true picture of an underlying trend. Natural rainfall variation is so great that it could take a human lifetime for significant climate change signals to appear in regional or global rainfall measures. Even exceptional events like El Niño could fit within natural variations in the long-term precipitations records but still distort a normal trend line. This has significant implications for policy makers in the water resources, irrigation and agricultural industries as research may not be able to recognise long-term or permanent changes in annual rainfall driven by climate change until they have already occurred and persisted for some time (Sun et al., 2018). Furthermore, the use of linear trend analysis is not particularly useful for making future projections (Adhikari and Agrawal, 2013), which are important in climate change research. A major problem in forecasting trends involves identifying turning points. With hindsight, turning points are clearly visible, but it can be difficult to tell in the moment whether they are mere aberrations or the beginning of new trends. Long-term projections need more data to support them, and that may not

always be available, particularly for areas with only one operational weather station such as Lamu. With only one station making observations, it is difficult to corroborate results. Furthermore, many regions in Africa show discrepancies between different observed precipitation data sets (Njang et al., 2014). This is a major weakness observed in the Africa region.

While the rainfall results for Lamu may be inconclusive from the present study, the findings present an opportunity for residents in Lamu to plan more efficient and sophisticated methods of water storage so as to meet their water demands and needs especially in between the rainy seasons. Generally the study found that most of the respondents who noted changes in temperature and rainfall were farmers, pastoralists, fishermen/women and mangrove harvesters. These livelihoods are highly dependent on rainfall and are more likely to perceive any negative changes impacting their access to water. Persistent water problems will make it more difficult for water dependent livelihoods in Lamu to survive and may result in a higher rate of rural-urban migration in the region. This will add to the already significant urbanization trend in the region. The findings from this study emphasize the need to improve the overall process of water access and use to support the ability of households to make strategic, long-term decisions that affect their wellbeing.

Climate change is a physical as well as a political, social and cultural phenomenon and as such poses significant communication challenges. Current research shows that the meaning people ascribe to climate change is closely related to how it is portrayed during communication (Flottum, 2016). The study found that the knowledge of the term ‘climate change’ is low in this area. This was the case across different ages, livelihoods and parts of Lamu. However knowledge of the term climate change does not necessarily reflect or indicate their awareness of the climate change process and concept. On one hand, respondents perceived changes in temperature and rainfall and were able to quantify these changes, showing they had climate change knowledge. The local population of Lamu have developed and implemented extensive coping strategies that have enabled them to reduce their vulnerability to past climate variability including livelihood changes and changes in crop rotation (this is detailed in chapter five of this thesis). On the other hand, it is important to note that some interviews were conducted in Swahili as respondents were not all fluent in English. There is no clear Swahili word for climate change, so the description ‘mabadiliko ya hali ya hewa’ was used. This directly translates to changes in weather over time. The

language discrepancies could contribute to the low knowledge of the term climate change found in the study.

Also some respondents noted that they were able to predict the start and end of the rainy seasons. In many cases across Africa, rain forecasting and predicting is evident in communities through indigenous knowledge systems. This knowledge is passed down to just a few members of the community and sustained through the generations, usually by word of mouth and cultural rituals. Indigenous local knowledge has been the basis of agriculture, conservation, education and a wide range of other activities that sustain a society and its environment (Senanayake, 2006). Moving forward, it would be valuable to see how to integrate the knowledge of the older generation into planning and management of water in Lamu. Widespread climate change awareness and education efforts could be one way of doing this.

4.4 Conclusion

The results from this study identified significant warming trends in the region as well as evidence for increasing trends in rainfall. Overall, there was a relationship between stakeholder observations and findings from instrumental data sets. However more observational data would be useful in strengthening the trend analysis, particularly for rainfall as the Lamu station was limited by spatial distribution of data as well as the lack of longer- term data. Further investigations using GCMs would benefit from integrating local and traditional knowledge in order to enhance planning and decision-making on water and infrastructural development at the local level.

CHAPTER FIVE

ASSESSING VULNERABILITY OF LAMU'S WATER TO THE IMPACTS OF CLIMATE CHANGE BASED ON EXPOSURE, SENSITIVITY AND ADAPTIVE CAPACITY

5.1 Introduction

Assessing the vulnerability of water to the impacts of climate change is important for any approach to water resources management. The study examined vulnerability of Lamu's water resources in terms of exposure, sensitivity and adaptive capacity. The results of this chapter accomplish the third objective of this study. The findings are presented from running descriptive and inferential statistical analysis. In addition, quantitative and qualitative findings are combined through triangulation analysis in order to understand the relationship between freshwater and climate change.

5.2 Results

5.2.1 Vulnerability of Water in Lamu: Exposure

Annually Lamu displays an increasing trend in temperature over the period 1974-2014. For rainfall, there appears to be an increasing trend in annual rainfall received over the same period. While this trend lacks statistical significance, it agrees with other studies, which conclude that there have been small increases in rainfall in the East African region (Watson et al., 1997, Njang et al., 2014; and Githui et al., 2009). The present study also found differences in rainfall trends according to the seasons. The 'short rains' (October – December) are receiving more rainfall while the long rains (March to May) are receiving less rainfall over the period 1974-2014 (Refer to chapter four for more detail).

In line with the observed changes in temperature and rainfall, Lamu's main sources of freshwater have also undergone changes over time. Lamu is predominantly dependent on wells and boreholes as a source of potable water (85% of the respondents). Additional sources of freshwater for residents include rainwater harvesting and piped water from the Water Resources Authority (WRA). While there are numerous wells and boreholes in Lamu, few of them are documented and

registered with the County government. Wells and boreholes are sunk haphazardly and not recorded with local officials. From the wells surveyed and tested, Table 5.1 illustrates the range of depth as well as quality of water in public access, documented wells in Lamu. Out of the 16 wells tested, average salinity was found to be 805 ppm, which by salinity status classifications (by total salt concentration) is classified as marginal (Mayer et al., 2005). At such levels of salinity, most irrigation is possible however adverse effects on ecosystems become apparent. However out of the 18 boreholes, two are classified as saline with limited use. A map of wells and boreholes in the study area is included in chapter 6 (Map 6.1)[2].

Furthermore, drilled boreholes as part of the LAPSSET project were also tested. The boreholes were drilled between January and July 2016 to supply water to the first phases of project implementation. Out of six of the boreholes drilled, five were operational. Water quality analysis results indicated that two of the drilled boreholes had high levels of mineral content beyond the World Health Organization (WHO) standards (Yamamura, 2003) and were unsuitable for use. Anecdotal observations from local residents highlighted the fact that in the "old days", water was abundant with every well dug up yielding good results in the form of clean, plentiful freshwater (refer to chapter six for more detail on the history of Lamu's water accessibility and availability). The findings from the examined wells confirm that water quality has changed from the "old days".

[2] This refers to the wells that have been registered with the Water Resources Authority (WRA) and boreholes that were sunk as part of the LAPSSET project.

Table 5.1 Sample of Public Access Wells[3] Tested in Lamu[4].

Date Tested	Name of Borehole	Locality	Ec (µS)	TDS (ppm)	Sal/NaCl (ppm)	pH
02/03/10	Daul Mosque-Shella	Lamu Island	295.2	148	0.1	8.35
02/03/10	Gullies Tunre	Lamu Island	293.4	148	0.1	7.33
02/03/10	Shella House	Lamu Island	437	219	0.2	7.4
02/03/10	Shella stadium	Lamu Island	431	219	0	7.5
25/03/10	Lakwa well 5A	Mpeketoni	866.2	1,126	829	7.26
25/03/10	Lake Kenyatta	Mpeketoni	550.5	727.2	509	7.25
25/03/10	Wiwa well 3	Witu	1,118	11,456	1,079	6.74
14/05/10	Visima viwili well	Lamu Island-Kipungani	4165	4702	4404	7.73
14/05/10	Mbirika moja well	Lamu Island-Kipungani	533.1	596.6	500.5	7.69
14/05/10	Kisima ya punda well	Lamu Island-Kipungani	1168	1292	1150	7.81
18/05/10	Shella construction site well	Lamu Island-Shella	644.8	705.4	595.5	9.69
18/05/10	Bahari Hotel well	Lamu Island-town	2053	2232	2068	7.32
19/05/10	Kijoka well	Lamu Island-Matondoni	1009	1110	922	7.53
19/05/10	Kipungani School	Lamu Island-Matondoni	876.5	1036	845.3	7.61
19/05/10	Lake Kenyatta	Mpeketoni	550.5	727.2	509	7.25
19/05/10	WIWA Well 3	Witu	1118	11456	1079	6.74

[3] Boreholes are drilled by machine and are relatively smaller in diameter. Wells are sunk by hand and are larger in diameter.

[4] Ec – Electrical conductivity; TDS – Total Dissolved Solids; Sal - Salinity.

As part of evaluating the impact of temperature and rainfall on freshwater accessibility and availability, the households were asked if they had changed their main source of water in the past ten years (1996-2016). Nearly half (47.8%) of the respondents had changed their water sources at some point in the past ten years, while 52.2% continued with their current source. As shown in Figure 5.1, majority of those who had not changed their water source listed rainwater harvesting and wells as their primary source of water.

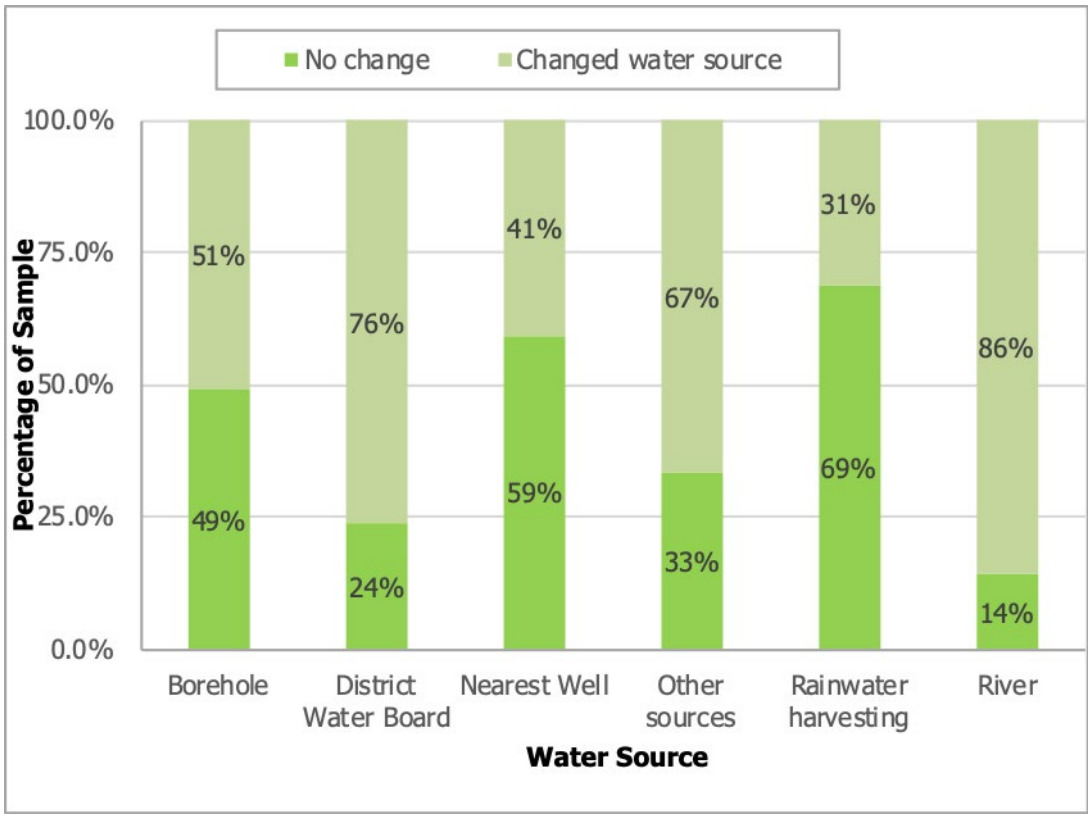


Figure 5.1 Respondents Choices to Change their Source of Water

At the same time, 86% of respondents who were dependent on rivers as a water source have had to change their immediate source of water. This correlates to interviews with stakeholders who revealed that seasonal rivers were becoming more difficult to access for a number of different reasons. In some interviews with local farmers, they claimed that the seasonal rivers have long dried up and as such they were forced to change their water source. This shows that seasonal rivers and streams in the region have become more short-lived than the past. Red Cross officials agreed with this view claiming that seasonal rivers are drying up at an alarming rate and they are noticing more water related illnesses coming up in the region.

Furthermore, interviews with a local NGO representing the Boni Aweer indigenous community revealed that the seasonal river previously accessible to the community is now under the control of Kenya Defence Forces (KDF) soldiers. On the other side, in the Manda area of Lamu, community members expressed frustration a small stream they previously used for water was inaccessible due to the foreigners who had taken up residency in the area. The Lamu Coal Plant set for development in the area has brought several Chinese residents affiliated with Amu Power (the company tasked with building the coal plant) and according to local residents; they have taken ownership over the local stream that previously supplied them with water. They have done so by erecting structures to keep locals from accessing the water source. Currently, there are no actions being taken to restore locals access to the local stream. At the same time, the water dependent livelihoods of pastoralism, sand and quarry mining on average, have had to change their water source (Figure 5.2) in the last decade. Furthermore, 47% of farmers have had to change their water source in the same period. This could suggest a number of things including water storage problems, insufficiency of rains to meet the commercial demands of water in the area as well as the possibility that water is spatially variable.

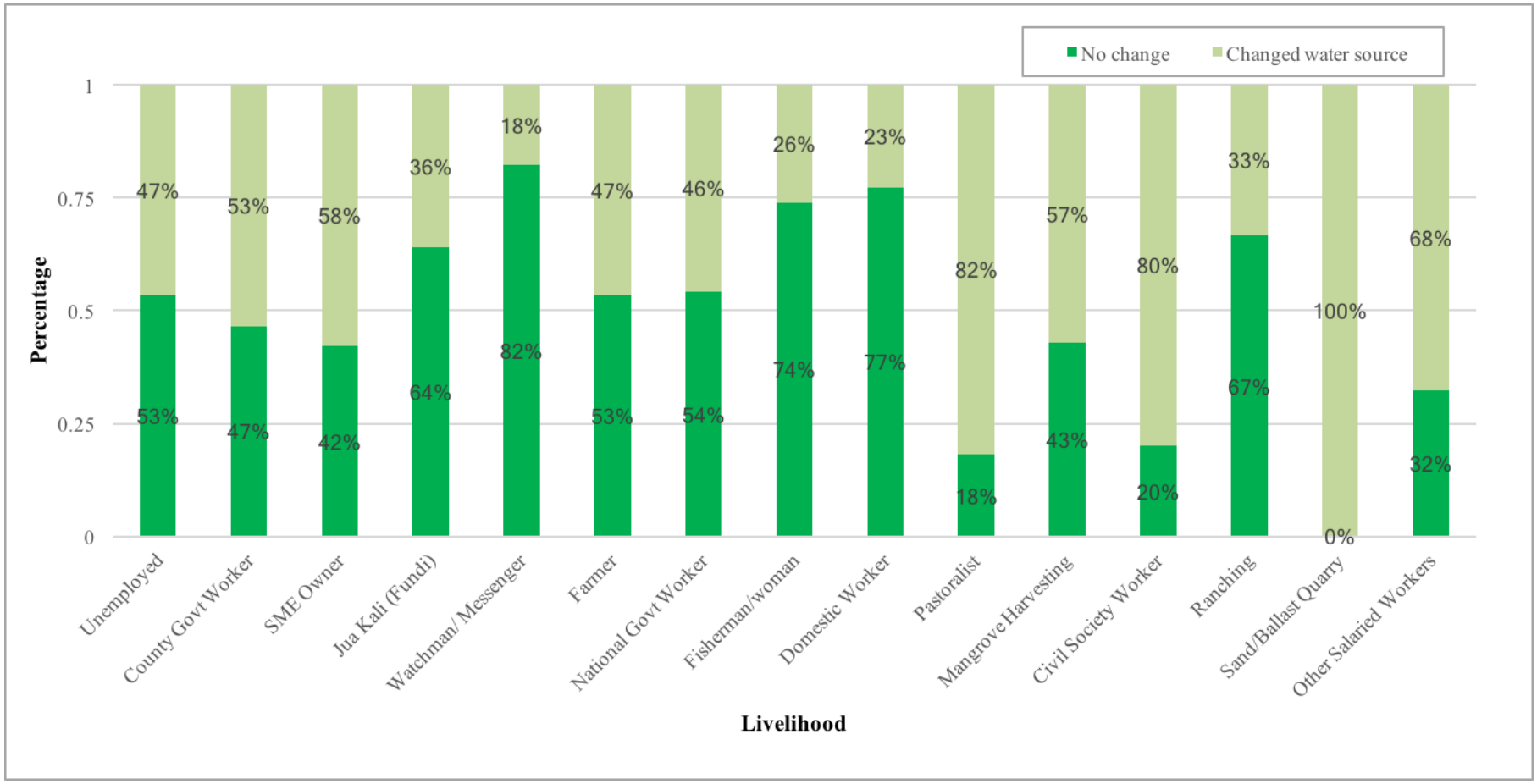


Figure 5.2 Respondents Choice to Change Water Source According to their Livelihoods

In some of the interviews conducted, respondents stated that they changed their water source to the nearby wells and boreholes because they didn't have to pay for it. They could just dig their own wells, as it was uncontrolled and more reliable than waiting for the County water supply. Wells are sunk by hand and the associated costs are considerably cheaper than paying for water from the County supply. According to a County water representative: *"The boreholes are too many, too many to even take count"*. Out of the 52.2% who did not make any changes to their water source, four in every five respondents affirmed that their main source of water was both reliable and accessible. Of these, 87.78% indicated that their main use of water was 'household other'. In other words, majority of those who found their water source reliable were not depending on that water source for drinking water. When housewives were interviewed on their 'other' uses of water within the household, they mentioned religious reasons as well as cleaning clothes, dish washing and household cleaning. Arguably the quality of water is not as important for other household uses as it is for drinking and could explain why they found this water more reliable and didn't need to change their source of water.

Furthermore, of those who listed that their main use of water was household – drinking (52.7%), majority of them source their water from boreholes and wells and have not had to change their water source (Figure 6.3) in the past ten years suggesting that the wells and boreholes provide water of acceptable quality for drinking. But when some of these households were interviewed, they claimed that they hadn't changed their water source because drinking water in Lamu was very expensive and they could not afford it. Private companies based outside of Lamu supply bottled drinking water to local shops and hotels. Some of these companies include Coca Cola and Keringet.

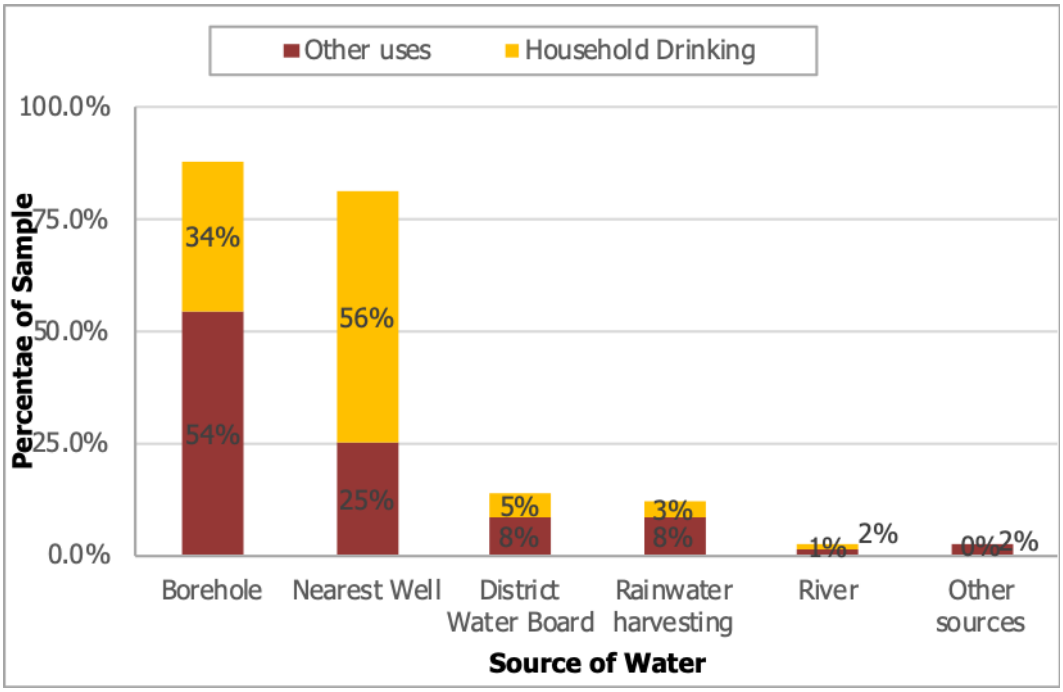


Figure 5.3 Community Uses of Water against Source of Water[5]

Conversely, households in Shella where the overall earning is higher than the rest of Lamu (Beyene et al., 2018), claimed they were buying water for drinking because the water quality had changed over the years. Shella residents are predominantly supplied with water from the Shella aquifer (see chapter six for more detail). From an observation point of view, this was most definitely the case. During the course of the study, the water supplied to the household in Shella where I was residing was very difficult to cook with/drink due to the excessive salinity. Bottled water sourced from Nairobi and supplied in the local shops was used for drinking, as well as cooking.

From the survey, a significant majority of respondents noted changes in temperature and rainfall, however this did not significantly affect whether or not they changed their water source. For instance, as shown in Figure 5.4, out of the 288 respondents who did not change their water source, 96% of them noted a change in temperature. Similarly, of the 264 who did change their water source, 97% of them did not note a change in temperature over the years. This suggests that changes in temperature and rainfall were not the main influencers of changing their water source.

[5] Community uses - Household Drinking and Household Other

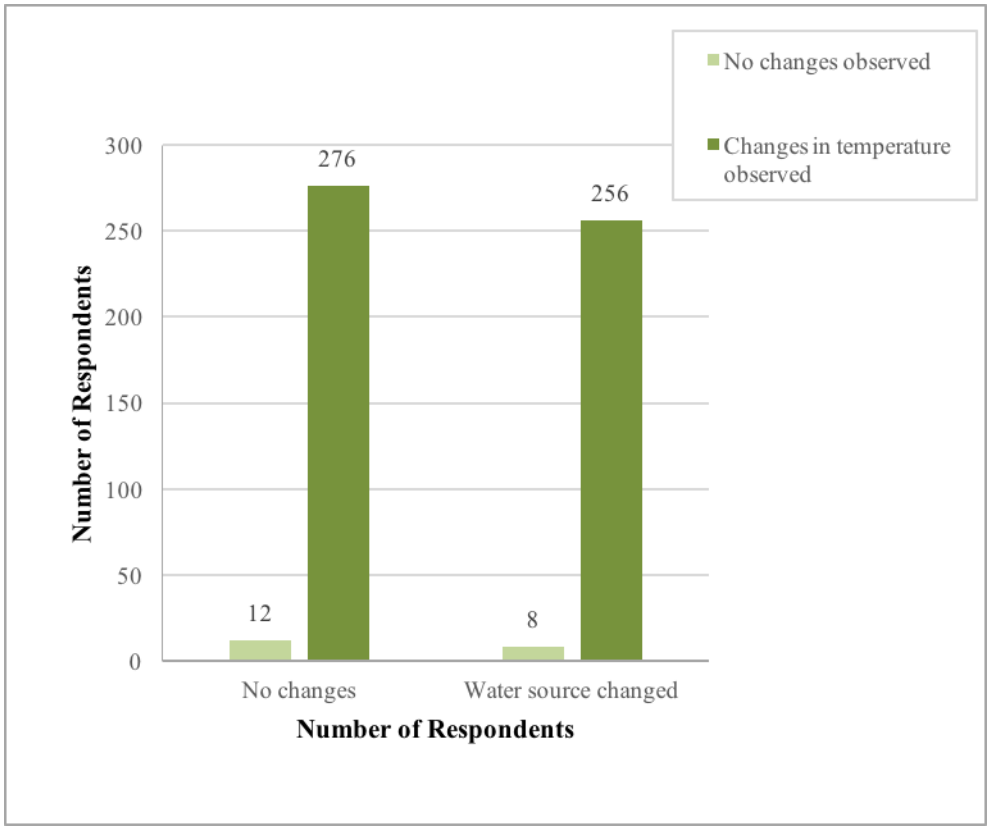


Figure 5.4a Changes in Water Source versus Changes Observed in Temperature

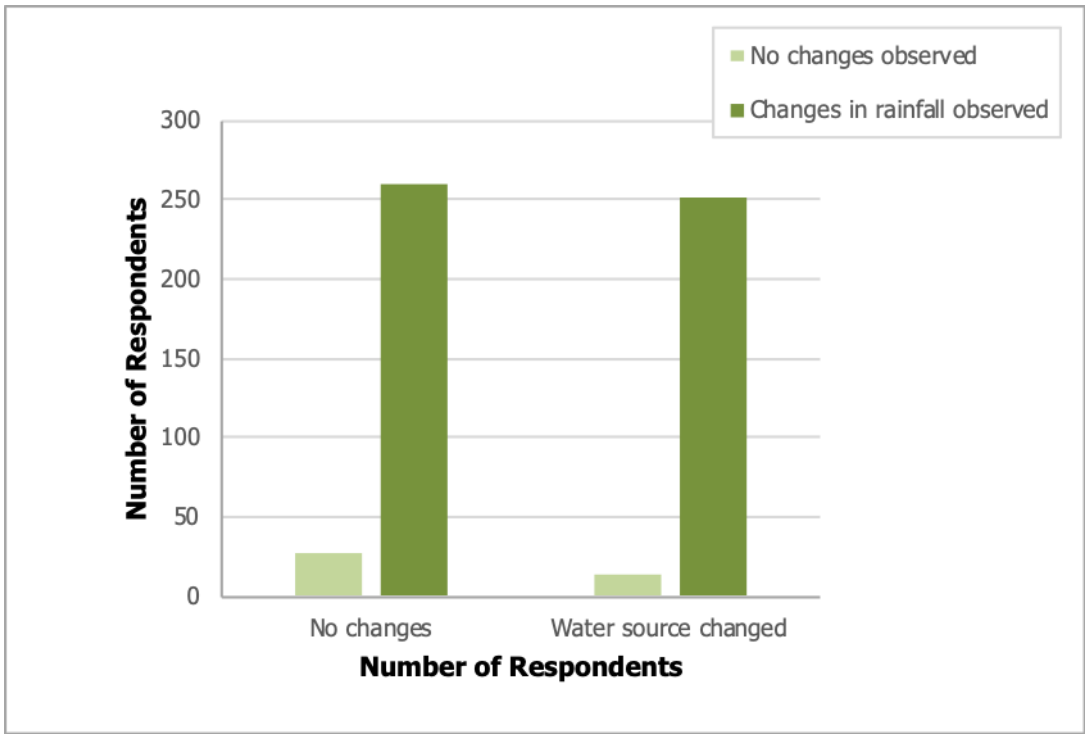


Figure 5.4b Changes in Water Source versus Changes Observed in Rainfall

On the other hand, 86% of the respondents who reported changes of the source of water made this change between 2011 and 2015. Correlating to the temperature and

rainfall data from the Kenya Meteorological Department (KMD) in that time, it is possible to note the following:

- In 2011, there was unusually more rain during the short rains season compared to the long rains season. Further, in 2011 and 2012, long rains started a month late (April instead of March).
- During 2013 and 2014, normal rain was recorded during the long rains season while relatively low rainfall than usual was recorded during the short rains season

It is therefore suggested that this fluctuation in the rains received, points to the changes in the water sources by majority of the residents in this study. As illustrated in figure 5.5, more than half of the respondents did change their primary source of water in that time period to nearby wells.

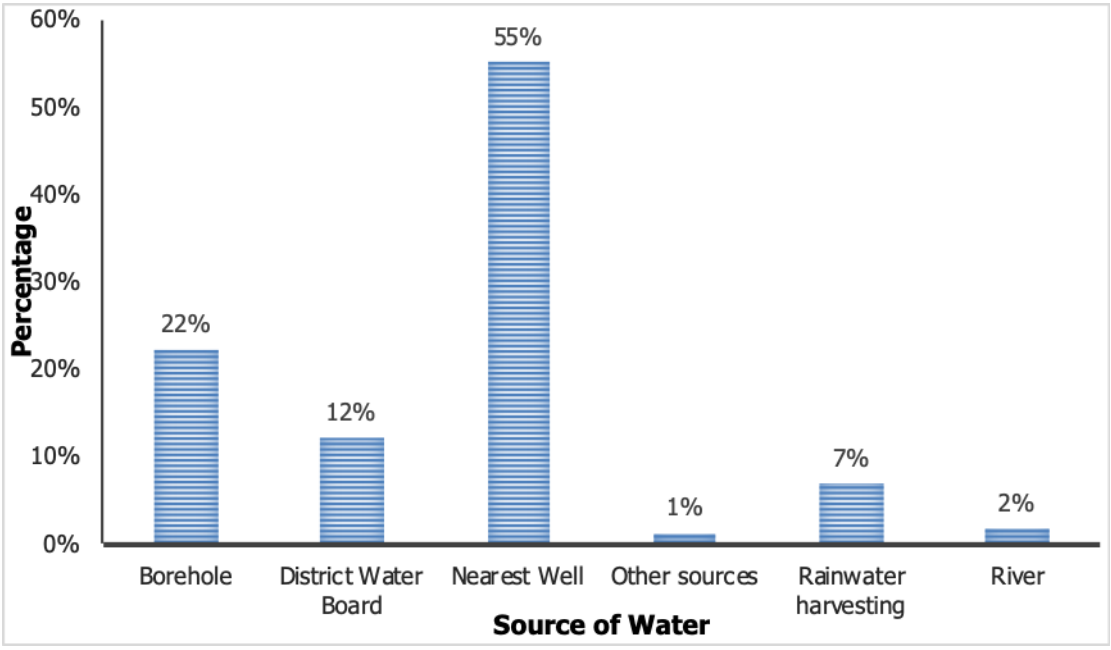


Figure 5.5 Water Sources that Respondents Changed to during 2011-2015

5.2.2 Vulnerability of Water in Lamu: Sensitivity

On one hand, results confirmed that Lamu's water storage systems as well as supply infrastructure are especially susceptible to the negative impacts of climate change (Table 5.1). There is evidence of increased salinity from water testing as well

as the fact that boreholes and wells tested were all classified as shallow. Interviews with water experts in the area confirmed that they were outdated and not built to withstand extreme weather conditions. Residents complained of the continuous occurrence of pipes bursting on the mainland (this was also confirmed by the County government officials). Instances of damaged pipes and as such a breakdown in piped water supply is becoming more frequent in the area. Residents indicate that the pipes are not well maintained and are in poor condition. In several instances, burst pipes have been left unattended for many days at a time leaving residents without water. The County government water supply is prone to shortages and negligence, forcing residents to go for weeks without any supply of water. This is confirmed by the survey findings where several respondents reported changing their source of water from County (District Water Board)[6] to borehole and nearby wells (Fig.5.2). This refers specifically to piped water supplied by the water service provider.

For those who changed their water source to wells and boreholes, they claimed in the interviews that while the well water was saltier than government piped water, at least it was always there and accessible to them. On the other hand, according to the interviews with the Lamu County water authorities, the County's budget for water is exceptionally low, with little additional support from supplementary budgets. To put this in context, Lamu's County Budget (2019) allocates 2.4% of its total budget to water. This is approximately 78,416,933 out of the total County budget of 3,297,785,402 (Lamu County Government, 2019). In many cases, the national government receives additional financial support in the form of grants and donor funding for improving water provision nationally (Mvulirwenande & Wehn, 2020). According to the Lamu government, when this money is disbursed, Lamu is not included as one of the County beneficiaries. This is due to the fact that Lamu is a tourist site and as such, is perceived to be a "rich" County that does not require as much financial support. Thus, Lamu receives a relatively low supplementary[7] financial allocation from the national budget in relation to the County's water needs. This results in poor service delivery, and frequent shortages in water supply.

[6] County District Water Board – is in reference to the water service provider LAWASCO. This term was used in the questionnaire as during the survey testing, county district water was more commonly used than LAWASCO.

[7] Supplementary budget for water – refers to additional donor or grant funding distributed nationally for water projects. This is separate from the County budget allocations.

Local residents brought up sea level rise as a significant concern. Community members spoke of the sea level starting to surpass the sea wall, which was confirmed by personal observations.

"When I was younger, I would go up to the sand dunes where I would collect 'vikoma' (a small fruit from the palm trees). After eating them you would get very thirsty. So after eating them I would go down to the beach about 5 meters from the ocean and dig up the sand. There we would find water. We would collect the water in empty coconut shells, cover them with our t-shirts or kikoys as a filter for the sand and drink the water. The water was very fresh. You can't do that anymore, now the sea water is closer and deeper…"

Narrations such as this were recorded during the study, particularly in interviews with older members of the community. This provides evidence of changes in sea level, which could be indicative of global climate change. Also, images taken during the course of the study show the sea wall, and water levels surpassing the barrier during the high tide (Fig. 5.6).

Figure 5.6 Sea wall in Shella during sunrise

Additionally, religion plays a significant role in the accessibility of and use of water in Lamu. In several household interviews, it was revealed that Muslim households use water as part of prayer rituals, practices that non-Muslims viewed as wasteful and extravagant. At the same time, it was also revealed that Muslims are encouraged as part of their religion to conserve water and not be wasteful. They therefore view swimming pools and water features in hotels and residential homes as frivolous causing some tension between locals. Furthermore, a young lady interviewed in Shella, but originally from Mpeketoni claimed she had moved to Shella because she couldn't access basic amenities in Mpeketoni as a non-Muslim Kikuyu:

"People in Mpeketoni have many issues. The Muslims don't get along with us, and they control basic amenities including access to water. Kikuyu's really have to hustle to get any water"

In 2014, more than 60 people were killed in what was deemed a terrorist attack in and near Mpeketoni. Since the attack, tensions have been high between the Muslim and non-Muslim population in the region, trickling down to disproportionate control over water access.

5.2.3 Vulnerability of Water in Lamu: Adaptive Capacity

Lamu County is experiencing a surge in water demand resulting in current pressure on local water supplies. This is predominantly due to a major infrastructural development (LAPSSET) in the region. The project is attracting people into the County from around Kenya, as well as encouraging rural to urban migration within the County borders with the promise of new opportunities and jobs. County Government officials confirmed that since the start of the project, they have noticed a surge in population of youth in the region. They stated that former President Mwai Kibaki instituted an initiative in the region under the LAPSSET project mandate, to give youth educational scholarships to be better suited to attain jobs once the project is complete and fully functional. This has encouraged wide spread rural to urban migration within the region and neighbouring counties. Another point worth noting is that residents of neighbouring counties are migrating into Lamu in search of water. This is confirmed by interviews with pastoralists who revealed that majority of them were not original residents of Lamu. This would explain why most of the pastoralists

surveyed noted they had changed their water source (82% of pastoralists surveyed showed they had changed their water source). These included Maasai herders who had moved from Garissa in search of better water supply in Lamu. The reason for their change in water source was therefore likely their migration.

Furthermore, some respondents indicated livelihood changes as a result of water issues. One resident in Shella claimed it was impossible to farm commercially in the area, saying: *"…You would be competing for water with hotels and their swimming pools and their washing machines, it's better just to farm small things for your family"*. Additionally, majority of the farmers interviewed claimed to have more than one job and did not solely rely on farming for their livelihoods. They relied on their farms for their household needs rather than meeting commercial supply. Similarly, fishermen interviewed claimed they were diversifying their income to include income from conducting tours on their boats. They claimed this was due to the change in their harvests, particularly those fishermen whose specialty is shellfish. This could be due to the fact that an increase in daily temperatures results in an increase in the number of days ideal for algal growth. Harmful algal blooms can be detrimental to molluscan shellfish that eat the toxin producing algae (Oxenford and Monnereau, 2017). They also claimed they had to travel further distances to meet their daily quotas and with the high cost of petrol, it was becoming more difficult for them to make profits.

Respondents who stated that water was more readily available during the rainy season were more dependent on boreholes, nearest wells and rainwater harvesting (figure 5.7). Some of the farmers interviewed insisted on using rainfall for crops, and well water for household use, as well water was insufficient to simultaneously sustain their farms and households. However, at the same time, some farmers reported uncertainty in predicting the onset and cessation of the rainy season, which makes it difficult for them to plan as well as have any sustainable commercial interests dependent on rainfall. This is confirmed by the household survey which showed that the ability of respondents to predict the start and end of the rains has significantly changed. Few respondents claimed that they were previously able to predict when the rains would come but are currently unable to and a majority of respondents (54.3%) said they did not receive the same amount of rainfall every year.

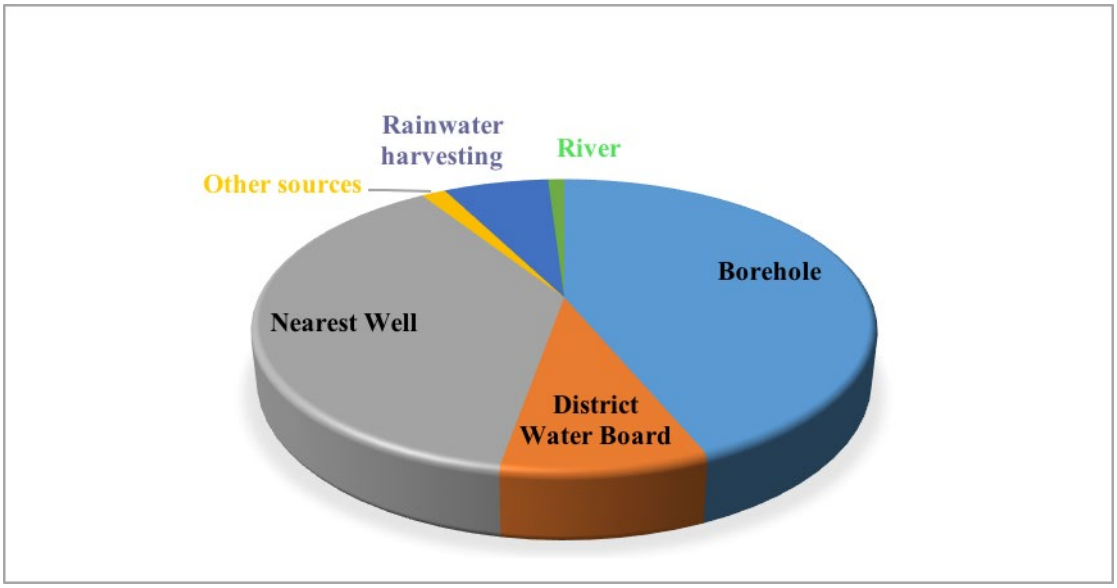


Figure 5.7 Water Availability during the Rainy Season by Source

In addition, some community members brought up the issue of new housing developments in the region and the additional pressures they are placing on local water:

> *"We get rainfall, but a lot of water rather than go into the ground, flows into the sea. This is because of all the buildings with cement floors blocking the water from seeping into the ground. So the water just flows to the sea instead of to our wells. Also, all these new houses mean more people are moving to Lamu and our water is not enough for the people who are already here!"*

Residents believed that their rainwater harvesting systems needed an upgrade to enable them to improve their water supply in light of the water demands of a surging population. They cited the lack of finances and the absence of political will as the challenges to up scaling their rainwater harvesting systems. They claimed that the County Government would rather supply them with water from water service providers (WSP's) and keep increasing the price, instead of building innovative water technologies.

5.3 Discussion

The first part of assessing vulnerability determines the exposure of a system whereby exposure refers to the magnitude of climatic changes affecting a particular system. Specifically for water, the study considered the changes observed in distribution to river flows and groundwater recharge over space and time. This was observed in relation to the changes in temperature and rainfall over time. The study concludes that there is a relationship between the changes observed in temperature and rainfall over the period 1974-2014 and the changes noted in Lamu's seasonal river flows as well as groundwater recharge. As temperatures are on the rise and seasonal rainfall patterns appear to have changed, seasonal rivers have disappeared and the quality of groundwater sources has significantly deteriorated.

This finding leads to three main concerns. The first is Lamu's unsustainable use of water amidst a deteriorating supply of water. To meet the demand for water, residents build boreholes and wells at a rate that is uncontrolled and unregulated. The County government is overwhelmed and as such, private wells/boreholes receive minimal oversight. This includes limited testing upon installation as well as inadequate documentation and tracking of water reservoirs. The increased use of unregulated groundwater reservoirs can potentially magnify other problems associated with over-pumping including contamination of drinking water, sinking land, depletion of water sources fed by the water table and disputes between adjacent land owners. In the midst of limited water supply, the community needs to understand the implications of their actions and work cohesively to avoid the 'tragedy of the commons'.

Second is the issue of unequal/biased distribution of clean drinking water due to the high cost of water. Drinking water is expensive to buy and as a result only certain parts of Lamu and members with higher incomes are able to access clean, quality drinking water. While piped water is available in some parts of Lamu, distribution is sporadic and during water shortages, residents are forced to buy water. Furthermore, while digging up of new wells or boreholes is relatively cheaper than buying water from the government, it still has an associated cost. Thus, not all members of the community are able to do so to supplement their water sources that are being depleted. Digging up a new well or borehole also requires that residents have access to land to be able to do so. Many of the residents do not have their own plots of land and are clustered together. For residents without sufficient means, the

high cost of water from unofficial and official sources is undermining their human right to safe and clean drinking water. This kind of inequality has huge knock on effects for other areas of development including health, education and productivity. It also impedes efforts to achieve targets associated with the sustainable development goals. Third, is the issue of increasing competition in the demand for an increasingly limited water supply. This is demonstrated in the regions of Lamu where on one hand seasonal rivers are drying up. But at the same time, competing interests in the water source limit access to the seasonal rivers. This is also posing a threat to local indigenous populations who have relied on these seasonal rivers to meet their water needs. To meet the increasing demands for water in the region (particularly on the onset of major infrastructural development), there is need for Lamu to augment the limited natural water supply.

Another part of assessing vulnerability is in the sensitivity of a system, where sensitivity refers to the characteristics of water systems that would determine vulnerability to climate change. This could include the social, economic, political and geographic factors that would make Lamu's water supply more susceptible to climate change. The results confirmed that water infrastructure in Lamu is outdated, and in dire need of an upgrade. Particularly as population increase is envisioned as a result of the LAPSSET project. Also, the pipes supplying water directly from the WSP are poorly maintained with residents complaining of frequent bursts and resultant water shortages. From a political standpoint, Lamu is perceived nationally as a rich County due to its status as a tourist haven. The reality is that this perception has caused Lamu to have an inadequate supplementary budgetary allocation for water services and in a way, increased their vulnerability to climate change.

Geographically, Lamu is at the risk of experiencing the negative implications of sea level rise as a result of climate change. This is evidenced by anecdotal narrations from local residents indicating that sea levels have risen, images taken during the course of the study and data showing that new boreholes in Lamu are saline (Table 5.1; Fig. 5.6). Climate change heightens the pressure on coastal zones, endangering socio-economic activities, ecosystems and coastal infrastructure with direct impact on the economy of these areas (Mussi et al., 2018). The present study provides information on a local scale of coastal hazard effects, encouraging a more effective urban and natural resources management plan for the region. A social factor that is a cause of concern in Lamu and is potentially a factor that is intensifying

Lamu's vulnerability to climate change is the current tension between the Muslim and non-Muslim community. While there is no direct, linear relationship between climate change and violent conflict, certain circumstances can influence factors that lead to or exacerbate conflict. Limited water supply and extreme weather events may negatively affect food security and undermine the livelihoods of vulnerable households and communities. The chances of this happening are heightened by the already existing religious tensions in the area. The study recommends that understanding this relationship and taking measures to prevent such conflict occurring, should be a matter of urgency for Lamu County.

The final aspect of a vulnerability assessment looks at the adaptive capacity of a system. This references the ability of people or ecosystems to deal with the resulting effects of climate change. The study identified three factors that play a role in determining the adaptive capacity of the Lamu community. First, the surge in population weakens the ability of the community to deal with the impacts of climate change on water. This is predominantly due to the fact that the surge in population is occurring without any corresponding infrastructural changes or developments to support it. Furthermore, there appears to be no clear plan by the relevant stakeholders to improve the current infrastructure. Second, the changes made to livelihoods could potentially strengthen their adaptive capacity. Thulstrup (2015) explain that some households possess more adaptive capacity than others owing to their ability to diversify their livelihoods. Households remain more vulnerable when they have limited access to capital and engage in non-diversified livelihoods. The present study found that farmers and fishermen in particular are minimising their vulnerability to changes in water access by seeking alternative livelihoods, or expanding the ambit of their current work. Alternative livelihoods in this case include the farmers having more than one job, while fishermen are using their boats to conduct tours in addition to fishing. But on the other hand, this could result in greater food insecurity in the region, which would negatively influence their adaptive capacity. Resource declines can impact not only fishermen and farmers, but also shore-based businesses (business whose premises are along the shoreline) including wholesalers, distributors, restaurants and markets that are dependent on locally sourced produce. Third, the ability of the community to use local indicators for weather forecasting and climate prediction can also play a part in strengthening adaptive capacity. Integrating local knowledge systems with the efforts of climate scientists can contribute to effective

adaptation initiatives. However, results from this study showed that majority of respondents were never able to predict the start and end of the rainy seasons, suggesting that local knowledge systems are being eroded and becoming less accurate in seasonal weather prediction. Or alternatively that this knowledge is held by certain members of community, and they need to be engaged in order to build coping and adaptation strategies. Either way, future studies on local and indigenous knowledge in the region could explore the use of multiple methods to integrate such knowledge with scientific weather data in order to obtain more complete and accurate information for the prediction of local area seasonal characteristics.

Unsustainable water use and unequal water distribution and accessibility remain characteristic water concerns in Lamu. Lamu's water is disproportionately used and factors such as religion (Muslims have access to cleaner, reliable water supplies than non-Muslims) and economic class (price of drinking water) determine consistent access to water. These issues need to be addressed urgently as Lamu is already experiencing severe water shortages.

5.4 Conclusion

The results from this study clarified the relationship between water and climate change, in that rising temperatures and increased variability of rainfall are having a negative impact on freshwater availability in the Lamu region. The continuous warming and resulting change in rainfall patterns over the Lamu region is adversely impacting the water resources on which the population is dependent. Thus, there is an ever-increasing recognition of the need for micro and macro level assessments for greater understanding about the impact and implication of climate change.

CHAPTER SIX

STAKEHOLDER ENGAGEMENT IN THE MANAGEMENT OF LAMU'S FRESHWATER: NEEDS, PRIORITIES AND POWER DYNAMICS

6.1 Introduction

Any participatory approaches to water management require the involvement of concerned, key stakeholders. This means identifying public concerns, values and priorities and developing a broad consensus on planned interventions. It is also important to utilise the vast amount of knowledge and information that stakeholders hold to find workable, sustainable solutions. The purpose of this chapter is to situate stakeholders in Lamu's water management, realising the third specific objective of this study. The chapter first illustrates the main sources of water in Lamu. Following this, the chapter characterises Lamu's stakeholders according to their interests in water as well as their influence over the decision-making process. Findings are presented from running descriptive and inferential statistical analysis. A stakeholder map is developed from conducting triangulation on qualitative and quantitative methods.

6.2 Results

6.2.1 Sources of Water in Lamu

The main sources of potable water for households in Lamu include wells, boreholes and rainwater harvesting. Sand dunes form a water catchment area, collecting water during the rainy season, which then seeps underground and water wells are dug to collect the clean water. The sand dunes are known as the Shella-Kipungani catchment zone or Shella aquifer (Figure 6.1). The aquifer is the only source of freshwater for Lamu Island (including Shella village) and neighbouring Manda Island. Some parts of Lamu are also supplied with piped water through the Water Resources Authority (WRA)[8]. Figure 6.1 illustrates some of the major wells in Lamu as documented and quality tested by the WRA. The map also includes drilled boreholes as part of the LAPSSET project – Lamu Port.

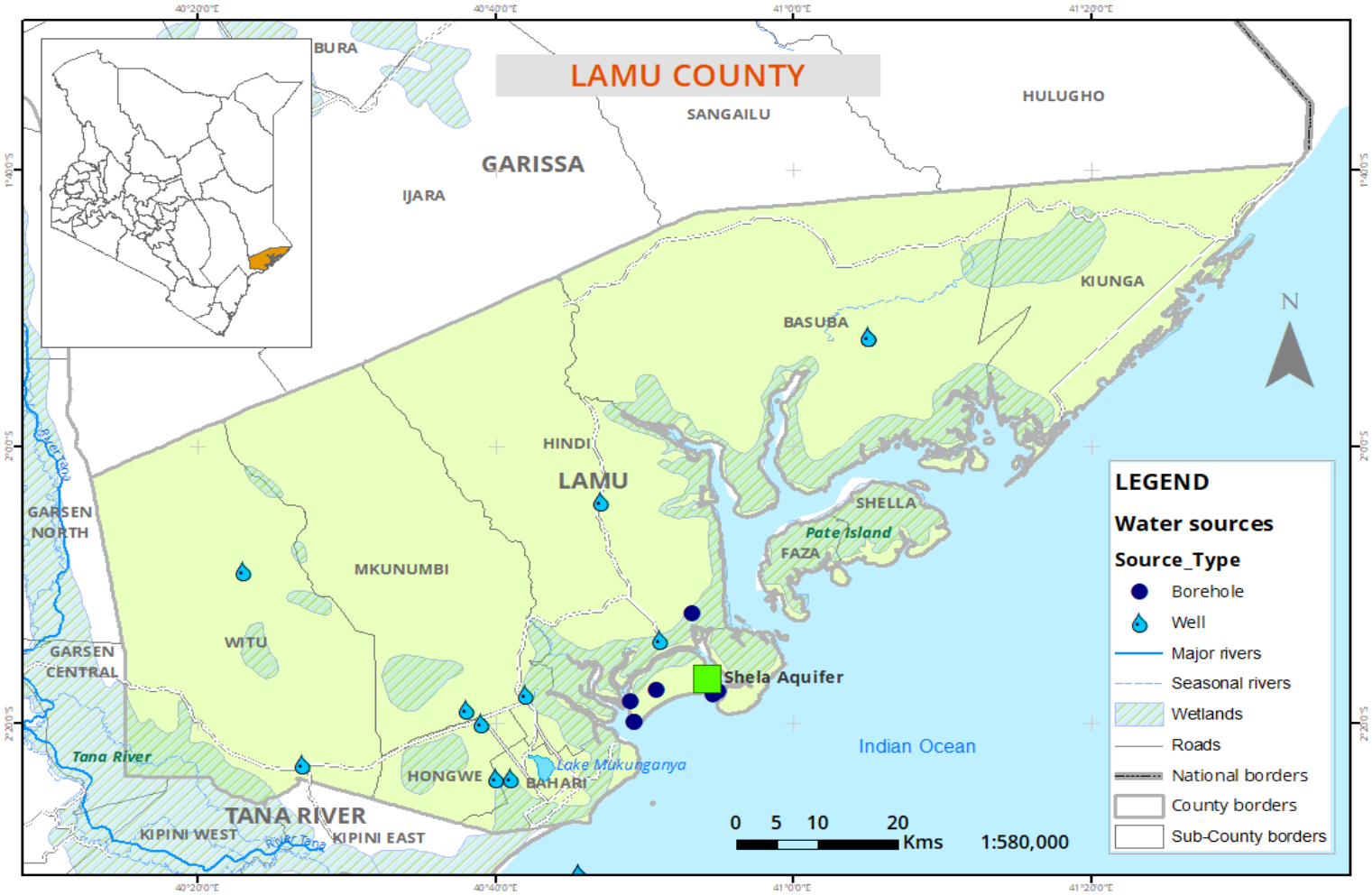
[8] This is referenced as County (District Water Board) which is essentially the same as the Water Service Provider (WSP) – LAWASCO.

Historical Ownership of Water on Lamu Island

The Shella region is entirely dependent on water from wells. An elder interviewed in the Shella region revealed that Shella's ownership of wells has historical significance, which is worth a brief discussion. In the past, Lamu was made up of Lamu town, Takwa and Manda villages and there was a lot of competition for trade amongst the people (Takwa was part of Manda Island - see Figure 6.1). The Takwa and Manda regions produced the best millet and as a result, there was a lot of jealousy amongst these villages. Jealousy turned into hostility, until eventually the people of Takwa, Manda and Lamu could not pray together. A deal was struck by the Sultan who resided in Lamu, to expel the Takwa people to Shella. White sandy beaches, and not much fertile farming land covers Shella. The people of Lamu thought they had overcome their adversaries by giving them a useless piece of land; however, the people of Takwa (which means 'honoured people' in Arabic) were only concerned with having freedom to pray. The elders claim that their desire to pray pleased Allah, and he blessed them with abundant, clean, pure water from the sand dunes to conduct their prayers. It is for this reason, that Shella is predominantly made up of the Muslim community and they have 'ownership' over the Shella aquifer.

Current Water Sources

The need for clean pure water to meet Islamic prayer needs was brought up repeatedly in discussions with Lamu residents. During prayer rituals, Muslims carry out cleansing practices before they begin praying. These cleansing practices involve washing themselves with clean water in order to 'prepare' them to go before Allah. The main sources of water in Lamu are boreholes and wells (that are located less than one kilometre away). Lamu also relies on rainwater harvesting and around 5.8% of the survey respondents are dependent on this as a source of water (Table 6.1). From interviews with community members, the method of rainwater harvesting is through traditional 'djabias' scattered through the city and residential areas.



Map 6.1 Showing Documented Water Sources in Lamu

Table 6.1 Sources of Water in Lamu

Source of water	**Number of respondents**	**Percentage of Sample**
Borehole	240	43.5%
Well	229	41.5%
District Water Board	38	6.9%
Rainwater harvesting	32	5.8%
River	7	1.3%
Other sources	6	1%
Total	552	100%

The data shows that water-reliant livelihoods including farming and pastoralism are most dependent on boreholes and wells as their main source of water. This indicates that a decline in freshwater availability at these sources would have dire consequences for these livelihoods. This is supported by interviews with key informants from the National Drought Management Authority (NDMA) who raised concerns that the number of pastoralists coming into Lamu from the Garissa region has increased. Garissa pastoralists believe that there is more water available in Lamu due to the abundant boreholes and wells, with free/open access. This is significant for pastoralists as they do not have to seek permission or own land in Lamu in order to access water. Pastoralists are heavily dependent on wells as a source of water for their livestock. Officials of the NDMA are concerned that the relocation of pastoralists to Lamu in search of water is becoming a huge security concern for Shella residents, as they are very protective of their water. They are protective as water is already in decline in the area, with residents complaining that the available supply is inadequate to meet their needs. This makes the local residents less inclined to share with pastoralists from Garissa.

6.2.2 Water Stakeholders in Lamu

In addition to households, the Lamu County Integrated Development Plan (2013) identified development partners including the United Nations, World Bank and the Africa Development Bank as stakeholders in Lamu's water. This is as a result of the direct financing by development partners of various projects and research into Lamu's water. Small business owners were also identified as stakeholders due to their dependence on water for day-to-day functioning. This included small restaurants, shops and stands (mobile shops) (Fig. 6.1).

Results showing the additional stakeholders (over and above those identified in the CIDP) in relation to freshwater use and access unique to Lamu are illustrated in Figure 6.1. Mosques and their elders/leaders were identified as having a strong interest in local freshwater. A member of a household claimed:

"There may be water shortages in local households, but never in the mosques. The Imam's make sure there is always a steady supply of clean water, it can't be contaminated or too salty".

Additionally, hoteliers/homeowners were also identified as major stakeholders in Lamu's freshwater use and access. The distinction between hoteliers and homeowners lies in the size and nature of the establishment – while the formal hotels are run like any standard hotel, several homes in Lamu are rented out as holiday homes for tourists. They are mostly foreign owned, and rented out while the owners are back in their home countries.

Kenya Defence Forces (KDF) emerged as a stakeholder owing to the current security concerns in Lamu. Several soldiers have been deployed in the area after the 2014 terror attacks in Mpeketoni and the soldiers are stationed in lands predominantly owned by the indigenous community of the Boni Aweer in Lamu. They too are placing additional demands on freshwater sources in Lamu, while creating tension with the Boni Aweer who now have limited access to their water sources due to competing interests. The County Government suggested the NDMA as a stakeholder in Lamu's water as they work with the County and local residents to avert the negative impacts of drought.

Government agencies interviewed in the area identified nomads from Garissa as well as domestic migrants from around the country as players in local freshwater use. According to the NDMA, Garissa is also going through a major water crisis, forcing several pastoralists to move to Lamu in search of water for their animals.

These nomads are taking jobs as security guards/watchmen by night, while grazing their flocks during the day. Meanwhile, migrants from around the country are moving to Lamu in search of jobs and opportunities arising from the promise of the LAPSSET project. Foreign Governments were suggested as another stakeholder in Lamu's water. In particular, the Chinese Government was referenced due to their significant interests in infrastructural development projects in the region. Chinese nationals are already residing in Lamu as part of the management teams of these projects.

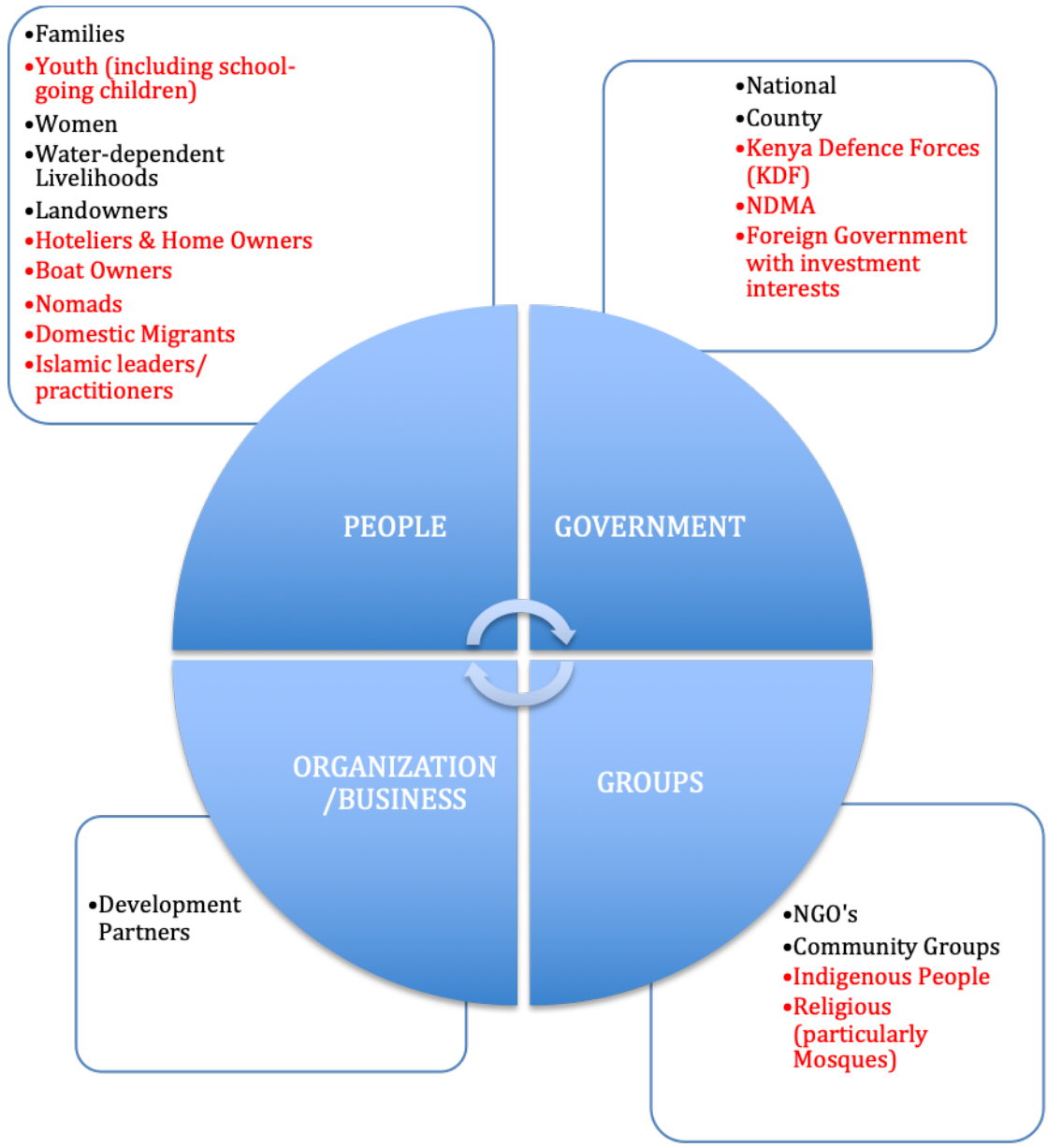


Figure 6.1 Baseline Stakeholders and New Stakeholders (written in red) identified in Lamu's Freshwater Resources

The different stakeholders identified are illustrated in a power versus interest matrix (Figure 6.2). This results in four categories of stakeholders: (i) players who have both an interest and significant power; (ii) players who have an interest but little power; (iii) context setters who have power but little direct interest; and (iv) the rest, which consists of stakeholders with little interest or power. Perceived power is also accounted for in the power and interest matrix. Perceived power in this case refers to players who believe that they have power to change a result, but this is not confirmed in the formal water management decision making process. For instance, the youth interviewed were concerned about the water issues in Lamu and believed that through their grassroots organizations they had the power to induce changes. During the survey, the youth mentioned that they were actively involved in protests and demonstrations against the latest development project proposal in Lamu – a coal plant in addition to on-going protest against the LAPSSET project. They believe they could stop the project from being developed, as it would negatively affect their water, as well as local environment. Another example of perceived power is in the hoteliers/homeowners interviewed. "Individuals in high places" own hotels in the area and as such, the staff interviewed claimed that the hotel owners had the power to get more water for their hotels. Perceived power and actual power are not mutually exclusive, rather the current decision-making processes around water in the region do not match the players perceived power to influence the decision-making process.

The matrix (Fig. 6.2) helps determine which players' interests and power bases should be taken into account in order to address the water issues in Lamu. High interest and high-power players are those stakeholders who need to be managed closely in order for interventions to be successful, while high power and low interest players are those who need to be kept satisfied and whose 'buy in' should be sought. High interest and low power players are stakeholders who need to be kept informed, representing coalitions that should be encouraged throughout the intervention process. Finally, low power and low interest stakeholders require minimum effort but do need to be monitored throughout the intervention process.

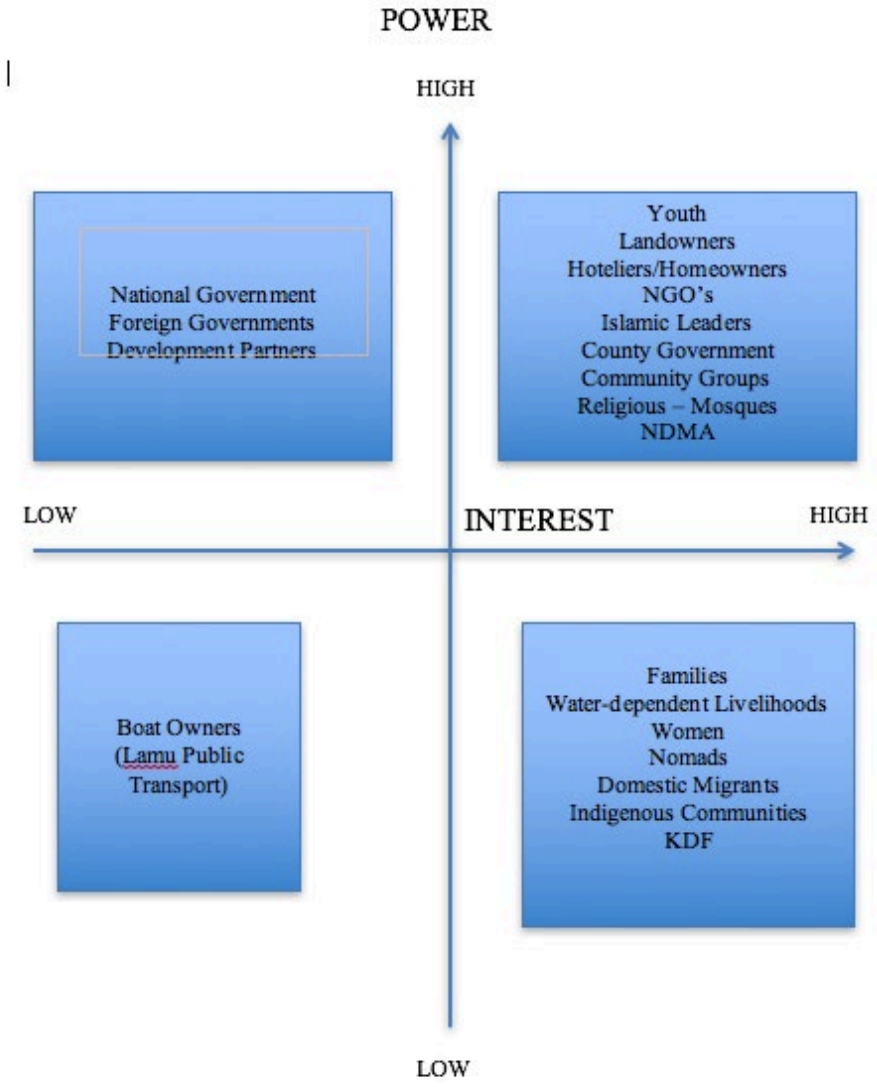


Figure 6.2 Power versus Interest Matrix Showing Stakeholders in Lamu's Freshwater Resources

The relationships between the stakeholders are more adequately defined in terms of the increasing influence of each stakeholder (Fig. 6.3). As you go up the stakeholder influence diagram, stakeholders have more influence over decisions on water. The top of the diagram represents the stakeholders who have the most influence as they have high power as well as high interest in any decisions around water issues.

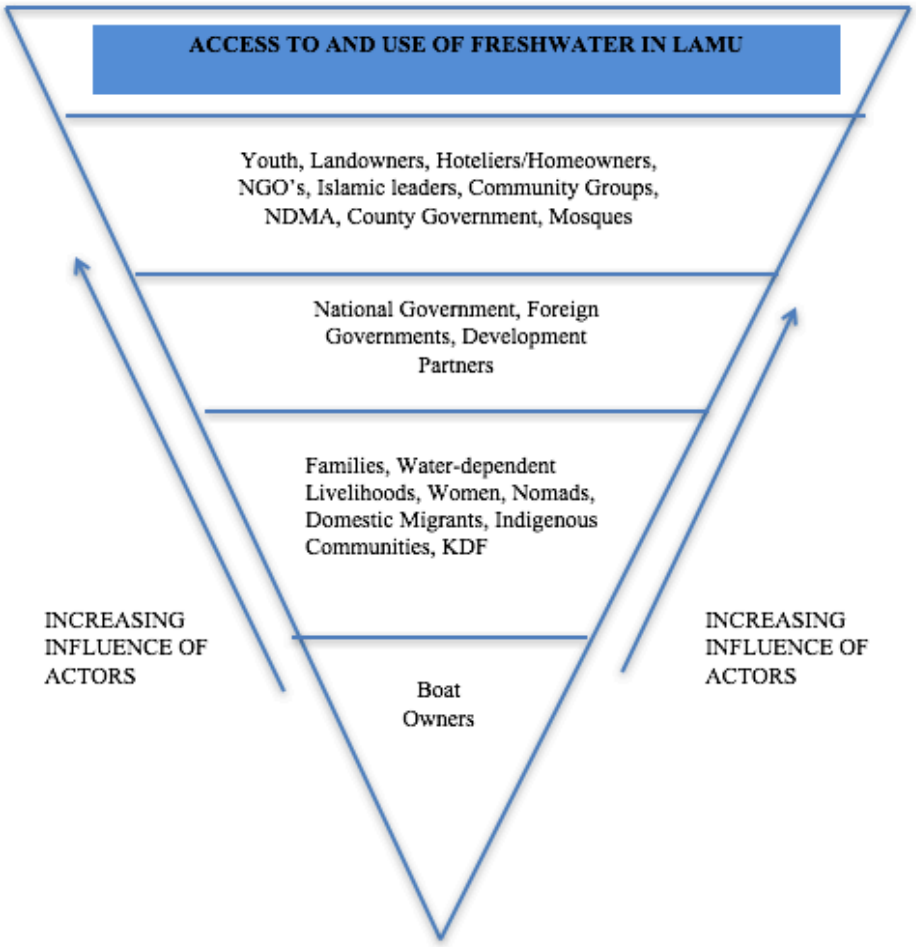


Figure 6.3 Stakeholder Influence Diagram

6.2.3 Use of Water in Lamu

Freshwater in Lamu has a variety of different uses for the community. The major uses of water for respondents included carrying out 'household other' (chores which includes household cleaning and cooking), 'household drinking', commercial and subsistence farming. Both women and men listed 'household drinking' and 'other household' as their predominant use of water. There were more men than women who listed subsistence farming and cash crop farming as a primary use of water (Table 6.2). This is not surprising as women in Lamu have the primary responsibility of tending to and maintaining the household. While the men have the responsibility of financially supporting their households. Some of the men interviewed who conducted subsistence farming said they did so to supplement their household needs. Their

incomes were insufficient to buy enough food for their households, so they would grow their own food to support the household needs.

Table 6.2 Uses of Water by Gender

		GENDER		
		FEMALE	**MALE**	**TOTAL**
PRIMARY USE OF WATER	Cash farming	12	14	26
	Subsistence farming	1	3	4
	Household Drinking	127	134	261
	Household Drinking + Cash farming	4	6	10
	Household Drinking + Subsistence farming	12	16	28
	Household Drinking + Subsistence farming + Cash farming	0	3	3
	Household Other	103	87	190
	Other uses	8	22	30
	Total	267	284	552

Key informants around Lamu County described the main use of water in the household (other than chores, cleaning and cooking) as for religious purposes. Water plays a major role in households in Lamu for the purposes of cleansing and purification rituals associated with Islamic prayers. A mosque worker explained that the main use of water in his workplace was for facilitating necessary rituals for prayers. He said that poor water quality would have a detrimental effect on Allah's response to their prayers, as they would not be completely clean and pure. Hoteliers in the region (particularly in Shella and Lamu town) noted that freshwater was also used to fill swimming pools. This was a major concern for Shella residents, and in particular the elders of Shella. Shella is where most of the hotels and tourist houses are located. Every new house and hotel (built by non-Lamu residents) has a swimming pool, which requires large amounts of water. However, because tourists are seasonal visitors, swimming pools are emptied and filled according to the season when tourists are visiting. One elder noted:

"They build swimming pools and then completely empty the same pools once they are done with their holidays. Such a waste of our water!"

It would appear from the views of residents that the use of freshwater from wells and boreholes for swimming pools is wasteful and uncontrolled.

6.2.4 Access to Freshwater in Lamu

Majority of the respondents (86.21%) are located less than two kilometres from their source of water. Of these, 51.37% are women while 48.63% are men. While water in general is close to households in the area, the responsibility for fetching it as well as organizing water collection is different across the board. Particularly, significant water collection disparities exist between Muslim and non-Muslim residents. Interviews with residents revealed that for the Muslim communities, water collection is a responsibility of the men. They are responsible for collecting water, ensuring maintenance of pipes and finding water from additional sources when there is a shortage. Conversely, in the non-Muslim communities it is the women who are responsible for water issues in the household. They fetch water and find water from additional sources when there is a shortage and generally manage all water concerns within the household. Increasingly, school-going children in non-Muslim communities are being made responsible for fetching water. This is because the

women are overwhelmed with other household duties and opt to send out their children instead. In most of the households interviewed, it is the girls who take up this responsibility, as they are the ones who are tasked with helping their mothers with most chores around the house.

Lamu residents have access to freshwater sources that are generally close to their homes and do not require them to travel long distances. However, certain livelihoods (particularly watchmen/messengers) have to travel further distances to access freshwater (Figure 6.4). Interviews with government personnel and local residents confirmed that the majority of watchmen in the County were actually from the Maasai community. These are pastoralists who have migrated to Lamu from Garissa County who serve as watchmen by night and herd their cattle by day. This could explain why most of the watchmen surveyed stated they had to travel further distances to access their water.

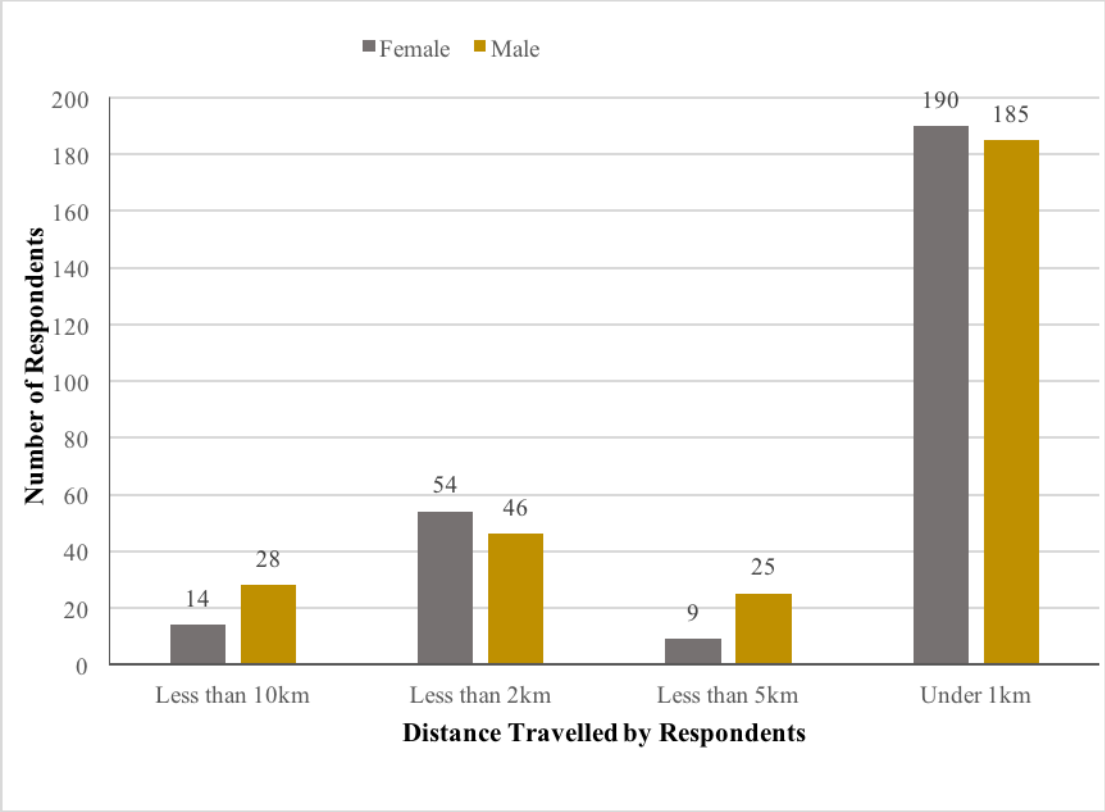


Figure 6.4 Distances to Main Water Source

6.2.4 Regulation of Freshwater in Lamu

Majority of water sources in Lamu County are not regulated by the national and/or County government (this includes boreholes, wells, djabias and seasonal rivers). Public wells are generally 'free for all' to access, while privately owned wells and boreholes are limited in access but unregulated in terms of digging and drilling. Some of the boreholes (50.4%) are managed and controlled by the Government, while some are managed and controlled by 'private entities'. This refers to groups of elders in certain regions of Lamu such as Shella, whereby to access any well or dig any borehole, one has to consult them first. The elders grant 'access' but have no control over how the water is used or managed. Hence, the numerous complaints recorded of water being misused for swimming pools that are emptied out during the low season and refilled during the high season. Piped water is supplied by the WRA who ration water on certain days of the week and for specified times. Piped water does not flow freely throughout the week and those dependent on it have to wait for the pipes to be switched on to fill up their tanks. Residents who rely on piped water complained about pipes being in bad condition and regularly bursting, leaving them without access to water for weeks at a time until the pipes are fixed.

6.3 Discussion

Studies (Alam et al., 2011; Tanner and Allouche, 2010; Edelenbos et al., 2011) in freshwater management has identified the need for stakeholder engagement and inclusion to be effective and sustainable. The present study found that it is useful to locate key stakeholders within local contexts to ensure that no group is left out. Furthermore, it identified that participation of stakeholders should be meaningful and prioritise participation according to relative interests in water (power versus interest grid). To tackle freshwater management, it is also useful to understand local key stakeholders in relation to their demand for and use of freshwater. This study found that it was necessary to prioritise stakeholders (i.e. match stakeholder engagement to stakeholder interest in water) in order to pinpoint the inequality when it comes to local freshwater management. From the results, stakeholders with high interest had low power when it came to decision making while those stakeholders with low interest had high power in the decision-making process. It is for this reason that decisions made around Lamu's local water supply often leave out the concerns of the stakeholders who ultimately are most affected by the decisions made. Moving

forward, an integrated water management approach will benefit from prioritising stakeholders in local water, and balancing their interest with their power to make decisions.

The stakeholder analysis also identified Islamic elders and leaders as key players in water management. This is problematic for two key reasons. One, while Lamu is predominantly a Muslim region, it is also made up of other religious groups and cultures. This means that earmarking local water for religious purposes would be to the detriment of other cultures and religions that do not follow the same practices. It means that an already limited water supply in the region is preferentially supplied to one group, and the other smaller groups in the region may have a hard time finding water. In the Shella region for instance, local elders (Muslim) have assumed a leadership role over the Shella aquifer. They determine who can put up a borehole or well for private use. This gives rise to the second concern - conflict. Lamu is a region that is already experiencing tension between the Muslim and non-Muslim communities. These tensions have heightened since the terror attacks in Mpeketoni in 2014[9]. Declining water supplies, with limited access (to the detriment of the non-Muslims who are not in control of local water supplies) could ultimately lead to conflict among the communities with religion playing an amplifying role. At the same time, residents also expressed frustration with the herders from neighbouring counties coming to Lamu in search of water for their livestock. The tension between Lamu residents and Maasai herders over local water was apparent. These tensions and potential conflicts need to be addressed both at the County and national level as a matter of urgency.

The misuse of water by hoteliers and foreigners with holiday homes is another issue that was repeatedly brought up by residents as a perception. It would be useful to measure this water use to compare to the perception that it is wasteful, however access to these hotels and holiday homes is a challenge. Nonetheless, moving forward, any strategy for integrated water management in the region would have to include homeowners who are not Kenyan nationals, as well as hotel owners. These are stakeholders that are often left out of the dialogue as they do not reside in Kenya

[9] More than 60 people were killed as a result of a series of terror attacks in Mpeketoni between 15th and 17th of June. The Somalia based Al-Shabaab militant group claimed responsibility for the attacks but the Kenyan Government asserted that the attacks were locally organised. It was suggested that the attacks may have been motivated by ethnic or religious hatred, or revenge for land grabbing.

full time and are not involved in the day-to-day activities of the region. While it emerged that they have a significant interest in Lamu's water supply. It would also be useful to look at the methods for recycling water used in swimming pools in the high season, or using recycled water for recreational water uses.

Water is a key driver of economic and social development in Lamu. It also has a basic function of maintaining the integrity of the coastal environment and as the results show, it has high religious and cultural value to the people of Lamu as well. Managers of water (whether local, government or in the private sector) have to make difficult decisions on water allocation in Lamu. Poor, out-dated storage facilities and misuse of water both contribute to the water insecurities that Lamu is currently facing. Increasingly, those in charge of local water have to apportion diminishing supplies between competing demands. Demographic and climatic changes will further increase the stress on local water resources. It is imperative that management decisions reflect the competing demands on water as well as the negative impacts of climate change that local water is exposed to. A fragmented approach is no longer viable, and a more holistic, integrated stakeholder approach to water management is essential in Lamu to ensure equitable and sustainable access to water.

6.4 Conclusion

Stakeholder mapping is a useful tool for integrated water resources management. The study suggests its use in the decision making process around local water management as it matches decision-making power to interest in water. It also supports better management of stakeholder relationships, helping them to respond practically and appropriately to challenges in water availability and access. Engaging stakeholders early in the decision making process and maintaining relationships is important in implementing an integrated water resource management approach. Future research in integrated water resource management should look at a means of fostering on-going, long-term relationships with stakeholders to ensure sustainability and longevity of management activities.

CHAPTER SEVEN

MAINSTREAMING CLIMATE CHANGE AND INTEGRATING WATER RESOURCES MANAGEMENT IN THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

7.1 Introduction

This chapter seeks to analyse the environmental policy process informing the licencing of infrastructural development projects in Kenya. Given that policy on climate change and water are fairly recent additions to the environmental policy landscape, this chapter examines the extent to which the current legal framework informing infrastructural development integrates water concerns and climate change impacts. It combines the research findings from the fourth and fifth objectives of this study. First, a historical analysis is presented in order to comprehend the genesis of the existing environmental policies. Then the chapter reviews the current environmental legal framework informing infrastructural development, situating the LAPSSET project. In doing so, the chapter divorces theory from practice. Finally, it presents a dynamic model utilising the current environmental impact assessment (EIA) process. The model offers a restructure of the current EIA process to assimilate two key components. The first, an integrated water resources management (IWRM) approach in assessing environmental impacts. Second, mainstreaming climate change into the EIA process to ensure that climate change impacts are assimilated into development planning.

7.2 Historical Underpinnings

In order to evaluate the environmental policy process, it is important to first understand the historic underpinnings of environmental protection in the country. Kenya's environmental governance history is encumbered by efforts to balance sustainable development with free resource use and allocation. This is exemplified by the environmental debates of the early 1970s when the global South viewed the environmental initiatives in the North including higher environmental standards and cleaner production, as preventing them from industrializing and insisted on a historical right to development (Bassow, 1979). In the post-colonial and the Cold War era, environmental concerns literally pitted the global North and South against each

other. The global North was ready to push for tighter environmental standards and the global South presumed that such measures would negatively influence their development, harming the competitive position of developing countries (Ivanova, 2007).

It is also a history that has exemplified Kenya as a model for environmentalism in the global South, a position that Kenya has always sought to maintain. It is argued that the decision to place the United Nations Environmental Programme (UNEP) in Nairobi was the beginning of environmental governance in Kenya as well as in the global South (Johnson, 2012; Ivanova, 2007). The placing of UNEP in Nairobi was not just a symbolic act, "it was a strategic necessity without which the developing countries might never have accepted the creation of an environmental organ" (Najam, page 370, 2003). UNEP's establishment in Kenya played a significant role in building and strengthening Kenya's capacity for understanding and responding to critical environmental issues that affect ecosystems and urban environments. Consequently, UNEP significantly influenced the development of environmental legislation in the country. Primarily, it exerted a direct influence through its close contact with the Kenyan Government. This began in 1975 when UNEP's first executive director Maurice Strong resigned from the organisation. During this time, he wrote a long, detailed and confidential letter to the President at the time – Mr. Jomo Kenyatta. In the letter he expressed his worries about Kenya's future, stating that he was leaving with "deep apprehension" at the current state of environmental affairs in the country and the disturbing course on which the country seemed set on:

> *"My belief is that Kenya is heading for major ecological disaster involving destruction of the very resources on which its future depends if it follows its present course of development"* (Maurice Strong's letter to Jomo Kenyatta, 1974).

He felt that as the executive director of an organization with global responsibilities and a large amount of information available to it, it was well placed to diagnose the state and trend of Kenya's environmental health:

> *"In inviting UNEP to establish its headquarters in Nairobi, Kenya had put itself on display to the world; it cannot afford to be second best to other countries in facing up to the environmental challenges of development. Indeed, if it is, my fear would be that the rest of the world may begin to question as to whether UNEP*

can continue to have its headquarters in a country which does not itself set an example of sound environmental management" (Maurice Strong's letter to Jomo Kenyatta, 1974).

His words appeared to have had an impact on the government, which was eager to keep the UNEP headquarters in Nairobi. In 1976 soon after Strong's letter to Kenyatta was received, Kenya drafted and passed its first piece of environmental legislation. The Wildlife Conservation and Management Act (1976) formed the legal backdrop for the protection, conservation and management of wildlife in Kenya.

Additionally, Kenya's environmental history is one that has pitted the government's development agenda against actions for conservation and preservation by civil society and environmental activists and heroines such as the late Prof. Wangari Maathai. Through her organization - the Green Belt Movement and their symbiotic relationship with UNEP, the Green Belt Movement indirectly influenced the development of numerous significant environmental laws. Most recently, the Green Belt Movement was heavily involved in the review process that led to the promulgation of Kenya's new Constitution in 2010. The Constitution drastically increased environmental protection measures as well as placed emphasis on the need for public participation in shaping national development. Notably so, Kenya's environmental provisions have been the result of concerted efforts of key stakeholders to put sustainable development and conservation at the heart of the decision making process.

In terms of policies determining water management, a thorough historical overview of water supply in Kenya over the past 100 years was recently undertaken (Nyanchaga, 2016). Nyanchaga (2016) states that historically water was a resource commonly held by the community. Certain water rights were allocated to groups or individuals for specific uses through a social negotiation process. Water management throughout the years has developed through flexible water rights that the society was able to sustain and ensure effective and efficient water use. After Kenya gained independence in 1963, the management of water was transferred from the Ministry of Natural Resources to Agriculture. It remained a function of the Ministry of Agriculture until 1972 when the World Health Organisation suggested key reforms that included the development of a separate body tasked with managing Kenya's water supplies. This led to the formation of the Ministry of Water Development in 1973 (Nyanchaga, 2016).

The history of environmental governance is entirely significant to the current debates surrounding the LAPSSET project, as well as other development projects in the Lamu region. Historically, social movements led by powerful personalities have played a role in putting environmental issues at the forefront of the national agenda. Policy formation tends to follow advocacy and campaigning around a specific environmental issue. Similarly, the LAPSSET project has given rise to a new wave of social action. The Lamu community and its supporters around the globe are protesting the lack of due diligence in the EIA process for the LAPSSET project. They have raised concerns with the severe water shortages and the gaps in managing Lamu's water supplies amidst an expansive development agenda. They have also raised concerns around the negative impacts of climate change currently being experienced in Lamu, and the failure to integrate these impacts in the project's planning and implementation phases.

7.3 Current Legal Framework

Both the institutional and legal framework for environmental protection in Kenya is fairly comprehensive, incorporating a whole gamut of guidelines. The main pieces of environmental legislation concerning water and national infrastructural development include the Environmental Management and Coordination Act (EMCA) of 1999, the Water Act (2016), the Climate Change Act (2016), the National Climate Change Response Strategy Paper (NCCRS) (2010) and the National Climate Change Action Plan (NCCAP) (2013). The Environmental Management and Coordination Act was amended in 2015 to align it with the new Constitution (2010). A key part of EMCA (1999) was that it established the National Environment Management Authority (NEMA) with the purpose of exercising "general supervision and co-ordination over all matters relating to the environment and to be the principal instrument of government in the implementation of all policies relating to the environment" (EMCA, 1999, Section 9.1).

According to the Environmental Management and Coordination Act (1999), any development project must be subject to an environmental impact assessment and licenced by NEMA before implementation. In this way, potentially damaging projects can be identified at the proposal stage. Other than NEMA, several actors have responsibilities in the environmental impact assessment process including community members, civil society, private consulting firms and development banks, who finance

infrastructural projects. Commenting on the EIA process in Kenya, Barczewski (2013) lists a number of issues that challenge the efficacy of the process. These include inadequate funding, corruption, lack of engagement with important community stakeholders, gaps or duplications of regulations and misunderstandings by society at large of the benefits of a sustainable project. As a result of these issues, Barczewski (2013) argues that key environmental impacts are often overlooked during the screening of development projects. The subsequent sections analyse the environmental impact assessment process involved with the LAPSSET project, showcasing a number of these issues at play.

The Water Act (amended in 2016) is an important piece of legislation of relevance to national infrastructural development. The Water Act (2016) set up the Water Resources Authority (WRA) and the Water Services Regulatory Board (WSRB) (refer to section 2.4 for a discussion on the history of the Water Act (2016)). The WRA has the mandate to regulate the use and management of water resources while the WSRB's principle objective is to protect the interests and rights of consumers in the provision of water services. As part of regulating water rights and services, the Act requires that a permit be issued by the WRA if the abstraction or use of water is for non-domestic purposes. This would include the use of water for major infrastructural development, such as the LAPSSET project. It is also a requirement that an application for a permit is subject to public consultation. For projects with large demands on water, it is a requirement that the application is conducted in conjunction with an EIA. However as demonstrated by Barczeweski (2013) and Vasquez (2013), environmental impact assessments are fragmented in their approach. That is to say, an environmental impact assessment is less likely to consider water issues if the project is not a water resource project (such as a dam, irrigation facility etc.). For other projects (not exclusively centred around water), an evaluation of water availability, equitable distribution of water and coordination of the resource is absent. Consultants teams tasked with the work of conducting these EIAs, cite budgetary restraints as the main reason why they do not include water issues (and include water specialists) in their assessments. Another issue to consider is that the Water Act (2016) prioritises the use of water for domestic purposes over the use of water for any other purpose. Therefore, theoretically, if a project's water demands will negatively affect community water use and access, then a permit should not be issued. Further, a permit will be reconsidered if any 'natural changes' occur that result

in increased demand for water for the project. While the term 'natural changes' could allude to climate change, the Water Act (2016) does not explicitly deal with climate change impacts on water resources or how to integrate these impacts into the permit issuing process.

The policy around climate change in Kenya is fairly robust. The Response Strategy Paper (2010) set the scene for addressing the impacts of climate change on a national scale. It provided understanding of the global climate change regime and the impacts of climate change in Kenya. The strategy formed the framework that would guide the integration of climate concerns into development priorities, government planning and budgeting. Soon after, the implementing plan (NCCAP, 2013) was launched. The implementation action plan sought to operationalise the NCCRS by providing the analysis and enabling mechanisms to make implementation successful. In particular, the NCCAP sets out a vision for a low-carbon climate-resilient development pathway. This includes an assessment of the technology requirements, a financial mechanism and a national performance and benefit measurement system. The processes of formulating the NCCRS and its implementation action plan were participatory and consultative, and all the key sectors of the economy were addressed. However, before 2016 the policy documents were criticized for poorly integrating overlapping sectoral policies (such as agriculture, energy and forestry) (Ongugo et al., 2014). It was argued that Kenya needed an exclusive and comprehensive climate change legislative framework that spearheads the nations' efforts in climate change adaptation and mitigation (Ongugo et al., 2014). With this in mind, both the NCCAP (2013) and the NCCRS (2010) provided the technical backdrop for the Climate Change Act (2016). The Act set up the Climate Change Council, which is responsible for providing an overarching national climate change coordination mechanism. Part of the Council's mandate is to ensure the mainstreaming of climate change by the national and county governments. This includes advising the county governments on priority strategies and actions that should be considered as part of county functions in order to integrate climate change in the decision-making process. The Council reports to the President, with powers to impose climate change obligations on public and private entities. The Council is to be led by guidelines in the National Climate Change Action Plan 2013 (NCCAP). Apart from the institutional framework, the Climate Change Act (2016) creates an avenue for citizens to hold governments and corporations accountable for reducing greenhouse gas emissions. The Act sets a fairly

low bar for establishing culpability in that the plaintiff merely needs to demonstrate that a corporation is not undertaking sufficient measures to address climate change. There is no requirement to actually demonstrate harm, loss or injury to any person. This paves the way for potentially costly compliance requirements. Nevertheless, the Act validates Kenya's public commitment towards action on climate change.

The study identifies that coordination between policy instruments is essential. However, in practical terms, synergy between these regulatory instruments is a complex task. The government has attempted to harmonize policy regulations for the management of natural resources in Kenya through the EMCA (1999). However, the effective implementation and enforcement of the EMCA is prevented by a number of factors. Ongugo et al. (2014) state that NEMA has poor human capacity on the ground. For instance, it has only managed to post one officer in the counties. Considering the level of interaction predicated by the regulatory instruments, this is simply inadequate. In addition, Kenya in general lacks an up-to date inventory of the amount of land under different uses such as forests, water and infrastructure, among others. Lack of this vital information complicates effective planning, zoning and overall management of both urban and rural areas. It also complicates the conducting of EIAs. Kenya is confronted with the challenge of coordinating the implementation of the various environmental legal guidelines at the national and local levels. More often than not, the approach to implementation of environmental policies is sectoral and as such compartmentalised in decision-making process. Coordinating compartmentalised decision-making on a national level and across different policy instruments is a complex task. The coordination between policy instruments requires a simplified, organised approach that is yet to be established. Additionally, it also requires a synchronised approach from decision makers, to enable them to coordinate between the different legal guidelines.

7.4 Policy and Practice: LAPSSET Environmental Impact Assessment Process

This section considers if the LAPSSET project followed the due legal process. While there is significant ambiguity and speculation surrounding the project's compliance to the current regulatory framework, it is feasible to identify what elements of the legal process were adhered to, where there are gaps and inconsistencies, and the impact of these discrepancies. It is also possible to separate

the process in terms of compliance, from the politics and problems associated with the development of the project.

The study found that it did not. Brown (2015) documents the history of the LAPSSET project highlighting that the impetus for the project is quite political in nature. When petroleum was first discovered in the southwest of Lake Turkana in the South Lokichar Basin, Uganda pledged to work with the Kenyan Government in an inter-state public-private partnership to develop a crude oil refinery in Uganda and a pipeline through Kenya (Brown, 2015). While the path to regional integration continues to be laden with complexities, politicking and uncertainty, the economic case for LAPSSET succeeded in 2012 when LAPSSET was officially launched. There are a number of steps to date tracing the LAPSSET project development. These are chronologically arranged (Figure 7.1) to illustrate the contradictions with the current legal framework. Although the project was launched in 2012, the environmental and social impact assessments were conducted after the launch in 2013 and 2014 respectively. These assessments were only conducted on two components of the project (figure 7.1) despite the project having several components.

Another issue to consider is the fact that LAPSSET is an extremely large, transboundary project with several project elements. It was initially estimated at $16 billion, however after further studies were carried out this rose to between $22 and $23 billion (Wanderi, 2018). The project was launched without conducting transboundary EIAs including all the countries involved. To date, an environmental and social impact assessment of the transboundary resources is still lacking. Significantly, the project was also launched before the strategic environmental assessment (SEA) was conducted in 2017. This is significant because the SEA plays a pivotal role in ensuring that environmental issues are integrated on a decision-making level.

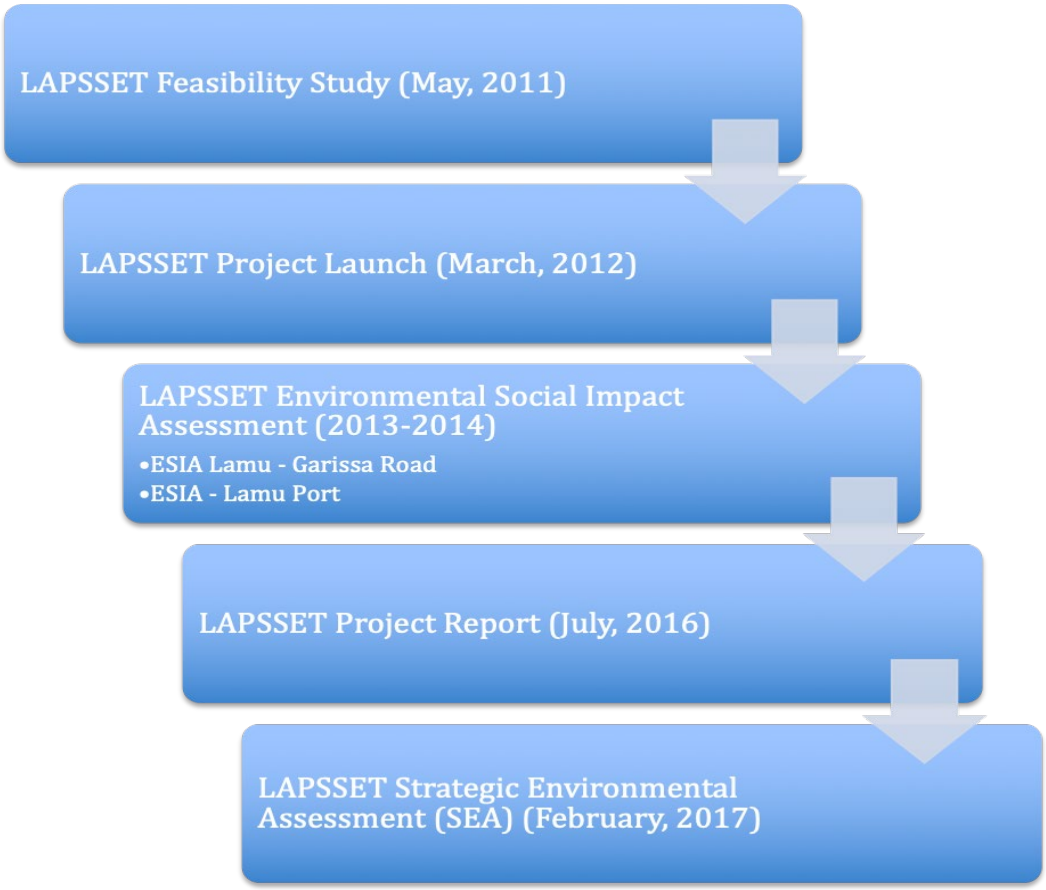


Figure 7.1 LAPSSET Steps in Development

The project was also launched before any water permits were issued as per the Water Act (2016) requirements. Essentially the LAPSSET project did not follow the due legal process. There are a number of possible reasons why it did not and these are explored in the subsequent sections.

7.4.1 Public participation

Public participation is a crucial, integral part of the environmental impact assessment process mandated by the EMCA (1999). In addition, stakeholder involvement is provided for explicitly in the Kenyan Constitution (Constitution of Kenya, 2010). Article 35 stipulates that the government is obliged to increase public awareness and foster healthy debate of any proposed infrastructure project. The goal of public participation is to bring to light any contentious issues at the initial stage of a project and give a chance to those affected by the project to air their respective concerns. In the EIA process, the public have three avenues where they can actively participate. During the screening and scoping phases, and then during the review

phase when the EIA report is submitted to NEMA for review. The experts conducting the EIA are expected to organise meetings in which they seek to get the views of the people likely to be affected by the proposed project.

Inadequate participation of the public is a major challenge in the EIA process in Kenya. This emerged as a significant issue in the LAPSSET case, where the public were insufficiently engaged as per the legislative provisions. For one, the views of the public were sought well after the project was licenced and officially launched. According to the consortium of civil society organisations in Lamu under the banner 'Save Lamu':

"*The EIA's were prepared after the project was launched. EIA's only became available when pressure was placed on the government to release it!"* (Save Lamu, 2012)

The household survey indicated that majority of the respondents (86.9%) are aware of the LAPSSET project. They indicated that their knowledge of the project came about as a result of several visitors in Lamu. One elderly man stated:

"I heard about LAPSSET when President Kibaki came to Lamu and talked about this big big thing that would change Lamu. People were excited but they were also scared. Where would they get the land for such a big project?"

While another elderly man said:

"I first heard about LAPSSET when I saw Chinese people walking around the community. They were with some Kenyans from Nairobi and they were using equipment to record things in the neighbourhood"

Public knowledge of the LAPSSET project occurred coincidentally rather than as a result of a concerted effort by the government to provide necessary information on the project. It is reasonable to determine that this is the main reason why the public viewed the EIAs conducted with such distrust. It was also problematic for locals to see foreigners and strangers in their communities, conducting research without giving them any information as to what the research was for.

This was also in clear contravention of both EMCA and the Constitution. Vasquez (2013) argues that the government was reluctant to share reports for fear of attracting criticism. At the point when the EIAs were being conducted, it appeared that public participation in the process was reduced to a procedural exercise rather than a substantive process to include the public in environmental decision-making. Barszewski (2013) argues that public participation in the EIA process can be cosmetic

rather than functional in large-scale projects. He argues that when a project is particularly important to the government, any delays or criticisms may be interpreted as attempts to either obstruct progress or hinder efforts to create jobs. This argument finds weight in the LAPSSET example, whereby the project was of particular importance to the government. As such, legal requirements for an EIA were bypassed and the project implemented without following the necessary due process.

Public participation and stakeholder engagement is predicated on the belief that the views of the people matter. It is probable that public distrust of the project began when their views were considered after the launch of the project. From interviews with NEMA officials, it was realised that the role of public engagement during the EIA process is to ensure that the perspectives of stakeholders are taken into account when licencing a project. However, the role of NEMA is to facilitate the participation process. Ultimately it is up to the public affected by a project to show up and contribute to the discussion. NEMA advertises meetings through posters, local radio announcements, social media and sometimes through television (depending on the location of the study). Unfortunately, they claim that in most cases there is low public turnout in the meetings:

"We make calls for public participation, but we can't be held responsible if people don't show up to the meetings or respond when we call for their participation." (NEMA Official, 2016)

However, the means of communication that NEMA uses are quite formal in nature, and it is quite possible that not everyone in the community has access to this information. Particularly in a region like Lamu where access to formal media is limited and literacy levels are also quite low. In the same regard, EIA reports are difficult to understand and there is a complete lack of dissemination activities to enhance public comprehension. Furthermore, the companies tasked with conducting EIAs for large-scale infrastructural development projects are often international ones. This means that there is often a disconnect from the local public when it comes to collating data and engaging the public in discourse on the project. For example, a foreign engineering firm conducted the EIA for the Lamu Port. The organisation 'Save Lamu' argued that the necessary series of public meetings mandated by EIA Guidelines never occurred. Furthermore, the consultations were not spread out to stakeholders outside of Lamu who arguably have an interest in the project's outcome. Save Lamu (2014) asserted that the facilitators of the group discussions were

government officials and as such, prevented Lamu residents from being open. The final study report was only available in English; further limiting public engagement as majority of Lamu residents speak Kiswahili and not English. It is for this reason that perhaps there is necessity for NEMA to go beyond the minimal requirements for public participation and make a more concerted effort to reach a wider range of stakeholders. This would benefit the public, promote ownership and inclusion and ensure that key public priorities are addressed in the process.

Also, while the LAPSSET project directly impacts Lamu residents, Lamu is also a world heritage site[10], which means it has global as well as national interests. NEMA was criticised for not appropriately engaging global stakeholders. However, NEMA argued that they had sufficiently engaged local residents in the EIA process and did not have interests in global calls for public engagement. But even local engagement of stakeholders was disparaged. According to 'Save Lamu', the EIAs conducted did not undertake a needs assessment or identify the interests of stakeholders in the LAPSSET project. As in most cases, stakeholders are affected to different degrees and understanding these differences is an important part of mitigating the impact.

Further, an additional issue that emanated from the study was that the public did not believe that their views were actually relevant to the projects' approval. For example, one young man claimed:

"We raised issues on water repeatedly, but this is not reflected in any of the environmental assessments! The project was still approved with no measures to deal with our water issues"

This is evidenced in the SEA report that stated that the most significant concern from the stakeholders was water. This was also the case reported in several media stories (Daily Nation, 2015; Indian Ocean Observatory, 2015) after the launch of the LAPSSET project. This was confirmed by the household survey that found that 78% of respondents who had knowledge of the LAPSSET project were concerned about the projects negative impact on water accessibility. However, in spite of all these public concerns raised in the media, in the public consultations and confirmed in the present study, water issues remain largely overlooked. In that there is currently no

[10] World Heritage Site is a landmark selected by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) as having cultural, historical, scientific or other form of significance. It is a site legally protected by international treaties and identified as protected zones.

comprehensive plan to increase water for residents in the region. This gives weight to the public sentiment that their views are not necessarily relevant to the approval process around large-scale, high profile infrastructural development projects.

On the other hand, the SEA, which was conducted by a Kenyan firm was more elaborate in integrating the perspectives of the public. This could be a response to the public outrage that emerged following the EIA on the port. For the SEA, a total of 47 meetings were held – most of which were done at the National Museum in Nairobi and in Lamu town. This meant that public participation included Lamu residents as well as non-Lamu residents who had an interest in the project. They included grassroots communities from Lamu to Lodwar and a total of 1871 individual stakeholders participated. The SEA was released in 2017 (Figure 7.1). But this occurred well after construction on the various elements of LAPSSET had already begun, further supporting the argument that public views are not necessarily relevant to the approval process around large-scale, high profile infrastructural development projects.

7.4.2 Subjective environmental impact assessment leading to problematic mitigation measures

Mostert (1996) states that subjectivity occurs when the norms, values and interests of one or more of the parties involved influence the results of an EIA. To the extent that project approval is prioritised at any cost, with mitigation actions not well matched to the projects outcome. In the LAPSSET case, the project's impacts on water were significantly downplayed in the EIAs. For example, before LAPSSET was officially launched, the feasibility study (Republic of Kenya, 2011) clearly identified that Lamu's water supply was insufficient to meet the current demands. The feasibility study indicated that in Lamu town, the current water supply of 3,000m^3/ day was solely being met by supply from the Shella aquifer. Furthermore, the study showed that the aquifer has reached its capacity and would not be able to meet any additional demands placed on it. In 2011, the total population of Lamu was estimated to be 101,539 (Republic of Kenya, 2009) with an annual growth rate of 2.47%. The LAPSSET project envisions that the Lamu population could more than double by the time the project is fully implemented. With this in mind, the EIAs conducted between 2013 and 2014 did not identify water as a major concern for Lamu. In the EIA for the Lamu-Garissa road (2013), it was suggested that the project would have some impacts on local water during the construction and operation phase of the road. Specifically,

minor changes in hydrology and drainage near seasonal streams were anticipated. Further, water quality tests were carried out on a few boreholes in Lamu and it was determined that "water is potable". The assessment did not account for current water levels, access or constraints in the region. It also failed to address the impacts the roads construction and operation would have on current water systems (quality and access). The assessment suggested, "sensitizing construction staff to avoid irresponsible water use" as a means of ameliorating increased water demands. It did not account for increased water demand in already water scarce Lamu and Garissa counties as a result of the project's operation.

The mitigating actions recommended as part of the environmental impact assessment were insufficient. It can be argued that subjectivity played a part in this as the measures suggested were included without ensuring that they were workable, and the best option for Lamu. To illustrate, suggestions were made as to how water supply can be increased in the region. One of the suggestions offered was to supplement Lamu's water with water from the Tana River. The Tana River currently supplies 80% of the water for Nairobi residents (over four million people) and for another five million people living in the Tana watershed. It is also the country's primary source of hydroelectric power (Beukering et al., 2015). According to Beukering et al. (2015), the Tana River Basin is already facing a number of challenges that are undermining key ecosystem services. The upper catchment is threatened as more land is allocated for farming, while poor farming practices have led to pollution and soil erosion. However, the greatest pressure on the basin will be from supplying water to the LAPSSET project. There are major concerns that the massive water demand of the project will lead to over-abstraction of water to an already overwhelmed river basin. Thus, supplementing Lamu's water with water from the Tana River is highly challenging.

A second suggestion offered was to obtain water from the High Grand Falls Dam (HGFD) project and pump to Lamu. The HGFD (conceived in 2009) is also problematic. It is an ambitious project expected to hold 5.6 billion m^3 of water that will supply the LAPSSET project while adding nearly 700MW to the national power grid. However, according to Duvail et al. (2012) the dam will result in negative ecosystem impacts in the Tana Delta. This includes the degradation of mangroves (including two species unique to the Tana delta environment) and the deterioration of riverine forest areas. Moreover, the HGFD also imposes costs on the Kenyan

population that would be difficult to meet. Beukering et al. (2015) argue that water related conflicts would increase in the region, further increasing the magnitude of issues around the Tana River Basin. The 2016 EIA of the project (Tana and Athi River Development Authority, 2016) confirms that the majority of people who will be negatively affected by the project live in areas historically neglected by the government. The assessment while rich in technical details, bypasses key socio-economic and cultural issues that would result in communities being marginalised as a consequence of the projects implementation. Currently the project valued at Ksh 200 billion, is still yet to start with an expected completion in 2031. It is encumbered by opposition and has been widely described in media reports as a 'pipe dream' project that may never come to fruition (Goldsmith, 2018).

Desalination is offered as a third option to mitigate the water problems in Lamu. This alternative appeared to be a popular option with the LAPSSET authorities (interviews with LAPSSET officials, 2015) due to the abundance of seawater. They also cited the use of desalination plants in the Middle East as an example of their usefulness. With current technology, desalination methods require large amounts of energy. This is costly to the environment in terms of pollution, and costly in monetary terms (Karagiannis and Soldatos, 2008). In the largest desalination plant in North America, persistent operating problems and escalating costs have caused US water service providers to re-evaluate their reliance on desalination as a long-term regional water supply strategy (Yuhas and Daniels, 2006). This indicates that it might not be the most efficient solution for Lamu, where resources for water management are already scarce. Lattemann and Hopener (2008) suggest that the impacts of each desalination project should be investigated through an EIA. This way specific impacts can be better understood and mitigated against on a location specific basis. Ultimately, the option to use desalination in Lamu is relatively inchoate. To sanction and commission the start of the LAPSSET project without concretising any of the above mentioned mitigation plans remains the fundamental problem.

7.4.3 Lack of synergy in the current policy framework on environment and development

As discussed in section 7.3, the current policy framework influencing development in Kenya is fairly robust. However, the challenge is implementation and cohesion between the different arrangements. From an analytical perspective, Nilsson et al. (2012) argue that synergy and conflict in policy arrangements can be identified

on three fronts: policy objectives, policy instruments and implementation practices. Objectively, the Water Act (2016), the Climate Change Act (2016) and EMCA (1999) are structured to improve the management of natural resources, while promoting the sustainable development agenda. In this regard, there is synergy from an objectives point of view. Instrumentally however, there is conflict in the policy frameworks and implementation practices. EMCA mandates NEMA, while the Climate Change Act developed the Climate Change Council and the Water Act set up the Water Resources Authority. Practically, there is no express cohesion between the institutions when it comes to licencing development projects. This is illustrated in the LAPSSET project.

Development projects have clear effects on water, as well as on mitigation of and adaptation to climate change impacts. In spite of this, NEMA has often left out the assessment of climate change impacts and water concerns in the EIA process, as was the case for LAPSSET. For example, the EIAs produced for the LAPSSET project did not report on climate change, despite the regulatory framework around climate change. Neither did the feasibility study conducted in 2011 contain any mention of climate change impacts. Granted that the Climate Change Act was passed in 2016, the NCCRS was developed in 2010 with a clear intention and guidelines to mainstream climate change into development planning. These were ignored in the LAPSSET licencing process. The EIAs did not consider the impact of LAPSSET on CO_2 emissions, or the implications of transporting and promoting crude oil development in Kenya. The concerns around sea level rise in Lamu were not addressed, and there was no mention of how this could potentially affect the location of the project in the future. Neither did it consider the impacts of climate change on the already inadequate supply of water, and how this will be mitigated as local populations increase. In fact, climate change is mentioned as a "positive environmental and social impact of the operation phase". The report states:

"By developing this new road, this will decongest the existing Mombasa to Uganda Northern Corridor route and help reduce CO_2 emissions" (ESIA Lamu-Garissa Road, 2013).

The statement is factually incorrect, in that it equates developing alternative road routes to lessening traffic with no evidence to support the conclusion. NEMA contracts the actual work of conducting the EIAs to licenced companies or consultants. While there are a number of companies who in theory have the expertise to produce EIAs, the reality is that the finished EIA reports are of dubious quality

(Barszewski, 2013). They tend to leave out important environmental impacts (such as water and climate), and undervalue their significance. To the extent that the final EIA reports often appear as a means to an end: a way for developers to get the necessary planning licence to commence their work.

In addition, the EIAs failed to address the impact of the LAPSSET project on Lamu's mangrove forests. They also did not adequately report on the water situation in Lamu. Key experiments such as aquifer tests, water quality tests and remote sensing were not undertaken due to financial constraints. The assessment did not look at the additional pressure on local water systems with the population increase expected as a result of LAPSSET's construction. The requirements of the current policy around development are distinct, however the EIA process fails to adequately integrate all aspects of the current framework. According to Barczewski (2013), the lack of synergy is because fieldwork is often omitted. EIA experts use templates prepared in advance and carry out their assessments without ever going into the field. As a result, considerable issues that needed to be addressed in order to produce a substantive EIA are left out.

The strategic environmental assessment (SEA) ought to give a comprehensive view of projects impacts, ideally integrating the various policy arrangements. In practice though this is not quite the case due to the timing of the SEA and the timing of project implementation. The LAPSSET SEA (2017) noted that climate change would exacerbate most of the negative environmental impacts already highlighted in the EIA of the project, including extreme water shortages. Further, it identified climate change impacts on rainfall (increased drought frequency) as a potential cause for conflict within the LAPSSET region. It highlighted the fact that LAPSSET traverses the most water scarce parts of the country, which are already experiencing severe water shortages. It noted that all three aquifers within the boundaries of the project are projected to experience huge deficits in water supply, predominantly as a result of over abstraction due to population increase.

The National Water Master Plan (NWMP) 2030 is an intensive study of Kenya's water resources and meteorological conditions conducted by the Water Services Regulatory Board (WASREB). The SEA points to the report, stating that by the year 2030 due to projected population growth, the national water availability situation will drop to absolute scarcity in spite of all measures recommended for

boosting annual water supply from 22,564 MCM[11] to 26,634 MCM between the year 2010 and 2030. As a critical measure, the SEA recommended that the LAPSSET project should include the development of essential water storage infrastructure in Lamu. Considering that the project was well underway when the SEA was conducted, the extent to which the SEA recommendations will be applied is nebulous. LAPSSET was given a go ahead without the SEA. The SEA was commissioned after public outrage around the project. It was not (as EMCA prescribes) a part of the licencing procedure. The idea that the SEA plays a significant role in integrating environmental policy in project decision-making applies only when the SEA actually informs the projects development. This was not the case in LAPSSET, contributing to the lack of cohesion in policy arrangements.

7.5 Bridging the Gap Between Policy and Practice

The LAPSSET project provides an example of the divergence from policy and practice. Kenya has an abundance of regulations that call for the integration of environmental impacts in development planning. The main contention is the implementation and application of these policies. This was exemplified in the LAPSSET project whereby corners were cut, and legal guidelines bypassed. As a result, the implementation of the current legal framework was unsatisfactory. At the same time, LAPSSET illustrates some fundamental flaws in the EIA process. For instance, it is apparent that EIAs are not equipped to address the negative impacts of climate change in project planning. They are also ill equipped to incorporate rising water demands and declining water supplies in the project-planning phase. This presents a significant challenge to the sustainable development arena. It is important that EIAs integrate climate change and water effectively, as the EIA is an essential tool in the current legal framework directly shaping national development.

As a whole, the EIA process needs to be improved on to ensure that climate change and water issues are adequately covered in project planning. With this in mind, there is an opportunity to mainstream climate change in the licencing process for development projects. There is also an opportunity to enhance EIAs to apply an integrated approach to water management. The EIA process should provide a consolidated platform for EMCA (1999), the Climate Change Act (2016), and the Water Act (2016). The study suggests two ways of approaching this through the

[11] Million cubic metres

current EIA framework. This includes applying an integrated water resources management approach and mainstreaming EIAs.

7.5.1 Applying an integrated water resources management approach (IWRM) through EIAs

EIAs need to be more thorough in assessing the potential impact of a project on local water. This process needs to be closely tied to the work of the Water Resources Authority (WRA). The study identified a divide in the implementation of EMCA (1999) and the Water Act (2016). In the LAPSSET example, the EIAs conducted were not explicit in their consideration of water issues despite water being a significant concern to the residents of Lamu. This was also in spite of the Water Act (2016) provision that any project causing large abstractions of water should be issued with a special permit in line with the EIA. This did not occur with LAPSSET, suggesting that EIAs are missing out on the key issues that are salient to water availability and access in a community.

Lamu is experiencing serious water shortages, due to worsen as a result of the negative impacts of climate change and the effect of the LAPSSET project on demand for water. The potential for conflict around Lamu's declining freshwater supply is not mentioned in any of the EIAs on the LAPSSET project. Yet, the issue was repeatedly brought up in the study. For example, one young man stated:

"Lamu is already insecure, the security issues here are known nationally. But people don't talk about the ethnic and religious tensions we have here in Lamu. The rains in Mpeketoni have been so bad for the past three years and as a result we are struggling with water. I had to come to Lamu town in search of work. The people in Lamu town have it easy and they treat us badly because the people of Mpeketoni are the only ones qualified in the region to get the good jobs. The port will bring opportunities to us forgotten people"

While another young man stated:

"We will fight to protect the Shella sand dunes. That is our heritage and belongs to us from our ancestors. We will not allow anyone to take it over"

The goal of the EIA process is to pinpoint issues that are important to the community, and then provide actions that would mitigate against potential negative impacts of the development project. An integrated water resources management approach includes elements of good water governance such as inclusiveness, participation and equity. Applying this approach to environmental assessments would support the identification

of key issues that may otherwise be left out of the EIA process. It may also bring about cohesion between EMCA (1999) and the Water Act (2016).

Implementing IWRM through the environmental impact assessment process will help local communities affected by new projects to manage their water in the face of development. The overall goal of the IWRM approach is to promote the sustainable use of local water in a coordinated manner, equitably maximising social and economic welfare. Several of the recommendations shared by residents build on the key tenets of an IWRM approach to water management. For example, participation of all stakeholders was highlighted as an important part of managing Lamu's water supplies. The participants stated that their participation in the policy process should be real and not "for show". It should also be based on full disclosure and information regarding potential development projects, identifying values that are locally relevant. Participation in water management should also determine stakeholder needs and priorities, ensuring that women and girls who are often left out of the discussions are included. Efficient participation of different actors in managing water resources promotes social equity, a fundamental principle of IWRM.

Another example is the cost of water; residents reiterated that water prices in Lamu are on the increase and that these costs will continue to go up with the LAPSSET project. They recommended that affordable alternatives to the current sources of water in Lamu are made available to local residents. They also recommended that water infrastructure in Lamu should be upgraded and made more efficient to ensure that the local community have better access. Further, with the LAPSSET project placing additional demands on local water supplies, they recommend that the LAPSSET project be responsible for investing in better water provision services. This is a fundamental principle of IWRM. Applying IWRM in the EIA process would ensure that water is valued and this value is translated into the final project costs. Treating water as an economic good is an important means for decision making on the allocation of water between different water use sectors and between different uses within a sector.

While it is possible to argue for an IWRM approach in EIAs, it is important to consider the challenges of implementing such an approach. One challenge is the land use changes that complicate discussions around water management. For example, in Shella, fishing was historically the main livelihood for the people of Shella. However,

farming for both subsistence and commercial purposes is rapidly changing the land use pattern:

"My husband has a lot of land here in Shella and we have the best water here. He started farming on our land because there is no fresh produce in Lamu, and there is a lot of money in selling fresh fruit and vegetables. All the 'mzungus' buy mangoes and melons from us. It has brought our family a lot of extra income"

(Woman from Shella).

The changing land use pattern is increasing the demand for water from the Shella aquifer. The Shella aquifer is further overwhelmed by the rise in the number of hotels, 'holiday homes' and hostels in the area. The Shella aquifer is a major source of water for residents in Lamu town and as such, any additional demands on it will affect a wide range of users in the region. Land use changes have some effect on water resources. Applying an IWRM in the assessment process would evaluate these concerns, allowing the development project to truly incorporate the most pressing needs of the community.

7.5.2 Applying a mainstreaming approach to integrate climate change impacts in EIAs

Adaptation to climate change will involve integrating adaptation into existing development processes and activities. As argued by Boruff & Morrison-Saunders (2011), the EIA process is one where climate change could be potentially integrated. It is suggested that specific climate change related regulations should be applied to each step of the EIA process in order to synchronise adaptation efforts in a cost effective and efficient way (Boruff & Morrison-Saunders, 2011). This study found that the existing EIA process does not expressly consider climate change impacts. Neither do they consider the impact the infrastructure development project will have on global greenhouse gas emissions. Furthermore, the study also concludes that there is a gap in terms of synergy between the environmental legal guidelines (EMCA 2015, Water Act 2016 and Climate Change Act 2016). Considering that part of NEMA's mandate is to bring about synergy in environmental management, the EIA process is an ideal tool to address this gap. NEMA commissions EIA studies, and as such they have the opportunity to mainstream climate change and streamline EIAs across the different legal provisions.

Participants are aware that the climate is changing, even though their knowledge of this phenomenon is largely experiential. They are also aware, to some extent, of the

EIA process necessary to licence a development project. While the process is not perfect, NEMA officials and residents agreed that the EIA facility was the most ideal to integrate climate change impacts in development planning. This is because the EIA process provides a framework for influencing decision making at an early stage when plans are still being developed. The EIA process can also help identify projects that are especially sensitive to climate change. Officials from NEMA stated that they are considering various means of integrating climate change into the EIA process (particularly the opportunities brought about by adapting to climate change). They also argued that integrating climate change into the EIA process would make EIAs a stronger decision-making tool. Before a project is licenced, decision makers would have the opportunity to modify the project, develop alternatives or adopt other measures to mitigate against climate related risks.

This study recommends restructuring the current EIA process to mainstream climate change as well as apply an integrated water resources management approach (IWRM) to water decision making amidst infrastructural development. A restructure would include a mainstreaming framework, an IWRM strategic plan and a climate change 'cell' (Figure 7.2). The mainstreaming framework would be incorporated into the initial project proposal stage, including a plan for implementation throughout each stage of EIA licencing. The framework would cover mainstreaming across different elements including water resources, agriculture, transport, energy, housing and health. The framework will allow EIA practitioners to evaluate the interaction between the project's actualisation and climate change. The IWRM strategic plan, would entail guided steps towards engaging stakeholders (including mapping them out) in decision making around water issues. This would be a prerequisite to the auditing and monitoring process. While the climate change 'cell' would be responsible for coordinating and harmonising overall EIA process to ensure integration of climate change into the environmental impact assessment. The cell will conduct relevant research and modelling, as well as guide the mainstreaming framework. The cell will present opportunities for cohesion and coordination between different institutions including the Kenya Meteorological Department and the Water Resources Authority. The cell will also be responsible for ensuring coordination and cohesion between different actors including national and county government, as well as community stakeholders.

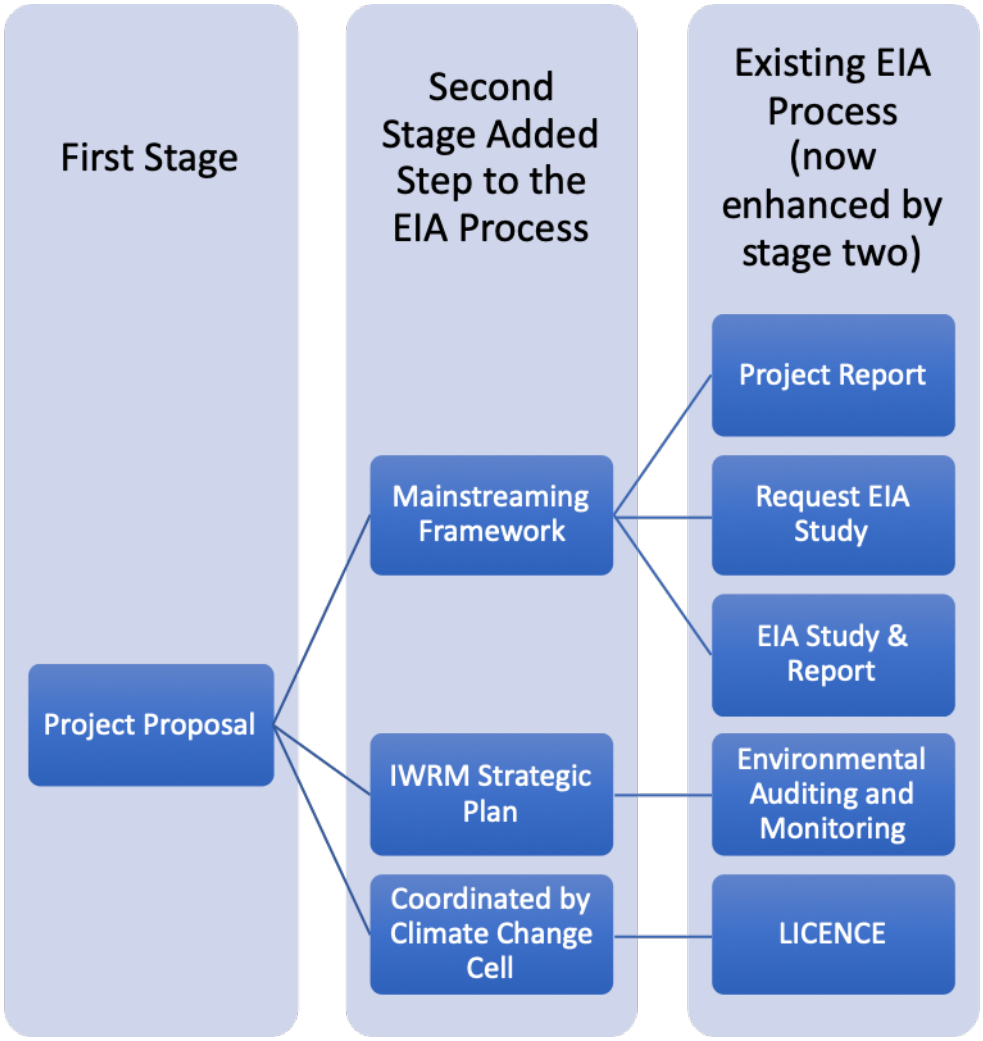


Figure 7.2 Mainstreaming climate change in the EIA process

7.6 Discussion

Large-scale infrastructural projects have explicit impacts on freshwater sources and systems. They require and depend on water for their development and continued function. Further, they increase the demand for water (as a result of surging population), placing additional pressure on local water systems. In theory, EIAs should account for the negative effects a project will have on local water. Practically, the LAPSSET example demonstrated that this is not the case. In addition, the study found that the threats and opportunities climate change poses to the national development agenda are still unaccounted for. The study recommends improving and restructuring the current EIA framework to take into account the impacts of a project on local water and apply an IWRM approach. A fundamental element of IWRM is stakeholder participation, which the study noted was low in the LAPSSET EIA process. Stakeholder involvement is provided for explicitly in the Kenyan

Constitution as well as EMCA (2015). The LAPSSET project skipped essential steps that were important in ensuring all stakeholders were brought to the discussion table. Consequently, the relationship between the community and the government (local and national) is broken and in dire need of mending in this region. This is necessary to ensure a successful approach to IWRM.

The brief outlook on the history of environmental movements in Kenya provides a platform to understand current debates around sustainable development. The environmental debates of the early 1970's highlighted the significance of community organising and NGOs in shaping environmental policy. Similarly, the LAPSSET project has stirred the local community and a host of NGOs to demand accountability, better environmental planning and action on climate change. 'Save Lamu' and others have turned to the international community for support. There already exists extensive policy in place, and the question is now one of effective implementation. Drawing on the experiences of more developed economies, developing countries like Kenya have a chance to shape development in a way that is sustainable and accounts for the need to adapt to the impacts of climate change. The cost of inaction far outweighs the cost of mainstreaming climate change in development planning.

Thus, this study recommends restructuring the EIA process to assimilate climate change into development planning through a mainstreaming framework. This is an argument that is in part supported by Klein et al. (2007). Portfolio screening is suggested as a means to mainstream infrastructural development, whereby project portfolios are screened with two goals in mind. The first goal is to ascertain the extent to which existing development projects consider climate risks or address vulnerability to climate variability and change; and second goal is to identify opportunities for integrating climate change (Klein et al., 2007). The EIA in Kenya is structured in a manner that is conducive to portfolio screening. On the other hand, Matemilola et al. (2018) found that in Nigeria, political will plays an important role in the success of mainstreaming through an EIA. Attempts at mainstreaming have been largely problematic due to the lack of political will to address climate change on a national level. The political will in Kenya can be demonstrated through the attempts to legislate on climate change, Kenya is one of the first African countries to pass legislation on climate change (the Climate Change Act 2016). Furthermore, the social movements around climate change in Kenya have been invigorated by the LAPSSET

project. Organizations and individuals around the country are using the LAPSSET example as a rallying call for action on climate change. There is currently sufficient momentum to push for a mainstreaming framework within the EIA process.

Overall, there is a lack of cohesion between environmental polices relevant to development, notably so the EMCA (2015), the Water Act (2016) and the Climate Change Act (2016). Additionally, climate policy documents including the National Climate Change Action Plan (2013) and the National Climate Strategy Paper (2010) are not sufficiently integrated within the environmental impact assessment process that ultimately informs development initiatives in the country. They are also not integrated within the Water Act (2016) and neither is there integration and cohesion across the different policy practitioners. As such, real mainstreaming remains an aspiration that is yet to be actualized. The County governments needs to be aware of what the National government is doing and WRMA needs to be aware of what NEMA is doing while continuously engaging key stakeholders. Mainstreaming is not a simple add on process, but rather a system of continuous checks and balances to ensure that change is reflected in daily practice. Therefore, it is essential that collaborative approaches are favoured, as well as continuous community engagement in the decision-making process.

7.7 Conclusion

This study found that Lamu is already experiencing the negative impacts of climate change and these are intensifying the current stress on water availability and accessibility. Arguably, the greatest challenge at this point is designing holistic and workable plans that can be integrated into existing policy and processes to ensure that these threats and opportunities are responded to. Furthermore, the challenge is also to ensure that these plans are locally relevant and include the perspectives of local stakeholders. There is an opportunity to improve upon the current process and ensure that climate change impacts are accounted for in large infrastructural development projects. The potential for mainstreaming climate change into Kenya's EIA process is relatively unchartered territory and there is room to explore this further. There is also the opportunity to apply an integrated water resources management approach through EIAs to ensure equitable water allocation and sustainable development. The mainstreaming framework and climate change cell suggested as additions to the EIA process, are a potential avenue through which different actors can better interact to

draw more positive outcomes around water issues from large scale development projects such as LAPSSET.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

Lamu is experiencing critical water shortages. These are predominantly a result of poor water infrastructure, limited access to piped water and an over dependence on groundwater sources. Climate change is and will continue to exacerbate the existing challenges that the Lamu community are experiencing in regard to access and availability of water. Lamu is also the site of major infrastructural development including LAPSSET, a Vision 2030 flagship project. By the time the project is completed, it is envisioned that the population of Lamu will increase to at least one million people (12 times the current population). There are crucial concerns around the community's capacity to cope with the negative impacts of climate change on already declining freshwater sources. These concerns will be intensified by the rise in demand for local freshwater as a result of LAPSSETs completion and operation. Considering that LAPSSET is already at 40% completion, it is striking that there is no viable plan to address the water concerns of the community.

This study set out to investigate the capacity of the Lamu community to deal with the additional impacts of climate change and large-scale infrastructural development on declining freshwater resources. This was achieved by providing an evaluation of the trends in temperature and rainfall, and linking these trends to freshwater availability. This was based on the premise that severe freshwater decline in Lamu can be best understood by examining the trends in climate variables. Then, an assessment of stakeholder needs and priorities around water access and use was conducted. This provided a detailed understanding of the water concerns in the region. Further it was hypothesized that any interventions to improve water access and use in Lamu would require an understanding of the policy process determining the course of infrastructural development in Lamu. This contributed to an analysis of the relevant environmental policy provisions affecting the course of large-scale infrastructural development in Kenya.

The study applied a mixed methods research design with a sequential exploratory design technique. Whereby, qualitative and quantitative data were collected at

different phases of the study. The research captured the nuances and vicissitudes in the region's water use, relating them to localized impacts of climate change on freshwater. It also highlighted the potential impacts of large-scale infrastructural development on local water resources, illuminating the potential of national development policy provisions to integrate climate change. In addition, it sought to answer research questions on the nature and role of key stakeholders in relation to freshwater use in Lamu. This facilitated the restructures offered to the existing Environmental Impact Assessment (EIA) process including mainstreaming and applying an integrated water resources management approach (IWRM). The policy recommendations are rooted in stakeholder participation in the processes, and thus a detailed understanding of stakeholders is a key addition to the policy process

8.2 Summary of Main Findings and Conclusions

The results presented in the preceding chapters show that the Kenyan coastal region of Lamu is experiencing climate change. The study demonstrated strong evidence for warming trends consistent with climate change. While the trend analysis was inconclusive on average rainfall, the increasing trend identified for the short rainy season (October to December) corroborates current IPCC predictions for the region, whereby rainfall is projected to increase by the year 2030 (IPCC, 2021). It is evident that the impacts of climate change will play a role in exacerbating the already existing problems of limited water supply in the region. Furthermore, it is apparent that the Lamu region will experience additional pressures on local freshwater from the development of the LAPSSET project. Ideally, the policy process informing national development should have accounted for these issues before the project was started. However the study determined that there are sufficient gaps in the existing policy process, rendering it inadequate to integrate climate change impacts as well as apply an integrated water resources management approach. In addition to these gaps, it was identified that LAPSSET did not follow due legal process in its launch, adding another layer of challenges to the capacity of existing policy to integrate climate change.

The first aspect of the study sought to understand the impacts of climate change on water availability and access in Lamu. The assumption was that the coastal town of Lamu is already experiencing changes in rainfall and temperature, consistent with global climate change models. It was also presumed that Lamu would be

experiencing changes in the form of sea level rise and that in both cases, freshwater in Lamu would be compromised. The study verified that the Lamu region displays the scale of temperature changes that are consistent with global predictions. The general pattern in the trends indicated increased warming in Lamu, which will have implications for water availability in the area. Furthermore, the study also found significant evidence of sea level rise and groundwater sources showed substantial increases in salinity. As a result, changes in the community's land use and choice of livelihoods were detected across the region. One such example of this is the change in land use from commercial farming to subsistence farming. Commercial farming is no longer prevalent in the area and yet, historically certain parts of Lamu were known for a thriving commercial farming culture. Due to the reduction in available water, and the strain commercial farming places on water sources, local farmers are seeking additional employment to provide for their families. They are also converting to subsistence farming as a way to provide for their families. Pastoralism is also on the rise in the region. While this is not a typical livelihood choice associated with Lamu, domestic migration from neighbouring Garissa is increasing the pastoralists in the region. Pastoralists are migrating from Garissa to Lamu as a result of water shortages in Garissa, but the water in Lamu is also not sufficient to sustain these pastoral communities. It is implied that the competing interests for water is a potential source of conflict in the region.

The second question the research sought to answer was: who are the key stakeholders in Lamu with regard to the demand for and use of freshwater? The presumption was that an understanding of the key stakeholders in terms of water use and access promotes sustainable water management. The study collected data from a wide range of local stakeholders (including youth, homeowners, farmers, fishermen and local NGO's). The key issue that emanates is one of power: stakeholders that have major interest in water (for example local women) but have significantly little power in the decision making process to determine water access and use. As a result, the stakeholders who are most affected by decisions around water access and use are largely left out of the decision making process. Thus, it is deduced that competing interests in local water combined with inadequate power (power that does not reflect the stakeholders' interest in water) in decision-making will inevitably lead to unsustainable water use and management.

The third line of inquiry of the research looked at the anticipated impacts of large-scale infrastructural development on freshwater availability. The leading supposition here is that large-scale infrastructural development can negatively impact the availability of local water if not adequately planned for. Using the LAPSSET project as an example, the study identified inconsistencies between stakeholder's perceptions of LAPSSET's impact and the environmental impact assessment (EIA) reports. Stakeholders overwhelmingly cited declining freshwater as a significant issue in the region, however this was not adequately captured in the any of the EIA reports. Specifically, the feasibility study and EIAs for parts of LAPSSET (the port and the road network) did not take into consideration how availability and accessibility of water would be affected by LAPSSET. Neither did they take into consideration the impact climate change would have on water availability in the region. This is contrary to the current legal framework on climate change in Kenya, specifically the Climate Change Act (2016) and the National Climate Change Action Plan (2013). In relation to this, the study established that LAPSSET did not follow due process in its pathway to operationalization. Construction on LAPSSET was officially begun before any of the necessary EIAs mandated by the Environmental Management and Coordination Act (1999) were done. To date, EIAs on all elements of the project are yet to be conducted, including a trans boundary assessment of environmental implications. Further still, LAPSSET is yet to develop a comprehensive water plan to increase water supply in the region in line with provisions of the Water Act (2016). It is worth mentioning the Strategic Environmental Assessment (SEA) (2017) which was the first policy instrument that undertook a detailed analysis of water issues in the region. The SEA captured the water concerns of local stakeholders, projecting huge deficits in water supply as a result of operationalizing LAPSSET. The SEA also took into consideration the negative impacts of climate change, stating that climate change would intensify water problems in the area. The SEA however, was conducted five years after LAPSSET was officially launched and when the project was nearing 40% completion.

Overall, the study noted a discrepancy between EIA reports and stakeholder perspectives, implying that there are problems with the EIA process as a whole. Contributing to this discrepancy, the study identified the lack of sufficient public participation, the lack of cohesion between policy arrangements and subjectivity in reporting as some of the main weaknesses in the EIA process. Furthermore, the

inconsistency between the timing of the EIA process (as prescribed by legislation) and project implementation depicts a critical issue with the transparency of the EIA process as a whole. For these reasons and more, the study recommended enhancing the current EIA framework to integrate climate change and water issues in development planning. This would be in the form of applying an integrated water resources management approach in the EIA licensing procedure. It would also entail implementing climate change mainstreaming in EIA decision-making procedures. Failing to mitigate against and adapt to the impacts of climate change is incompatible with the sustainable development goals. Kenya's development planning mechanisms need to take on climate change mainstreaming as a priority in order to plan, integrate and ensure sustainable development pathways.

8.3 Policy Recommendations

There is a need for an integrated policy approach to promote sustainable development as well as adaptation to the negative impacts of climate change. There is also a need to re-emphasize the value and importance of public participation in shaping the course of national development. While this is a constitutional provision (Article 35, Constitution of Kenya, 2010), implementation in the environmental impact assessment process is far from the ideal. The study suggests integrating climate change policy and water policy with environmental impact assessments to have the most impact. This implies coordination between county and national government, state and non-state agents as well as local stakeholders (community). Furthermore, it is implied that the decision making process around developing and implementing an integrated water management framework should reflect stakeholder interests.

Based on the conclusions discussed in the above section, it is possible to make four key recommendations to the policy process (Fig. 8.1). These are as follows:

i. Apply an integrated water resources management approach within the environmental impact assessment process. This would ensure that interventions identified by the EIA to ameliorate the negative environmental impacts of the proposed project consider water issues as well as apply IWRM in community decision-making. Strategic planning around IWRM should be a requirement for the issuance of EIA permits.
ii. Integrate climate change with national development policy by mainstreaming climate change into the EIA process.

iii. NEMA and WRA (who have the mandate to coordinate water and environmental management in local communities) should undertake a stakeholder mapping assessment, determining priorities in terms of water access and availability. Decision-making around water should take into account the stakeholder interests and corresponding dependence on water. This way, stakeholders with a high interest in water are accorded corresponding decision-making power.

iv. Awareness and education initiatives should be developed and factored into the environmental impact assessment process. Entities conducting environmental impact assessments should be expected to attend regular trainings, keeping them up to date on various interventions and technological advancement.

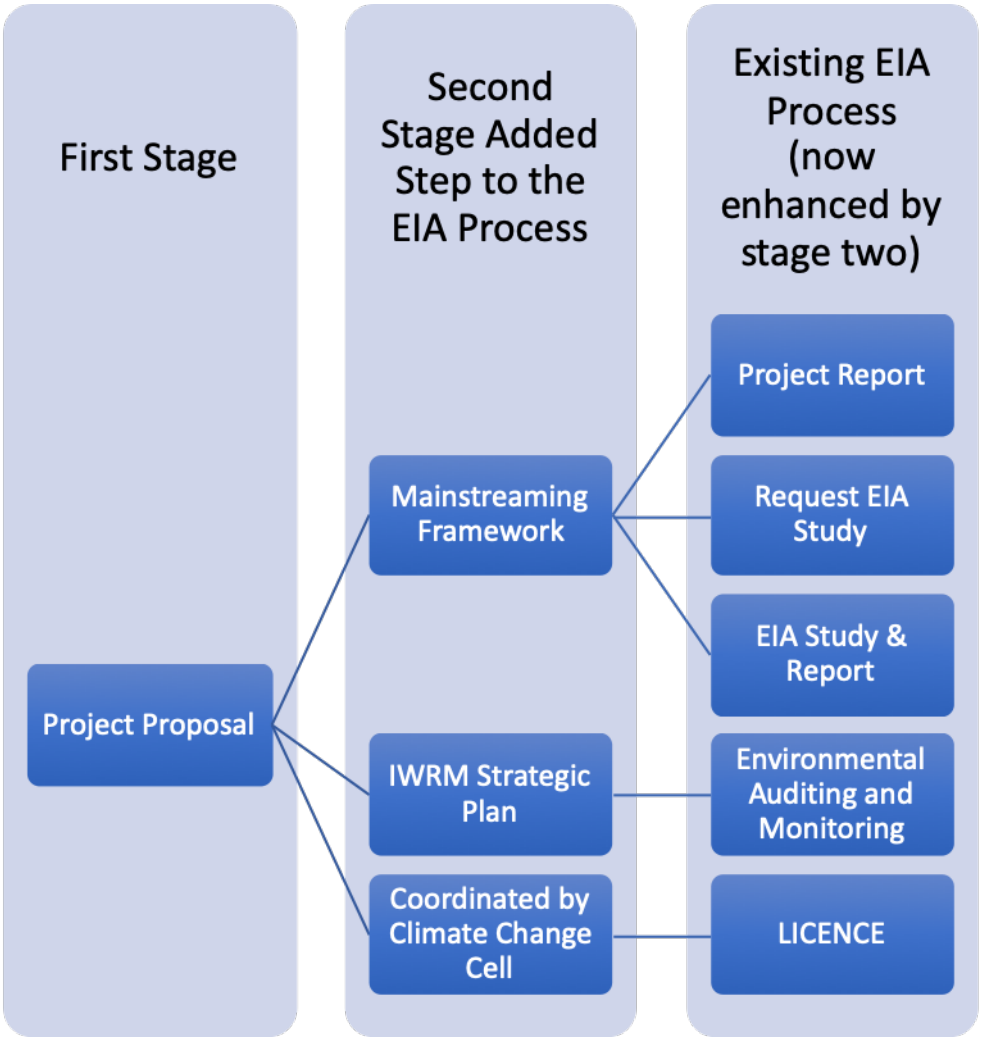


Figure 8.1 Enhanced Environmental Impact Assessment Process

Further it should go without saying that intrinsic to the success of policy is in the strict observation of rules and guidelines set out in the provisions. No project, individual or entity is above the process, irrespective of the perceived economic benefits of a plan. In addition to the above mentioned policy recommendations and with specific relevance to Lamu, the study further recommends building additional water infrastructure in Lamu County as a matter of urgency. This is crucial in supporting the current water needs of the community, sustaining large infrastructural development and adapting to the negative impacts of climate change. This should take into account technological innovations that minimize carbon emissions.

8.4 Future Research Recommendations

Climate change adaptation and integrated water resource management can be incorporated into existing policy structures informing infrastructure development. In particular, the environmental impact assessment process provides an ideal policy structure to integrate climate change impacts with the participation of multiple stakeholders. Such policy measures would improve the capacity of communities to deal with the additional impacts of climate change and large-scale infrastructural development on declining freshwater sources. In the course of conducting the research for this study a number of interesting aspects came to the fore, but which could not be covered due to resource constraints. For example, the potential for resource-based conflict arose as an issue in Lamu. However, this was not explored in sufficient detail. Also, the gender differentiated responses to challenges in water availability and access was alluded to in the findings, though there is an opportunity to explore this further in future research.

There are also a number of gaps in knowledge around the mainstreaming of climate change that emerged in the findings and would benefit from further research. For example, mainstreaming climate change in development planning amidst uncertainty on climate change impacts. Also it is apparent that there is a need to understand the communication of climate change to policy makers, and stakeholders alike. While communities have an understanding of climate change and how it is affecting them, incorporating this for policy purposes requires a more in depth understanding of communicating climate change for mainstreaming. On the IWRM front, there is a need for more methodological work on how to capture the impact and outcomes of stakeholder involvement in an IWRM approach, including further

economic analysis and exploration of impact when stakeholders are integral to the decision making process around water. Overall the policy process on water, development and climate change would benefit from understanding the capacity of the institutions (such as WRA and NEMA) to effectively integrate climate change into water management approaches.

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APPENDIX A

COMMUNITY OBSERVATIONS OF CLIMATE VARIABLES (TEMPERATURE & RAINFALL) AND WATER AVAILABILITY IN LAMU COUNTY

Questionnaire No: Name of Enumerator:

Thank you for agreeing to participate in this study. Your participation is expected to take about 15 minutes. During this time you will be asked a few questions about your experience living in the region, your understanding of climate change, your access to and use of water. If you're at any point feel uncomfortable for any reason and would like to stop participating, that is okay, please just let me know and we will stop the interview. Should you choose to participate in the interview, your data will be securely stored and coded, so your responses will remain confidential. If you have any questions, just ask me. Then, if you agree with the content of this verbal consent, state your name and that you consent.

PART A: DEMOGRAPHIC CHARACTERISTICS

1. **Name (Optional):**

Date of the interview: **Place of interview:**

Contact (Tel):

Location (GPS Coordinates):

2. **Age of Respondent**

15-19 ☐ 20-24 ☐ 25-29 ☐ 30-34 ☐

35-39 ☐ 40-44 ☐ Over 44 ☐

3. **Sex (Circle):** MALE FEMALE

4. Source of livelihood (Circle):

Housewife Unemployed Farmer Fisherman/woman

Service industry Sand/Ballast Quarry Ranching

Mangrove Harvesting Formal Sector Employment

Other

5. Level of Education

What was the highest level of education completed?

A) Primary
B) Secondary
C) University under graduate
D) University post graduate
E) Other tertiary college

PART B: TO DETERMINE CLIMATE TRENDS BASED CLIMATE PERCEPTIONS

6. Have you noticed any changes in temperature in the past ten years? (Circle)

YES NO

7. If you responded with yes, circle the most appropriate statement

A. It has become warmer over the years

B. Temperature has remained the same over the years

C. It has become cooler over the years

8. Have you noticed any changes in annual rainfall in the past ten years?

YES NO

9. If you responded with yes, circle the most appropriate statement

A. Rainfall has increased over the years

B. Rainfall has remained the same

C. Rainfall has reduced over the years

10. Are you able to predict the start and end of the rainy season?

A. Yes, it is fairly easy to tell when the rains will come and when they will end
B. No, they have always been unpredictable
C. No but I used to be able to tell when the rains will come but now I can't.

11. When was the last time (year) you were able to predict the start and end of the rains?

12. Do you receive around the same amount of rainfall every year?

YES NO

13. If you responded with no, circle the most appropriate statement

A. There has been more intense rainfall than usual
B. There have been more dry days during the rainy season than usual

14. Are the rains enough to meet your water needs until the next rainy season?

YES NO

15. Do you know what climate change is?

YES NO

16. If yes, what do understand by the term climate change?

PART C: TO DETERMINE ACCESS TO, AVAILABILITY OF & USES OF WATER BASED ON COMMUNITY PERCEPTIONS

17. Where do you get your water?

A. Nearest Well

B. District Water Board
C. Borehole
D. Rainwater harvesting
E. River
F. If Other source, please specify below:

18. What is the distance to your nearest source of water?

A. Under 1km
B. Less than 2km
C. Less than 5km
D. Less than 10km

19. During the rainy season, is water more readily available?

YES NO

20. If you responded with yes, what is the new distance you have to travel to get water during the rainy season?

A. Under 1km
B. Less than 2km
C. Less than 5km
D. Less than 10km

21. Who is in charge of this water source?

22. Is there a limit on how much water you can access at any one time?

YES NO

23. Is this a reliable water source (water is always available)?

YES NO

24. Have you had to change your source of water in the recent past?

YES NO

25. If you responded with yes, please explain (when did you change and to which water source)…

26. What do you use your water for? (You may tick more than one)

A. Household – Drinking
B. Household – Other
C. Subsistence farming
D. Cash farming
E. Other – if other uses not listed above please list below:

27. Do you know about the LAPSSET project?

YES NO

27. Do you think the LAPSSET project will change your access to water?

YES NO

28. If you responded with yes, please explain below:

THANK YOU

APPENDIX B

KEY INFORMANT INTERVIEW GUIDE
DETERMINING IMPACT OF CLIMATE TRENDS ON WATER AVAILABILITY IN LAMU COUNTY

Thank you for agreeing to participate in this study. Your participation is expected to take about 45 minutes. During this time you will be asked a few open-ended questions about your experience living in the region, your understanding of climate change, your access to and use of water. If you're at any point feel uncomfortable for any reason and would like to stop participating, that is okay, please just let me know and we will stop the interview. Should you choose to participate in the interview, your data will be securely stored and coded, so your responses will remain confidential. If you have any questions, just ask me. This interview may be recorded for analysis purposes only. Then, if you agree with the content of this verbal consent, state your name and that you consent.

Preliminary/Background Information

1. How long have you been living in this part of Lamu?
    Probes: What brought you to the region?
        Where did you move from?
2. How would you describe your work/involvement in the local community?

Knowledge of Climate Change

3. What do you know about climate change?
4. What do you believe the impacts of climate change are in this area?
5. How do you think climate change can impact water availability?

Use and Observations

6. In which ways do you use water in your day-to-day life?
7. In which ways do you source water in your day to day life?
8. Can you describe a typical day and how you use and source water throughout the day?
9. How does this routine change through the rainy seasons?
10. What is your primary source for irrigation and potable water?
11. What changes have you observed in the local water source during your time living in Lamu?
12. What factors do you think have contributed to these changes?
13. Do you think these changes are temporary or permanent?
14. What kinds of changes in rainfall patterns have you observed?
    Probes: How have these changes altered or impacted your use and interaction with water?
        What factors do you think have contributed to these changes?
        Do you think these changes are temporary or permanent?

Water Management

15. How is water managed in this region?
    Probes: Differentiate between how it is institutionally managed? How it is community managed and household management?
        Are there different roles for men and women as far as water management is concerned?
16. What do you think is being done well with the water management?
17. What do you think could be done better with the water management?

18. How much control do you have in the management of local water resources?
19. Would you like to have more/less? Why?

Wrap Up

20. Is there anything else you would like to say about water in this area?
21. Do you think there is anything I should be asking about these topics that I'm not already asking?
22. Is there anyone else you recommend I talk to?

APPENDIX C

KEY INFORMANT INTERVIEW GUIDE
PERCEPTIONS ON POTENTIAL IMPACTS OF LAPSSET ON WATER IN LAMU COUNTY

Thank you for agreeing to participate in this study. Your participation is expected to take about 45 minutes. During this time you will be asked a few open-ended questions about your relationship to Lamu County and your understanding of the LAPSSET project. If you're at any point feel uncomfortable for any reason and would like to stop participating, that is okay, please just let me know and we will stop the interview. Should you choose to participate in the interview, your data will be securely stored and coded, so your responses will remain confidential. If you have any questions, just ask me. This interview may be recorded for analysis purposes only. Then, if you agree with the content of this verbal consent, state your name and that you consent.

Preliminary/Background Information

1. What is your relationship to Lamu County?
    Probes: How long have you been living in this part of Lamu?
        How long have you been working on issues related to Lamu County?
2. How would you describe your work/involvement in the local community?
3. How would you describe your professional knowledge on water related issues?

Knowledge of LAPSSET

4. What do you know about the LAPSSET project?
5. Have you interacted with the LAPSSET project, if so how?
    Probes: If not, what is your understanding of the LAPSSET project?
        How long have you interacted with the LAPSSET project?
        When did you first hear about the LAPSSET project?
        How did you come to know about it?
        Are you in regular contact/ involvement with the LAPSSET project?
        Please explain your role/involvement with the project?
6. What do you believe the impacts of the LAPSSET project are in this area?
7. What provisions, if any, have been made to deal with these impacts?
    Probes: Was the community consulted on this project? If yes, how?
        What were the overall community concerns and issues that were raised?
        Were the community concerns/ issues sufficiently addressed? Please explain your answer

Water and LAPSSET

8. Can you describe the demands LAPSSET will have on water in Lamu County?
    Probes: Where does/will LAPSSET get water from for construction purposes?
        How will LAPSSET depend on local water in Lamu County during construction phase?
9. How do think these demands on water will change post construction?
10. How will LAPSSET impact water sources in Lamu County?
11. How will LAPSSET change residents water demands in Lamu?
    Probes: What impact will LAPSSET have on the local population?
        How were Lamu residents consulted on the impacts of LAPSSET on water?
12. What other impacts can you identify from LAPSSET's use of Lamu's water?

Wrap Up

13. Is there anything else you would like to say about LAPSSET in this area?
14. Do you think there is anything I should be asking about these topics that I'm not already asking?
15. Is there anyone else you recommend I talk to?

APPENDIX D

FOCUS GROUP GUIDE

Thank you for agreeing to participate in this study. Your participation is expected to take about 1-2 hours. During this time you will be asked a few open-ended questions about your relationship to Lamu County and your understanding of the LAPSSET project. If you're at any point feel uncomfortable for any reason and would like to stop participating, that is okay, please just let me know and we will stop the discussion. Should you choose to participate in the focus group, your data will be securely stored and coded, so your responses will remain confidential. If you have any questions, just ask me. This discussion may be recorded for analysis purposes only. Then, if you agree with the content of this verbal consent, state your name and that you consent.

Study Purpose:

Exploration: Find out about an issue of importance from the target population

- Water in Lamu and how it is impacted by climate change and development projects
- Are there any suggestions or recommendations on what do?

Methodology

1. Let's start the discussion by talking about what makes LAPSSET (and other development projects) a positive addition to Lamu County, what are some of the good things that will come out of it/them?
   - Economic benefits
   - Increased population / jobs / opportunities
2. What are some things that aren't so good about LAPSSET, and other development projects in Lamu?
   - Water situation
   - Population increase
   - Indigenous Communities
   - Land
   - Culture
   - Pollution and environmental degradation
3. What are some things you have noticed about the weather over the years?
   - Climate changes
   - Potential impacts of change: sea level, rainfall, temperature, salination of water, wildlife and fishing
4. Have you ever considered leaving Lamu? What factors contributed to your decision to want to leave and your decision to stay?
   - Community
   - Land ownership, economic benefits
   - Development projects: coal plant, the port
5. What suggestions do you have to improve the water situation in Lamu?
   - Water use – limits on access
   - Water management: government (county & national), community and individual
   - Water quality, Water availability (other points of access?)

APPENDIX E

Image 1: Group Decision Making: Nominal Group Technique

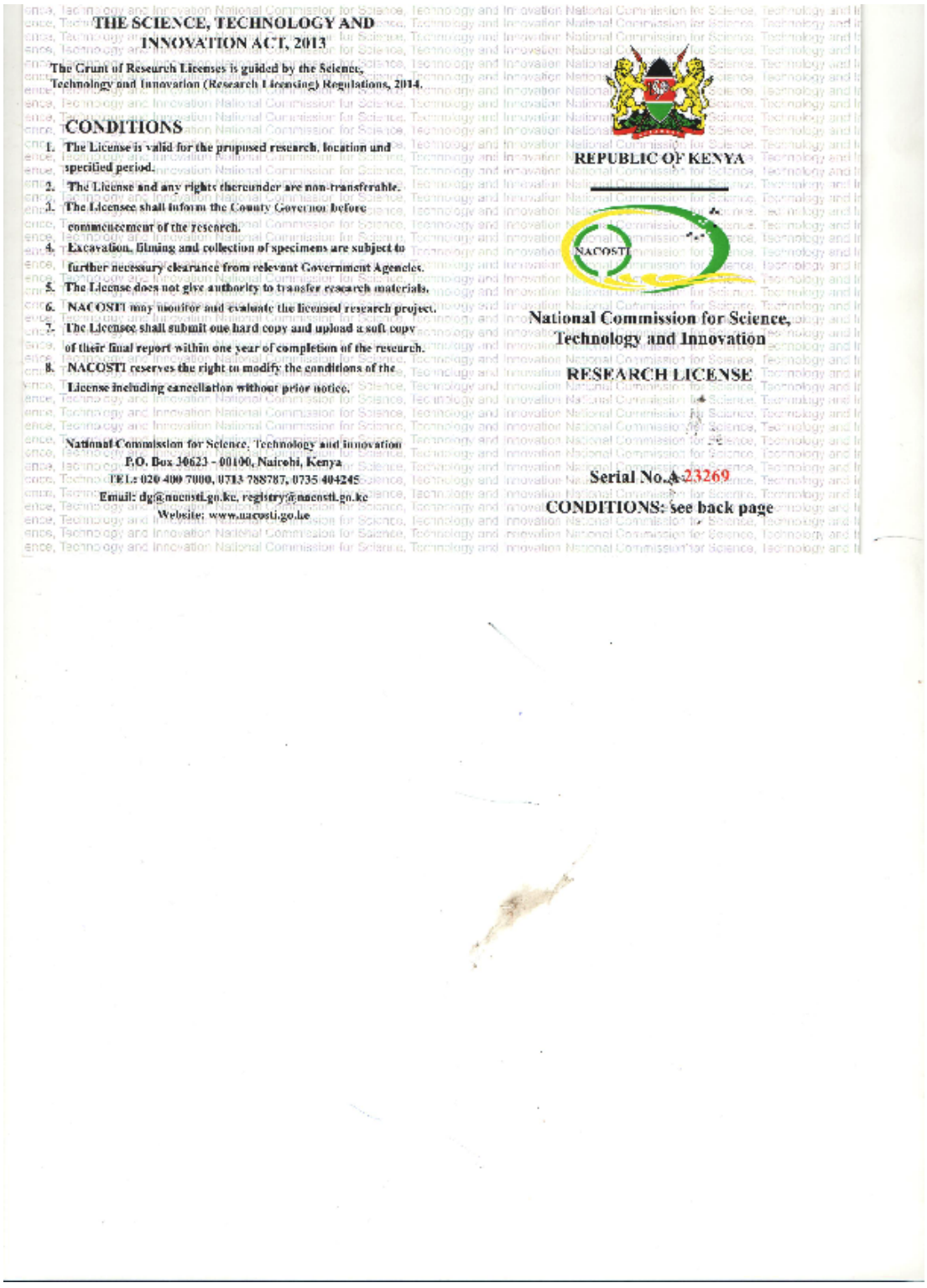
Image 2: Sea wall in Shella as the sunsets.

Image 3: Sea wall in Shella at sunrise

Image 4: Water from the sea touching the building and chair in Shella

Image 5 and 6: Djabia located in Lamu Island

APPENDIX F



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on the topic: *TRAINING FOR DEVELOPMENT: EAST AFRICAN GROWTH CORRIDORS AND THE CHINA TO AFRICA CONNECTIONS*

for the period ending:
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Permit No : NACOSTI/P/19/3232/27585
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1st December 2016

Neil Burgess, Professor
Head of Science, UNEP-WCMC
Cambridge, UK

Dear project coordinator

RE: GCRF Project

The Institute for Climate Change and Adaptation is delighted to join the proposed Global Challenges Research Fund project on building the national capacity in Eastern Africa to engage in the science and policy around the emerging development corridors in the region. Kenya has anchored the development of these corridors in its Vision 2030 flagship projects programme, and in other related development activities. Development corridors are viewed, by both the Presidents of Kenya and Tanzania, and in the eastern Africa region as a whole, to be essential parts of national development going forward.

The Institute for Climate Change and Adaptation, University of Nairobi, has the role of being an advisor, among other institutions, to government on matters of national development, and key among these is the need to ensure that corridor developments deliver the best possible economic and social development outcomes for all relevant stakeholders and to ensure the sustainable use of natural resources and conservation of the biological values of the country.

The ICCA, University of Nairobi, looks forward to engaging in this project

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5th October 2016

To Whom it May Concern,

RE: YVONNE MAINGEY ID NO. 30700018, STUDENT IDENTIFICATION NO. I85/90401/2013

This is to introduce Ms. Yvonne Maingey, a PhD student at the Institute for Climate Change and Adaption, University of Nairobi. Ms. Maingey is currently undertaking her fieldwork and in this regard, she would like to conduct interviews with various respondents and opinion leaders to facilitate her research.

We appreciate any assistance accorded to her during her field work.

Yours Sincerely,

DIRECTOR
INSTITUTE FOR CLIMATE CHANGE & ADAPTATION
CBPS
UNIVERSITY OF NAIROBI
Sign:

Prof. Shem O. Wandiga FRSC, D.Sc. (hc)
Professor of Chemistry
And
Ag. Director ICCA