

Assessing the Effectiveness of National Wetland Adaptation and Management
Frameworks in Kenya; The case of Nyando Wetland Ecosystem

By

Wilver Ongoro (8799428)

A Major Research Paper Submitted in Partial Fulfillment of the Requirements of
the Degree of Master of Science in Environmental Sustainability

Institute of Environment
University of Ottawa

Supervisor: Dr. Joshua Ramisch

© Wilver Ongoro August 2017

Abstract

Wetlands are among the world's most productive ecosystems. They are considered vital for sustainable development and human well-being. Development and implementation of programs for sustainable management and conservation of these wetlands, as well as for climate change adaptation, in resource poor settings of low and middle income countries remains a major challenge. In the face of climate change that is largely driven by richer countries due to their larger carbon footprint, the burden of disrupted livelihoods as a result of climate change, will disproportionately fall on poor communities like those residing along the Nyando wetland basin in western Kenya. This paper describes the Nyando Wetland ecosystem and its challenges and uses it as a case study to demonstrate the complexities of developing sustainable wetland management and climate change adaptation programs in a low and middle income country. The current Kenya national framework (environment), policy documents and strategies have been outlined and measured against international best principles and practices for wetland management and climate change adaptation. This framework has also evaluated for feasibility. In general, the framework is extensive and suitable and identifies all the main stakeholders and provides an excellent grasp of the challenges. Legislative documents are responsive to the problems identified. Nonetheless, there remain a few challenges, including lack of coherent institutional frameworks to provide coordinated programs, lack of sufficient mechanisms to involve local populations, lack of capacity to analyze and interpret data and absence of capacity for long term ecosystem service monitoring and economic analysis. More importantly, the socio-political and legal context of this framework is complicated by poor governance systems where political will to maintain responsible and accountable use of public resources is lacking. In addition, there is strong intention to prepare communities around wetlands for climate change, but adaptation mechanisms are not well described and pathways to obtain the best information for decision making are not well described. The formation of lean organizations with sufficient local participation and with the required capacity will be instrumental in developing and implementing relevant and context-specific wetland management and climate change adaptation programs in Nyando and other wetlands and ecosystems in Kenya. Notably, sustainable wetland management and climate change adaptability can only successfully be implemented if accompanied by socio-political reforms that achieve better governance and accountability.

Keywords- Wetlands, National policies, Management, conservation and Adaptation, Climate Change, Kenya, Nyando

Dedication

My deepest gratitude goes to my parents who stood by me and ensured my successful education and development.

Acknowledgement

I wish to express my great appreciation to the following people for their valuable contribution towards making this research a success:

My supervisor, Professor Joshua Ramisch for his tireless support and commitment during the development of this research work. His useful critiques, suggestions and encouragement were invaluable. My second reader Professor Sanni Yaya for his contribution in formulation and development of the research.

I also wish to give thanks to my family, for their support, patience and love throughout my study. Finally, a big thank you to my Creator for His grace and mercies.

Table of content

Dedication.....	2
Acknowledgement	2
List of Figures	5
List of Tables	5
List of Abbreviations.....	6
Chapter 1: Introduction	7
1.1 Background	7
1.2 The problem statement and Justification	9
1.3 Objectives	10
Chapter 2: Literature review.....	11
2.1 Definition of wetlands	11
2.2 Uses of Wetlands.....	11
2.2.1 provisioning.....	12
2.2.2 Regulation Services.....	12
2.2.3 Cultural services	13
2.2.4 Supporting services.....	13
2.3 Threats to wetland ecosystems	14
2.3.1 Land use/cover changes	14
2.3.2 Climate change.....	15
2.3.3 Pollution	16
2.4 Challenges of conservation and management of wetlands in low and middle Income countries (LMICs).....	16
2.4.1 Poverty	17
2.4.2 Institutional failure	17
2.4.3 Lack of information	18
2.5 Wetlands and climate change	19
2.6 The wetlands of Kenya	20
2.6.1 Kenya National Wetland Adaptation and Management Framework	23
2.8.1 Assessment of Ecosystem Management Frameworks and Strategies	25
2.8.2 Assessment of suitability of Wetland Climate change adaptation strategies	28
Chapter 3: The Case Study and Methodology	30
3.1 The Nyando wetland	30
3.2 Methodology.....	32
Chapter 4: Results and Analysis	34
4.1 The current state of Nyando wetland	34
4.1.1 The people of Nyando and their socio-economic state	35
4.1.1 Nyando wetland ecosystem services	36
4.1.2 Climate change impacts in Nyando	37
4.2 Analysis of the Kenya National Framework on wetland management and climate change adaptation	38
4.2.1 Indirect drivers of wetland ecosystem change	39

4.2.2 Direct drivers of wetland ecosystem change	40
4.2.3 Ecosystem services.....	42
4.2.4 Human well-being.....	43
4.2.5 The Social, Political and Economic context of Nyando and other wetlands in Kenya	44
4.2.6 References to Climate change adaptation	45
Chapter 5: Discussion	47
5.1 Wetland Management Framework and Strategies	47
5.2 Climate change adaptation	53
5.3 Wetland Governance Framework in Response to Climate Change	55
Chapter six: Conclusion and recommendations	56
6.1 Conclusion	56
6.2 Recommendations.....	57
Bibliography	59
Appendix 1	65

List of Figures

Figure 1: A map of Ramsar listed sites in Kenya	21
Figure 2: The MEA’s conceptual framework for assessing wetland ecosystem management and sustainability programs (Adopted from (Maclean, Boar, and Lugo 2011).....	26
Figure 3: Stage for environmental adaptation implementation programs, adopted-(McCarthy et al. 2012)	29
Figure 4: Study area of Nyando Wetland (Van Dam et al., 2013	31

List of Tables

Table 1: Summary of Assessment of Kenya Wetland management and Adaptation in relation to current International Benchmarks.....	52
Table 2: Climate change adaptation in the current framework and opportunities for improvement	54

List of Abbreviations

CBD - Convention on Biological Diversity
CBO- Community Based Organization
COP- Convention of Parties
EMCA - Environment Management and Coordination Act
IAB - Inter-American Bank
ICRAF-The World Agroforestry Center
IPCC - Intergovernmental Panel on Climate Change
ITCZ- Inter-Tropical Convergence Zone
IUCN- International Union for Conservation of Nature
KWA - Kenya Wetland Atlas
KWMCP - Kenya Wetland Management and Conservation Policy
KWS - Kenya Wildlife Service
KWSC- Kenya Wetland Standing Committee
KWF - Kenya Wetland Forum
LMIC - Low and Middle Income Countries
LVB - Lake Victoria Basin
MEA - Millennium Ecosystem Assessment
MEMR - Ministry of Environment and Mineral Resources
NEMA - National Environment Management Authority
NWSC- National Wetlands Standing Committee
SDGs - Sustainable Development Goals
UNEP - United Nation Environmental Programme
UNFCCC - United Nations Framework Convention on Climate Change
WWF - World Wildlife Fund

Chapter 1: Introduction

1.1 Background

Wetlands are among the world's most diverse and productive ecosystems (Bassi et al. 2014).

They are considered vital for sustainable development and human well-being. The importance of wetlands is demonstrated by the fact that they are one of the first ecosystems to gain a

multilateral global environmental agreement on their conservation, protection and sustainable

use: "The Ramsar Wetland Convention" of 1971 (Gardner and Davidson 2011; RAMSAR 1971).

Wetlands consist of different kinds of ecosystems that range from seasonal to permanent and are extensively distributed to form diverse habitats (Dawson, Berry, and Kampa 2003). These

include swamps, peatlands, marshes, mangrove, coral reefs, ferns, lakes, rivers, and bogs (Wood

2013). Wetlands cover at least 6% of the Earth's land surface (Junk 2013) and about 7% of the

total cover for Africa in both humid and (semi-) arid landscapes, which amounts to about 30.3

million km² (Meng et al. 2016).

The threat of anthropogenic climate change to wetland species and ecosystems has been formally and internationally recognized by the Ramsar Convention (RC) on Wetlands (Junk 2013; Nath et

al. 2016), the Intergovernmental Panel on Climate Change (IPCC) and the United Nations

Framework Convention on Climate Change (UNFCCC). Climate changes interact with other

pressures, such as land reclamation, intensive resource exploitation, poverty (food insecurity),

population increase, changes in hydrology, and pollution that threaten wetlands around the world

(An et al. 2007). As a result, ecological services, which comprise of flood control, water recharge

and discharge, nutrient storage and wildlife habitats, have been compromised (Meng et al. 2016).

Food security is one of the most pressing needs in the world, particularly in Sub-Saharan Africa

(Marambanyika, Beckedahl, and Ngetar 2016), and the depletion of wetland ecosystems would further aggravate this need.

The effective management, protection, and climate change adaptation of economically important ecological zones like wetlands in low and middle-income countries (LMICs), remain an uphill task. It is only until recently that LMICs began to establish and harmonize guidelines and frameworks that will be used to achieve the correct balance between wetland exploitation and protection while building the capacity for local communities to adapt to the effects of climate change. In addition, national or local resources are severely limited amidst establishment of seemingly progressive strategic plans. In Africa, the Ramsar Bureau notes that the future of wetlands will rely upon stronger political will to protect them, based on sound policies with sufficient resources and incentives for community participation in their sustainable management (Kabii 1996).

In Kenya, wetlands cover approximately 14,000km² of the country's land cover (Oduor, Raburu, and Mwakubo 2015). They are among the most important ecosystems playing a vital role in socio-economic development in the country. They directly or indirectly contribute to human livelihoods and well-being through supporting, provisioning, regulatory and cultural services.

The Kenyan government has produced the Kenya Wetlands Atlas (KWA) through the Ministry of Environment and Mineral Resources (MEMR 2012a) that maps the country's wetland resources. With this evidence, the government is promoting national programs that are in line with the indicators of the Ramsar Convention's National wetland policies (2010) and World Wildlife Fund (WWF) in minimizing harmful effects to ecosystems. In addition, there is also an ongoing nationwide inventory of wetland resources. Having elevated the right to healthy

environment, the Constitution of Kenya (GoK 2010), indicates that the country is on a journey to protection and conservation of ecosystems. Despite all these efforts, these wetlands continue to experience pressure and are highly degraded. This paper provides a detailed examination of current legal, political and social frameworks and their suitability to achieve effective and sustainable wetland management and climate change programs.

1.2 The problem statement and Justification

In Low and Middle Income Countries (LMICs), the livelihoods of low-income and subsistence farmers largely depend on how well their natural environment is managed in order to maintain current productivity and remain adaptive to future climate variability. One of the biggest challenges facing LMICs is how to develop effective climate change adaptation and ecosystem management strategies that are adapted to local and often impoverished populations. Such programs are required in order to achieve the concomitant sustainable use of environmental resources while supporting the community to enhance their risk to the effects of climate change. Unless this balance between exploitation and conservation is struck, poor communities will continue to lose valuable ecosystems and eventually fail to adapt to the harsh realities of climate change and the subsequent catastrophe. This paper has used the case of Nyando Wetland ecosystem in western Kenya to critically assess current national wetland adaptation and management frameworks and determine whether these could be effective in placing this ecosystem on a firm footing in the face of expected climate change effects. Application of national or regional strategies to a local situation is a critical approach to testing the effectiveness of these frameworks and is useful in the continual refinement of strategies in order to achieve greater impact, resilience, and adaptation to climate change.

1.3 Objectives

- To describe the current state of Nyando wetland ecosystem in the face of climate change and anthropogenic pressure;
- To describe the Kenya national wetland adaptation framework and strategies for sustainable use and management of the Nyando wetland ecosystems in Kenya;
- To compare the Kenya national wetland framework for sustainable management and use of wetlands with international standards with reference to the Nyando wetland ecosystem; and
- To develop specific recommendations that will enhance the effectiveness of the Kenya national wetland framework adaptation when applied to the Nyando Wetland Ecosystem.

Chapter 2: Literature review

2.1 Definition of wetlands

Wetlands are transitional zones that stretch between dry land (i.e. grasslands, forests) and aquatic ecosystems (i.e., lakes, rivers, and oceans). Consequently, wetlands have a broad range of context-specific definitions. This is primarily because of their diversity and the fact that there is a continuum between dry and wet environments. In addition, the scientific disciplines find it difficult to assimilate (Council 1995) pg. 22. However, the well-known and commonly used is the “Ramsar Convention on Wetlands” that took place in Iran in 1971. This Convention offers a general definition of wetlands as “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters” (RAMSAR 1971).

It continues in Article 2.1 to include “riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands.” An alternative definition is given, as “lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water” (Cowardin 1979).

2.2 Uses of Wetlands

Wetlands perform a significant amount of services and are among the most valuable ecosystems in the world (Junk 2013; Erwin 2009; Ellison 1994). Studies have grouped these functions into different type of categories, but in this case, we will use the Millennium Environmental

Assessment classification that groups them into four groups namely, regulatory, provisioning, cultural and supporting. These categories are described in detail below.

Whilst the functions performed by wetlands are of significant value to society, they also exist in the absence of society and are self-sustaining properties of a healthy ecosystem. Some of the major uses of wetlands are detailed below.

2.2.1 provisioning

Wetlands produce a variety of products (animal, plants) that can be used as food (fish, rice) as well as provide employment opportunities. Many indigenous people rely directly on natural ecosystems for their livelihood. For example, food, fresh water, medicine, fuel and clothes.

Wetlands provide fresh drinking water for majority of the rural poor households. For example, in Tanzania as (McCartney and Van Koppen 2004) describes, 80% of the poor households rely on the wetlands for drinking water.

2.2.2 Regulation Services

Wetlands provide a natural environment for the sequestration and storage of carbon dioxide (CO₂) from the atmosphere (Meng et al., 2016). They are the richest carbon sinks in the biosphere (IPCC 2010). It is estimated that wetlands currently are worth 830 Tg/year of carbon sink (Mitsch et al. 2013). Evaporation from wetlands and transpiration from forested wetlands helps in maintaining the humidity and rainfall levels. This contribute to local and regional weather patterns i.e. temperature Erwin (2009). Drainage of wetlands results in carbon loss through oxidation thus releasing carbon dioxide into the atmosphere. Wetlands help in reducing the risk of eutrophication of aquatic ecosystems through their ability to prevent nutrients from

reaching the level of toxicity in groundwater. Wetlands also contribute in improving water quality through sedimentation process, filtration and interaction of microbial. Consequently, wetlands can play important role in treating polluted waters (Kumar et al. 2011).

2.2.3 Cultural services

Wetlands provide cultural, spiritual and educational benefits to societies (De Groot 1992). They act as recreational places and tourist attraction areas i.e. hiking, walking, birding, and sports fishing. Wetlands provide learning opportunities like research services and educational centers. Human beings have utilized since time immemorial wetlands to bring up societies with many traditional cultures being strengthened by their relationship with wetlands like the Coburg Peninsula where the natives up to date have strong attachment to the traditions carried out within the wetland¹ for example hunting and gathering (WWF, 2017).

2.2.4 Supporting services

Wetland ecosystem provide habitat services to plants and animals thus significantly contributing to conservation of a diversity of biological processes (Clarkson, Ausseil, and Gerbeaux 2013). For instance, the gene pool production which is essential for ecosystem functioning (Russi 2013). Wetlands are natural habitats for many plant and animal species, some of which are endangered, endemic and migratory. It is estimated that wetlands support more than 40% of the world's species and 12% of all animal species (Siuta et al. 2016). For instance, Lake Tanganyika in Central Africa supports 632 endemic animal species (WWF, 2017), and the Amazon supports

¹ http://wwf.panda.org/about_our_earth/about_freshwater/intro/value/

2000 fish species (Keddy et al. 2009). Wetland biodiversity provide people economically through trading (buying and selling) of countless products that are harvested from these wetlands throughout the world. Global wetlands ecosystems are currently worth US\$4.9 trillion and support more than a billion livelihoods (Ramsar 2016).

2.3 Threats to wetland ecosystems

Wetlands are the world's most valuable environmental resource but also the most vulnerable (Kerry Turner 1991). Wetlands have suffered degradation through either direct alteration or indirectly through the consequences of change especially in the hydrological input. Factors that lead to the loss of these wetlands are poverty, population pressure, sectoral demands, lack of centralized planning and perverse economic policies.

2.3.1 Land use/cover changes

Wetlands have been reclaimed in the form of road constructions, agriculture, and deforestation. These activities have affected the natural state of the wetlands and impacted ecosystem function and value (Junk 2013; Bassi et al. 2014; Khisa et al. 2013; Mitchell 2013). The pressure from human population growth is a major threat to wetlands. In poor communities, the default temptation is to satisfy the most immediate needs by exploiting wetlands and concurrently depleting biodiversity. In South Africa as Junk (2013) notes, a significant amount of wetland areas has been converted to commercial agricultural land and spaces for urban development. According to Millennium Ecosystem Assessment (MEA; 2005), human activities present the most serious threats to wetlands ecosystems. These activities principally involve

conversion of wetlands into agricultural land (reclamation) due to increase in population density (Verhoeven and Setter 2010).

Wetlands have also been reclaimed for mining purposes. Rooney et al (2012), describes how over 29,500 ha of peatland habitat in Alberta have been converted into an oil and sand mining area. The biggest threat comes from low and middle-income countries because of uncoupling of tradition linkages of human society and the ecosystem functioning which leads to irreversible loss (Maltby 1991). This author states that the future of these wetlands now depends on trends in economic, social and political outcomes of legislative and administrative powers rather than previous, more locally-based and natural processes that made more sustainable use of indigenous knowledge.

2.3.2 Climate change

Climate change is likely to affect the structural composition of wetlands by altering the hydrologic cycle i.e. through temperature and precipitation (Barros et al. 2014). This happens through human-induced activities (IPCC 2007), which are causing biological and physical impacts around the globe. Proper and efficient functionality of wetland resources needs human adaptation mechanisms/activities as suggested by (Al-Obaid et al. 2017).

The future of wetlands is closely related to human well-being. There is such a strong interrelationship between climate change and human activities to the extent that describing inevitably describes the other (Mitchell 2013). However, the magnitude of these changes is relatively less compared to that of anthropogenic activities. The effects of global warming will continue to be felt even if greenhouse gasses (GHGs) is to be reduced or maintained at current

levels. In addition, changes in the characteristics of freshwater ecosystems will be much more pronounced as greenhouse gas emissions rise and ecosystems cross critical thresholds that cause occurrence of abrupt nonlinear system shifts (Martin Kernan and Brian R. Moss 2010).

2.3.3 Pollution

Wetlands are very sensitive to the quality of water inputs. Contaminated water presents serious problems that damage these ecosystems including the health status of the entire wetland ecosystem and its dependents. The primary pollutants at a global level are fertilizers, pesticides, sediments, metals, and chemical deposition. Although wetlands act as filters and absorbents of pollutants from polluted waters, there is a limit to which they can do so. Once a wetland has been so polluted, it is difficult to clean it up and thus the result is degradation. For instance, in China, rivers are amongst the most polluted water bodies leading to collapse of many ecosystems and loss of species (An et al. 2007).

2.4 Challenges of conservation and management of wetlands in low and middle Income countries (LMICs)

Wetlands in Africa cover an area of 30.3 million km², supporting a population of 944 million people (Junk 2013). Most of this area is dominated by rivers e.g. the Nile with floodplains and internal deltas (e.g. the Okavango or Mali's inland Niger delta) and African wetlands. Junk describes how these highly diverse and productive wetlands were colonized by humans for many years making them very important to their livelihoods. In many parts of the LMIC countries, wetlands have been sustainably managed by local communities without the depletion or

degradation for many generations in the past (Dixon 2005). This poses the question, “why is it that this historical management cannot be sustainably applied now or in the future”? Dixon argues that degradation is inevitable with a high level of exploitation of resources that exceeds the carrying capacity of individual wetlands.

The challenges faced by these wetlands are a consequence of the society’s failure to determine how to manage the remaining wetland ecosystem while sustaining their ecological functions and maintaining the integrity and their structures through smart exploitation or increasing access to alternative development activities. Finlayson suggests that the management of wetlands should focus on sustaining livelihoods through the bottom-up approach of understanding community situations, their hopes and their priorities (Finlayson 2013; Finlayson et al. 2017)

2.4.1 Poverty

Poverty is also a driving force of unsustainable use of wetlands in LMICs (Kumar et al. 2011). Most poor people are in rural areas with little or no income, and predominantly depend on local ecosystem services delivered by wetlands especially during extreme weather events like drought and flooding (Mitchell 2013). These conditions continue to threaten wetlands every day. These activities are described as “cyclic” - where wetlands get modified resulting to decline in services provided thus forcing people to further advance into poverty conditions and in return more degraded wetlands (International Water Management Institute (IWMI) 2014).

2.4.2 Institutional failure

Despite their historic importance to local livelihoods, African wetlands have been undervalued and indeed even taken underproductive in relation to the economic benefits of conserving them

especially for the rural poor. As a result, their ecosystems service continues to be degraded.

There is need to promote the wise use of these wetlands by making sure that better management plans are established in order to achieve a sustainable future (World Resource Institute 2005).

While it is important to conserve, and protect wetlands, the survival of the poor people who are dependent on wetlands services for their livelihood is of immediate concern.

The World Resources Report 2010-2011 notes that to help developing countries make effective decisions that support communities to be climate resilient, the answer is balancing the short term needs with long term policy objectives that have capacity to cope with uncertainties World Resource Institute, (2017).

2.4.3 Lack of information

Wetlands are dynamic and complex ecosystems. They keep on changing in shape and size as water balances change. Unfortunately, because of this complexity, inadequate resources have been invested in studies to generate comprehensive information detailing the changes occurring in these ecosystems. The little available information found is often out of date, irrelevant, or is neither reliable nor comparable (Lynch, Kalumanga, and Ospina 2016). Wetlands move, expand and contract with seasons and intensity, which makes them difficult to manage in a sustainable way (Keddy et al. 2009). Relevant technical know-how is very crucial in planning how to manage natural resources. Unfortunately, such knowledge is lacking in most of the African countries (Kangalawe and Liwenga 2005).

2.5 Wetlands and climate change

Currently, the world is facing destructive effects from rising global temperatures and extreme weather conditions (Erwin 2009). Some of these changes include thawing of permafrost, freezing, break-ups of rivers and lakes, altitudinal shifts of plants and animals and a decline of some plant and animal populations. Natural systems are vulnerable to climate change because of limited adaptive capacity (McCarthy and II 2001), leading to irreversible damages. The wetland ecosystem has not been left out of this change for example, the Hungarian nature conservation (Malatinszky 2013) which has observed a tremendous loss. These effects will impact ecosystems and human habitation; agriculture and water resources will experience greater impact as a result of climate change and its variability (Kebede et al. 2012). Climate change is considered a causal effect of habitat destruction, effect on the movement and shift in species composition and degradation of existing wetlands (Klemas 2011). The fifth Assessment report of the IPCC observes a growing human influence to climate change particularly the GHGs being of extreme high confidence (IPCC 2013).

In dry areas, wetlands are important for biological diversity. Most of the Sub-Saharan Sahelian climate is solely monsoonal system (IPCC report 2013) which brings rainfall to the region seasonally (Serdeczny et al. 2017). The projected global climate changes will have a significant impact on wetlands, although again the specific details of impacts on these ecosystems are not well described under such scenarios (Junk 2013).

Besides the unwise use of natural resources, climate change is considered an additional stressor which exacerbates unsustainable conditions. If business as usual scenarios continue, the result will be a net loss of global biodiversity, increased flooding resulting in a decrease in recharge of

some aquifers, decline in water quantity and quality, altered ecosystem functions and a shift in provisioning ecosystem services (Grimm et al. 2013; Khisa et al. 2013). In addition, drained wetlands, in particular, contribute solely to global warming through releasing methane and carbon dioxide to the atmosphere (positive feedback) (Burkett and Kusler 2000).

Temperatures in Africa are projected to rise faster than the global average increase during the 21st century (IPCC 2013) report. The continent depends mostly on agriculture for economic growth making it ill positioned for changing climatic conditions (Mitchell 2013). The IPCC (2007) observed an increase in temperature of between 1°C and 5°C that could affect millions of people and exacerbate the risk of food productivity in vulnerable regions. Africa has already attained the one-billion-mark population according to United Nation estimates, and now it is projected that this will increase by 44% by the year 2025. The outcome is needs will keep growing and ecosystems will continue to be exploited exponentially. These challenges as stated by Malatinszky (2013) require an integrated framework approach for biodiversity conservation i.e. cross-sectoral assessment of vulnerability and management plans (Mitchell 2013).

2.6 The wetlands of Kenya

In Kenya, wetlands are defined by the Kenya Wetland Standing Committee (KWSC 1995) as "areas of land that are permanently or occasionally waterlogged with fresh, saline, brackish or marine waters at a depth not exceeding six meters, including both natural and man-made areas that support characteristic biota." Up to 3 to 4% of the total landmass of Kenya (14,000km²) is covered by wetlands although many of the original wetland areas have been converted for alternative use or drained (Oduor, Raburu, and Mwakubo 2015). Kenya ratified the Ramsar

Convention in 1990, and since then, has designated Lakes Naivasha, Elementeita, Bogoria, Baringo and Nakuru (see figure 1) as wetlands of international importance (Ramsar sites²).



Figure 1: A map of Ramsar listed sites in Kenya

The distribution of these and other wetlands in Kenya depends mostly on the amount of rainfall received and on land topography (Macharia et al. 2007). It is because of these features that Kenyan wetlands are categorized into riverine, marine, estuarine, lacustrine, palustrine and constructed wetlands.

These wetlands are very productive and serve as sources for food, water, firewood, medicinal plants and crafting materials (Macharia et al. 2007; Oduor, Raburu, and Mwakubo 2015;

² http://archive.ramsar.org/cda/en/ramsar-documents-list-anno-kenya/main/ramsar/1-31-218%5E16536_4000_0__

Nasongo et al. 2015; Ajwang' Ondiek, Kitaka, and Omondi Oduor 2016; Kairu 2001). In some locations, wetlands have been used as places for cultural practices like circumcision and other rituals. The wetlands of Kenya also contribute to environmental health through the recharge of groundwater, flood control (Rongoei et al. 2013), storage of nutrients (Kebede et al. 2012) and general maintenance of a healthy ecosystem. In addition, these wetlands provide employment opportunities (e.g. fishing, basket making from reeds, etc.) for many Kenyans. Despite all the above uses, anthropogenic pressure and climate change continue to degrade wetlands.

The importance of management and sustainable use of Kenyan wetlands has been recognized by several organizations e.g. World Wildlife Fund (WWF), the Ramsar Convention Bureau (1980) and United Nations Environmental Programme (UNEP). Kenyan wetlands are exploited both on a short-term and long-term basis. The usefulness of Kenyan wetlands continues to decline due to reduction and encroachment of the land around the wetlands and vegetation cover. The “Kenya Wetlands Forum” 2017 summarizes the threats as lack of access to environmental information, land tenure insecurity, lack of civic access, weak sectoral strategy to resource administration and inefficient governance. As wetlands are lost, societies are deprived of their livelihoods because the demand for water, land, and food continues to increase amidst climate change intensity.

The majority of the population in Kenya and around the Lake Victoria basin [(where our case study is located (figure 3))] are less resilient to stress caused by climate change disasters and heavily rely on natural resources for their livelihoods. This is due to lack of alternative resources to draw on for their livelihoods. With the current situations of prolonged drought and lack of sufficient food and food storage capacity, more adversity is expected with the unsustainable use

of these ecosystems. The projected climatic change is likely to have a high impact on poor populations as food, water and health services become stretched (Finlayson et al. 2017). Turner et al observed that Climate change affects many ecosystems and increases the vulnerability of populations living in their surroundings (Kerry Turner 1991; Turner et al. 2003).

2.6.1 Kenya National Wetland Adaptation and Management Framework

As mentioned above, Kenya signed the Ramsar Convention in 1990 and aspires to manage its wetlands based on the guidelines that have been agreed by the Convention. In 2012, the Kenyan government with help from the United Nations Environmental Programme (UNEP) published the Kenya Wetlands Atlas (MEMR 2012a), that along with other pertinent information, provides a general strategy for sustainable exploitation and development of wetlands in Kenya. In addition to the Wetland Atlas, there are two principal documents that deal with wetland adaptation and management in Kenya. These are the National Environmental Policy of 2013 (GoK 2013b) and the Draft National Wetlands Conservation and Management Policy (GoK 2013a). All major documents including the KWA, the Draft National Environmental Policy and the Draft National Wetlands Conservation and Management Policy (NWCMP) (GoK 2013a) refer to functions that should be undertaken by other government ministries and departments in the implementation of the strategy. While these documents are not a comprehensive environmental adaptation and management strategy for the Nyando wetland, they can be understood along with other national legislation and policy drafts as a framework that can be assessed for effectiveness to achieve sustainable wetland adaptation and management emerges. Some of the legislation that these documents refer to include The National Land Policy (GoK 2010b); Land Use Planning Bill (GoK 2010b); Physical Planning Act Chapter 286; Fisheries Act

(Cap 378); The Wildlife (Conservation and Management) Act; The Water Act, 2002 and the Constitution of Kenya. Therefore, bits and pieces of the government framework to wetland ecosystems can be found in different pieces of legislation and would require harmonization to achieve coherence. Part of the current study will attempt to bring all these under one analytical framework, determine any internal inconsistencies and assess the feasibility and effectiveness of the proposed strategy. Housed in the Ministry of Environment and Natural Resources, The National Environment Management Authority (NEMA) is the principal institution that is expected to help formulate and execute all policies and strategies that relate to the environment, inclusive of wetlands.

2.8 Frameworks for assessing effectiveness of climate change adaptation and wetland management framework

This study is situated generally within the Sustainable Development Goals (SDGs) of 2015. The United Nations indicates that, Sustainable development depends on using resources (including wetlands) wisely and sustainably, as stated in the Brundtland Commission (1987).

To assess whether adaptation is adequate, it is useful to identify measures of both quality and quantity. Adaptation is fundamentally about finding creative solutions to a persistent, growing, and complex problem. To attain equity, a comprehensive strategy that responds to impacts of climate change is important (Fleurbay M., S. Kartha, S. Bolwig, Y. et al. 2014). This section will describe internationally accepted conceptual frameworks for assessing wetland programs for management and climate change adaptation.

2.8.1 Assessment of Ecosystem Management Frameworks and Strategies

To assess the relative values and functions of different elements of the Nyando ecosystem, this paper will adopt a comprehensive framework for assessing wetland values and evaluation of the effectiveness of intervention framework as proposed. This framework is one among a series of tools in the Millennium Ecosystems Assessment (MEA) suite of tools that seeks to define how ecosystem changes will affect human life and offer science-based interventions to conserve and sustain ecosystems for enhanced contribution to human well-being. The MEA is a platform that has brought together global experts to provide a “*state-of-the-art scientific appraisal of the condition and trends in the world’s ecosystems and the services they provide (such as clean water, food, forest products, flood control, and natural resources) and the options to restore, conserve or enhance the sustainable use of ecosystems*” (MEA 2005).

The MEA’s conceptual framework places human well-being at the center of a specific ecosystem and defines the relationships between the different aspects of the ecosystem through pathways of service delivery to humans but also recognizes the intrinsic value of the ecosystem. The conceptual framework correctly assumes that the relationship between people and parts of the given ecosystem is dynamic and both human and non-human factors drive change in a distinct ecosystem. The MEA framework is cyclical in nature; human needs (indirect drivers of change) produce actions that exploit and change the ecosystem (direct drivers of change) which in turn influence the breadth and extent to which an ecosystem provides services to human well-being. In the current study, The Government of Kenya Wetland Management and Conservation Policy (KWMCP) will be contextualized to the Nyando wetland ecosystem and will be summarized according to four categories of the MEA’s model. These are: 1) Indirect drivers of ecosystem

change, 2) Direct drivers of change, 3) Ecosystems services, and 4) How they all interact to determine human well-being and poverty alleviation. This framework is described in Figure 2.

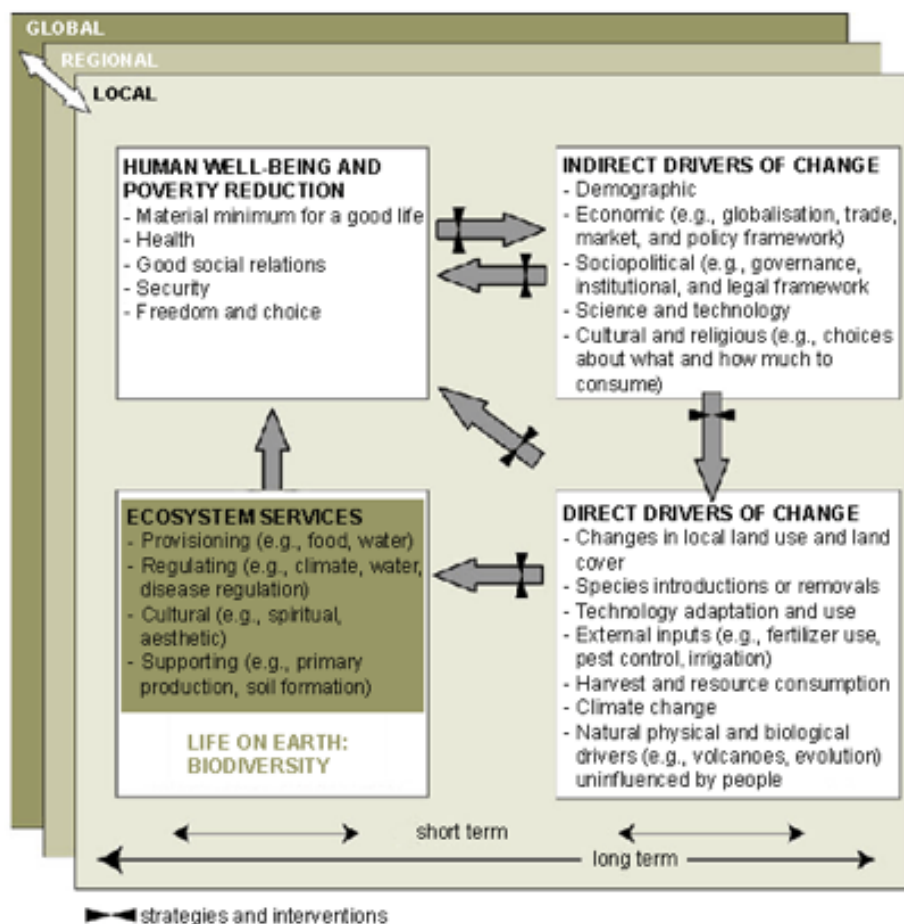


Figure 2: The MEA's conceptual framework for assessing wetland ecosystem management and sustainability programs (Adopted from (Maclean, Boar, and Lugo 2011))

The Kenya national wetland adaptation and management framework will also be examined for internationally accepted principles of effective and sustainable ecosystem management. These are: intra- and inter-generational equity, the precautionary approach, biological diversity and ecologically sustainable development (Mollica 2017).

Intragenerational and intergenerational equity: This principle encourages the development of programs that ensure the ecosystem is used in a manner that both the present and future generations are currently or will be able to access all the various parts of the ecosystem and is able to benefit from all valuable aspects of the ecosystem including aesthetics.

The precautionary approach: This principle incorporates the use of scientific evidence as the basis for making decisions and supports a guarded and progressive approach to new evidence for any radical changes and places the burden of proof to the party proposing the changes. The precautionary approach has four central pillars (Mollica 2017). These are preventive action when faced with uncertainty, placing the burden of proof on the party proposing an activity that could result in ecosystem change, exploration of many alternatives before a harmful action is done and enhancing public participation in decision making.

Biological diversity: Biodiversity is now accepted as an important element of a healthy ecosystem. International treaties such as the Convention on Biological Diversity have been established to promote the protection of biodiversity following recognition that ecosystem stability depends on preservation of biological diversity. This principle examines all species and their interrelationships in an ecosystem and monitors any changes that are harmful and makes correction.

Ecologically Sustainable Development: This principle deals with the intersection between issues of community justice e.g. meeting the needs of different community groups with more long-term sustainability objectives and includes economic objectives. It brings together all aspects of the ecosystem management strategy and analyses them for economic, social and ecological sustainability.

2.8.2 Assessment of suitability of Wetland Climate change adaptation strategies

One of the most common mistakes made in the development and implementation of ecosystem management strategies is the confusion between “development” projects and projects that specifically address adaptation, resilience or mitigation to climate change (McCarthy et al. 2012). It is predicted that climate change will in the long run result in changes in temperature and precipitation with major impacts on ecosystems. The short to medium term consequences of this are however uncertain, hence the need to design strategies that use the best available information to adjust to actual or expected environmental stimuli or their effects is to minimize harm or exploit beneficial opportunities.

The Inter-American Bank (IDB) presents four systematic stages that ecosystem projects or strategies should use in order to deliberately include climate change adaptation (McCarthy et al., 2012). These are:

1. **Collection of Information:** allows for collection of all relevant climate change information about a local ecosystem
2. **Capacity to analyze the information:** Synthesis of the collected information with climate change models and coupling them with biophysical, hydrological and socioeconomic data to design the best mitigation or adaptation pathways.
3. **Development of institutional systems to support implementation:** Building of strong institutions to oversee strategy implementation, anchoring all decisions into legislation, including sufficient public support and establishing proper governance mechanisms.
4. **Implementation of the specific project or strategy.**

The stages are summarized in (figure 3) below.

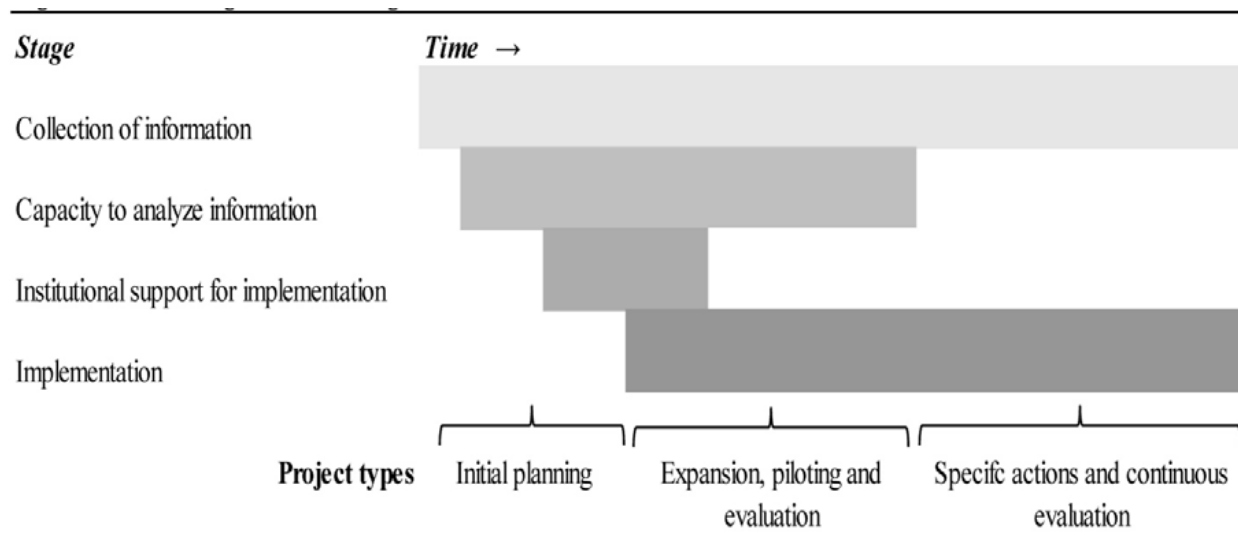


Figure 3: Stage for environmental adaptation implementation programs, adopted-(McCarthy et al. 2012)

The Kenya national frameworks for wetland management and adaptation will be assessed for the presence of these elements.

Chapter 3: The Case Study and Methodology

3.1 The Nyando wetland

Nyando wetland is Kenya's second largest wetland ecosystem (Okotto-Okotto et al. 2016) after the Tana River delta (Njuguna and Howard 1992), located at the delta of River Nyando on the north-eastern shores of Lake Victoria Basin (LVB) (a shared East African transboundary freshwater lake) in Kisumu County. The wetland lies between 0° 11' 0" 19" S/34° 47' -34° 57' E (Raburu, Okeyo-Owuor, and Kwena 2012) (Figure 3). It covers an area of 42.79 km² within the Winam Gulf of Lake Victoria in East Africa. This Wetland is a substantial floodplain, bounded by the Kano plains, Nandi Escarpments, and Western highlands. The wetlands form major swamps (Nyakach and Kano) and have an average elevation of 1134 m above sea level. The wetland has its water input from Nyando River which originates from the Mau escarpment and drains into Lake Victoria. The Nyando River's catchment area is 3600 km² with a discharge of 15m³ S⁻¹ into Lake Victoria. It is a major leading contributor to sedimentation and phosphorus into the lake (Opere and Okello 2011).

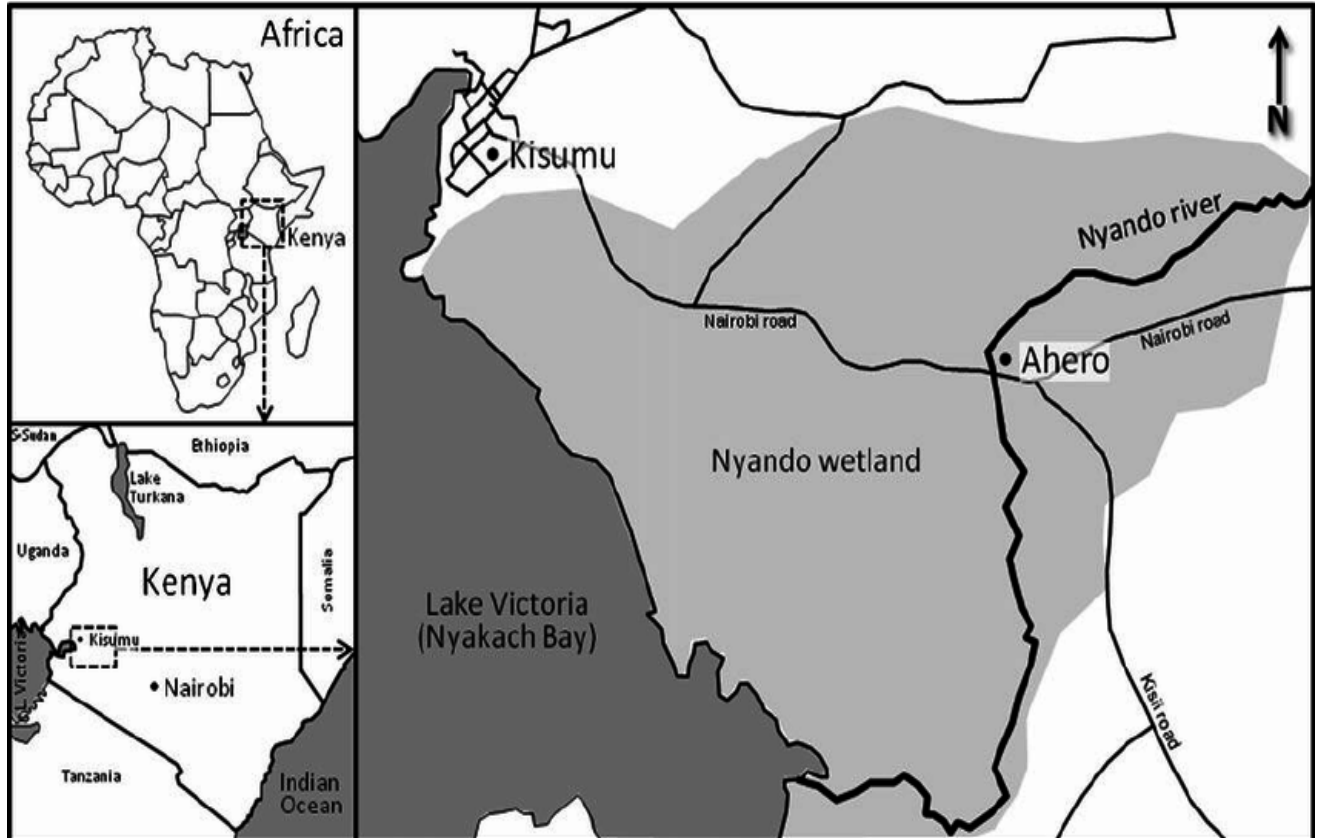


Figure 4: Study area of Nyando Wetland (Van Dam et al., 2013)

This wetland ecosystem (Obiero et al. 2012) is home to a wide range of biodiversity, including plants like the papyrus, and animals like the endangered Sitatunga and African civet. The climate of Nyando is sub-humid with an annual mean temperature of 23°C. The area receives bimodal rainfall: long rains in the month of March/April and short rains in Sept /October. The annual average of rainfall varies between 1000mm to 1600mm. Normally the long rains are very intense and heavy which sometimes cause flooding. Interestingly, this is followed by very dry spells between the month of June to September and December through February. However, the seasons are not consistent due to the changing climate. The area is one of the hotspots with the highest level of erosion due to its terrain features. The rainfall patterns are dictated by the northward and southward movement of the Inter-Tropical Convergence Zone (ITCZ) along the

equator where the wetland is mapped (McClain 2013). The IPCC Fifth Assessment report highlights a reduction in the long rains in response to warmer Indian Ocean Sea Surface Temperatures (SSTs). This is an indication of variability and unexpected patterns in the region. The area is dominated by sloping land that consists of volcanic hills and scarps from the rift valley faults with alluvial plains found at the surface. The region's highest altitudes are over 3000 meters above sea level and the basin drains to the shores of Lake Victoria at roughly 1,100 meters above sea level. The lowlands and floodplains region includes most parts of these wetlands ecosystems along the western parts of the basin. The upper Nyakach has a high of 1,650m (Sang 2005). The soils are classified as sandy loam soil. These soils can trigger convective systems to bring rains in the region.

3.2 Methodology

To achieve the first two objectives (see Section 1.3 above), an extensive search of relevant secondary data was performed to document the current state of the Nyando wetland. This description has been structured according to the conceptual framework that is proposed by Maclean, Boar, and Lugo (2011) as presented in section 2.7 above. Data sources included current Kenyan government national strategies and policies for wetland management, peer reviewed publications, peer reviewed digital journals and libraries relevant to this subject. News media reports, government databases and reports from international environmental organizations and non-governmental agencies that are involved in environmental work were utilized.

To achieve objective three, a comprehensive, online search of wetland adaptation strategies and climate change was conducted using key words. Priority was given to publications or reports

from recognized organizations that have been published within the last 10 years and which contain broad principles of ecosystem management and adaptation for climate change. Specific emphasis was given to internationally accepted principles. Wetland climate change adaptation strategies has been measured against the Kenya's current plan for wetland management and adaptation as would be applied to the Nyando Wetland ecosystem. The IPCC fifth assessment report was used to determine relevant climate change benchmarks and future projections.

Chapter 4: Results and Analysis

4.1 The current state of Nyando wetland

The world's wetlands ecosystem provides a wide range of benefits which have been grouped by the (MEA 2003) into; provisioning, cultural, regulating, and supporting functions. Wetlands, like any other ecosystem in Kenya that is linked to water resource category, have undergone significant and systematic changes over the past years. Many of these wetlands have been altered and converted to suit changing needs as experienced nationally, regionally and locally. This is due to the country's weak environmental and biodiversity-related laws, policies and institutional frameworks as well as overall political instability. Nyando wetlands face this exposure to climatic conditions through increased temperature and changes in rainfall (Kinyangi et al. 2015); (Serdeczny et al. 2017), social stressors like the channeling of waters for irrigation schemes and increased modification of the wetlands areas to agricultural zones. As a result, we have increased erosion and sedimentation which makes this wetland to be susceptible to climate change impacts (van Dam et al. 2011). Changes in climatic conditions are more likely to affect the species found in these wetlands in the sense that high temperatures especially ones coming from the burning of the land cover as a way of clearing land for agriculture will force animal species to retreat or migrate, others dying in the process as described in chapter five of (Raburu, Okeyo-Owuor, and Kwena 2012). All activities in the Nyando wetland basin are inevitably dictated by the amount of flooding which happens periodically leading to overflow and river inundation (van Dam et al. 2011). Flooding has a tremendous impact on human economic activities i.e. the papyrus, traditions and seasons.

4.1.1 The people of Nyando and their socio-economic state

The people of Nyando are majorly the Luo or river-lake nilotes who have settled along the lakeshores. Other communities in the catchment areas are the Kalenjin (Kipsigis, Nandi) and the Luhya. These communities are led mostly by community leaders and village elders who act as authoritative administrators. They practice customary law in most cases with taboos and cultural beliefs (Swallow, Onyango, and Meinzen-Dick 2003).

The area experiences frequent water borne diseases like malaria and cholera due to poor living conditions and poverty compounded by flooding. This diminishes their proper human capability of being independent. For instance, the areas have a large number of chronic illness and death that is associated with a high incidence of HIV/AIDS. The continuous decline of per household land size and cultivated land per person constitute threats to food security; The area has a high level of poverty (Okayo, Odera, and Omuterema 2015) with majority living on less than one dollar a day with no other alternative means of livelihood. Raburu et al. 2012 compared the national poverty percentile with that of Nyando, and the result was at 60%, Nyando is 14 percentile points above the national level. Mortality rate is also very high in the region with a crude death rate of 44%. It is estimated that about 199,318 people are below the rural food poverty (GoK 2001). Obiero et al. (2012) argue that the majority of the population are dependents and as a result, much pressure will continue to be exerted on available resources. The soil fertility of the wetland has reduced significantly due to natural and human pressures (crops, settlement, rainfall patterns).

In Nyando the literacy level is very low with children only attaining basic level education before dropping out to look for other ways of surviving the poverty road. This is due to poor infrastructure, inadequate learning resources, poor health conditions and frequent floods. Nonetheless, there are a number of projects in the wetlands that are trying to work with the local communities to attain sustainable pathways out of poverty but also conserve the wetland. These projects are yielding significant progress although not enough compared to the rate at which the wetland is being depleted (World Agroforestry, 2017). The World Agroforestry Center (ICRAF) has been implementing projects (Asset-Based Community driven development(ABCD), that are basically designed to enable communities in the Nyando watershed to mitigate the impacts of climate related challenges by improving their adaptive capacities (ICRAF 2017).

4.1.1 Nyando wetland ecosystem services

In Kenya, about 80% of the nation's population lives in rural areas and depends on subsistence agriculture . Of these, the majority live adjacent to water sources and wetlands, thus depend directly or indirectly from these sources through agricultural activities. The value of the ecosystem services was recognized as early as 1990 with the Ramsar designation that gave meaning to wise use of wetlands in the country. Nyando is a proposed Ramsar site as evidenced by Kenya Wildlife Service submission of National Report Format (NRF) on the Implementation of the Ramsar Convention on wetlands (COP12) that took place in Uruguay. This report indicated that a national strategy has been established for further designation of four other wetlands that meet the criteria for inclusion on Ramsar list to be (Nyando, Yala, Dunga, Sio Siteko) wetlands. The report gives a 2015-2018 strategy (“Ramsar Convention - National Reports COP12 (2015)” 2017) <http://ramsar.rgis.ch/pdf/cop12/nr/COP12NRFKenya.pdf>.

Nyando wetland provides the locals with crop production and hydrological services. Nyando ecosystem serves as a food reservoir to many species habitats and humans. The wetland also supports a multitude of biota that helps sustain productivity through supporting nutrient cycling and pest and disease regulation. Other uses are fish harvesting, household water provision, source of firewood (fuel) and fiber from papyrus harvesting (Rongoei et al. 2013). The ecosystem currently also regulates water quantity, climate change effects for example flood control and acts as sponge filter from contaminated input waters. In terms of supporting services, the wetland is the primary production area for plant life i.e. papyrus, animals (Sitatunga) and agriculture (crop farming). The benefits of this wetland ecosystem are immense; they significantly offer social economic values and meets the needs of their dependent societies in a diverse way. It is therefore critical to sustainably empower Nyando inhabitants towards achieving an economic development and adapt to changes that may arise from resource limitation as the United Nations Sustainable Development Goals (SDGs) stipulates.

4.1.2 Climate change impacts in Nyando

The impacts of climate change are as a result of variable rainfall patterns and an increment of surface runoff that result in flooding of downstream. Increased rainfall and related events are likely to magnify the intensity of events (flooding, droughts) (IPCC 2007).

There is evidence of such events like the El Nino of 2009 which had high variability in rainfall pattern within the areas surrounding Nyando e.g. Budalangi. These erratic rainfall patterns have impacted on food production and have had negative economic consequences on the local population (Okayo, Odera, and Omuterema 2015); GoK 2010). Increased temperatures as

witnessed with frequent droughts are likely to interact with land use land cover change compounding the resilience of habitats, ecosystems and species that are already threatened from wetland.

4.2 Analysis of the Kenya National Framework on wetland management and climate change adaptation

As previously described, the general approach of the Kenyan government towards wetland management and adaptation is to administer Ramsar approved sites according to the guidelines of the Ramsar Convention and to conduct sufficient research and interventions that would enable the qualification of non-Ramsar wetlands like Nyando to attain Ramsar status and receive management according to Ramsar guidelines (Ramsar 2010). While this is an appropriate framework, it is important to conduct closer analysis of all relevant documents that address wetland management and climate change adaptation in Kenya and apply this framework to the Nyando non-Ramsar wetland. In this section, an inventory of the current framework will be undertaken to assess internal consistency but also determine whether international guidelines including those of the Ramsar Convention are being followed and even if they are feasible in a low and middle income country like Kenya. Firstly, current policies and guidelines will be summarized according to the theoretical framework described in (Figure 2). Since the wetland ecosystem is dynamic, management and climate change guidelines should be as comprehensive as possible while accounting for changes that occur and taking corrective measures.

4.2.1 Indirect drivers of wetland ecosystem change

As previously described, the broad framework under which wetlands are managed and surrounding communities are prepared to adapt to climate change is anchored in various social, cultural, economic and political contexts but some common themes emerge with successful identification of indirect drivers of wetland ecosystem change.

All three main documents that contain direct reference to wetlands (Kenya Wetlands Draft policy, the National environmental policy as well as the Kenya Wetland Atlas) take into consideration all the indirect drivers of ecosystem change. The documents recognize the increase in population, especially of young people and the challenge that this poses to wetland ecosystems, in a cultural environment where land ownership is largely through inheritance from subdivision of often inadequate land sizes (Oduor, Raburu, and Mwakubo 2015). In addition, the draft wetlands policy correctly identifies the need for improved scientific information and strong knowledge base of the wetland ecosystems, and recognizes the right for Kenyan communities to decide for themselves how to assign cultural and religious significance to wetlands. The documents also refer to the socio-political environment of wetland ecosystems and highlight the different local/regional/international institutional and legal frameworks for governing wetland ecosystems and underscore the importance of public participation.

The most challenging aspect of the current framework environment is institutional governance and implementation of wetlands. Appendix 1 summarizes most of the stakeholders involved in policy making or implementation of wetland areas. This list focuses purely on the public and para-public institutions but is not exhaustive as it does include local community organizations and/or local business entities because of their sheer large number. There are two main

challenges in the current institutional framework; firstly, a large number of government authorities have been established over the years often with overlapping and sometimes contradictory functions and secondly, reference is made to the need for community and stakeholder consultation without explicit identification of who should be consulted. In the context of the Nyando ecosystem, these challenges are unique as the wetland is occupied by communities from four different ethnic groups spanning three counties (the main administrative unit in Kenya after the 2010 Constitution was promulgated). It is a very daunting task to coordinate an effective management and adaptation strategy for this ecosystem without a coherent governance and accountability structure and inclusive community participation. The government of Kenya in the Draft National Environmental policy attempts to address institutional coordination by NEMA and improving coordination between national county environmental authorities, but this falls short of the extensive changes that would be expected to achieve coherence in local but complex setting like the Nyando wetland basin.

4.2.2 Direct drivers of wetland ecosystem change

There is a strong recognition of direct drivers of ecosystem change in the current national framework for wetland management and adaptation. Two of the most documented of are changes in local land use/cover due to wetland reclamation for economic farming activity and contamination by external inputs like fertilizer, pesticides and other pollutants from surface runoff. The effects of all these are documented, with specific examples for Nyando wetland ecosystem provided in detail by Raburu, Okeyo-Owuor, and Kwena (2012).

While some progress has been made in identifying direct drivers of wetland ecosystem change, there is very little information on some of these drivers and this could prevent the development

of appropriate management and adaptation strategies. These include lack of information on species introductions (there is policy to discourage species removal or introduction in the context of conservations and reclamation), natural and physical and biological drivers and climate change. Climate change will be discussed in more detail below.

It is likely that in the absence of a policy statement on introduction of new species (except algae and deliberate human introduction), it likely that strategy development may not include adequate measures to monitor encroachment of new species into the wetland ecosystem. It is important to highlight this gap as the absence of measures to prevent the accidental introduction of new species has had devastating consequences in the wetlands around the Lake Victoria basin, where Nyando is located. The most prominent example is the south American water hyacinth weed that rapidly invaded Lake Victoria in 1989 and spread to all the neighboring wetlands including Nyando (Rahman 2010). The invasion of the lake took only a few months and took all stakeholders by surprise and by the time the true impact was realized, trade from fish and fish products and other farming practices around the Lake Victoria had taken a major hit. To date, there is a continuous fight to eradicate this weed. It is important that the current framework is updated to include a surveillance system that identifies and reports in real time any suspected new species to wetlands including the Nyando wetland ecosystem. In addition, it will be useful to develop a scientifically sound system to assess physical or biological drivers of climate change. For example, East Africa has some active volcanoes and it is important to understand how volcanic activity influences the soil, water and the flora and fauna of the Nyando wetland.

4.2.3 Ecosystem services

All the relevant documents in the Kenyan framework extensively describe the role that wetlands play in provisioning for human livelihood and well-being. The documents recognize wetlands for both subsistence and commercial activities including food from fisheries and food plants, source of building materials, providing materials for ornamental and aesthetic business, etc. The value of Kenyan wetlands from these economic activities is estimated at US\$ 2.1 billion, (MEMR 2012b). The current framework also recognizes the importance of wetlands in cultural and traditional practices of local communities surrounding wetlands. For example, the right of communities to use wetlands for traditional or religious rites according to existing guidelines is recognized.

One interesting observation in this framework is the focus and description of wetland services around common economic and cultural practices. The value of wetlands is presented largely in terms of current economic activities and does not include other functions like the role of wetlands in soil formation or regulating disease (reference to disease is only made with respect to disease transmitting vectors). This is likely due to absence of detailed knowledge on how wetlands provide for these less economically tangible benefits. The current framework views wetland use as a binary decision between “exploitation” of wetlands or “conservation”. In the specific context of the Nyando Wetland ecosystem, this dichotomy is best exemplified in a paper by (Oduor et al.,2015) who respond to whether the Nyando wetlands should be reclaimed or conserved. These authors conclude that reclamation would result in high economic costs (an infinite present value of US\$ 75.5 Billion) and it is more prudent to reduce the pressure of

reclamation. There is need to develop progressive approaches that have potential to achieve the correct balance to achieve sustainable use of wetlands.

4.2.4 Human well-being

The Constitution of Kenya (GoK, 2010) outlines principles that promote human well-being and happiness. When viewed together with the MEA framework, these principles fall in the first quadrant (basic human needs for a good life, human health, good social relations, security and freedom of choice) of the MEA conceptual framework. Therefore, the current national environmental and legislative framework recognizes these higher goals for human happiness. Nonetheless, the draft national wetland policy, the conservation masterplan and the environmental management plan, as well as other documents present a framework for wetland management and adaptation largely in terms of government directions for citizen compliance. Issues of public participation, equity and freedom of choice are not well articulated in this framework. For example, there is explicit reference to demanding financial compensation from individuals or entities that participate in unsustainable use of wetlands. This is a requirement that is difficult to uphold, especially in wetlands like Nyando, in which the majority of wetland users are poor and live below the internationally accepted poverty line of less than US\$2 a day. Indeed, their exploitation of the wetlands is driven by food insecurity and the search for income that stem directly from national policies that have marginalized this area socio-economically. Nonetheless, most documents in the framework recognize the need for involving women and youth in wetland decision-making/implementation processes. Finally, the framework encourages the inclusion of HIV Aids awareness programs in the conception and implementation of management and adaptation programs.

4.2.5 The Social, Political and Economic context of Nyando and other wetlands in Kenya

One of the aims of this work is to develop recommendations that will enhance application of sustainable wetland management and adaptation practices in Kenya, especially in resource poor settings like the Nyando wetland basin. It is almost impossible to satisfy this objective without a description of the social, political and economic environment in which these wetlands exist.

Kenya is a former British colony that attained independence and self-rule in 1963, after almost a century of British domination and Christian missionary activity (Overton 1987). The development of specific regions in Kenya has generally corresponded to two historical facts: i. the pattern of missionary and British colonialist settlements before independence in 1963 and ii. Political loyalties to the government of the day after independence in 1963. Regions that experienced higher settlement of colonialists and mission schools (which corresponded with more productive land) e.g. parts of central Kenya and Rift valley highlands became historically advantaged due to better education and economic growth opportunities, while others especially in western Kenya including Nyando remained poor. After independence, subsequent governments have typically provided resources for local development based on loyalty of specific ethnic groups to the government of the day (Friedrich-Ebert-Stiftung 2012). On both scores (historical colonial settlement and political loyalty), the Nyando wetland basin has been sorely disadvantaged.

To correct inequalities in distribution of development funds, a new constitution that reorganized the country into 47 counties with each county being semi-autonomous and receiving funding from the central government was enacted in 2010 (GoK 2010). While the aim of this change was to allow resource, allocation based on local and better coordinated priorities, after six years, the

county government system is still rife with corruption and mismanagement of development funds that is compounded by equally dysfunctional national government systems. General economic indices in Nyando show a strong increase in the proportion of poor households over the last 25 years, that was aggravated by International Monetary Fund's structural adjustment programs (SAPs) of the 1990s that placed a heavier burden on already poor people by emphasizing cost-sharing of public health and education services (Rono 2002).

4.2.6 References to Climate change adaptation

All documents in the current wetland management and adaptation framework include strong references to climate change. The Kenyan government places a strong emphasis on the need to continuously identify and document evidence for climate change and in 2011, NEMA provided a well summarized document called "The Kenya State of the Environment and Outlook" (S. Businge 2011). While the full impact of climate change has not been fully realized, there is evidence of temperature and rainfall trends that are indicative of climate change, with rising temperatures and cooling of coastal and large water bodies in the region. In 1997/98, devastating floods claimed lives and damaged property and infrastructure while in 2011, a severe drought resulted in famine and shortage of hydro-electric generated power. Lake Victoria, which has an intimate relationship with Nyando wetlands has over the last century experienced a reduction in lake levels although heavy rainfalls.

The effects of climate change are expected to affect all facets of the lives and livelihoods of communities that are adjacent to the Nyando wetland basin. The current framework focuses on implementation of the National Climate Change Strategy (NCCS), raising awareness for opportunities for adaptation including appropriate technology transfer and capacity building.

Other measures include implementation of programmes that adhere to the Kyoto Protocol and development of early warning and response systems to climate change (S. Businge 2011; MEMR 2012b).

While the framework speaks very eloquently to the expected effects of climate change, it presents in very general terms steps that should be taken to enable successful adaptation and resilience to climate change. Adaptation to climate change is a dynamic and complex process that requires adequate resources and clear implementation plans. Importantly, it is not uncommon to confuse ecosystem management with climate change adaptation (McCarthy et al. 2012). Consultation of the Kenya government Budget allocations for the last five years demonstrates a greater emphasis on conservation of wetlands and other ecosystems (Bird and Kirira 2009) but less emphasis on deliberate development of local programmes that match expected change and loss of livelihoods with enhanced awareness and adaptation by communities who occupy these ecosystems. This is important, especially with projections that a temperature increase of between 1 and 3°C by the year 2050 (IPCC 2013).

Chapter 5: Discussion

5.1 Wetland Management Framework and Strategies

The aim of this paper was to assess the Kenya wetland management and adaptation framework against internationally accepted best practices and principles for sustainable wetland management and climate change adaptation. The Kenya Wetland management and climate change adaptation is not a single harmonized strategy, but rather a combination of Ministry of Environment documents and a number of other government legislations, all superseded by the Constitution of Kenya (2010). Therefore, in a sense, this is an evaluation of the generation environment or context in which specific local wetland management and adaptation strategies are developed in Kenya. While there is no specific local Kenya government strategy for the Nyando Wetland ecosystem, this paper makes an attempt to contextualize this framework to the Nyando wetland basin and discuss whether strategies that are developed in the current framework would be effective or not.

The current wetland management and adaptation framework in Kenya is comprehensive and covers a wide range of areas and outlines a wide range of programmes and policy provisions that have strong potential to deliver localized and relevant environmental management and climate change solutions for wetlands. Nonetheless, while these documents are well-structured and even ambitious, a number of areas require more attention, especially for LMICs like Kenya. The most important and possibly urgent step to improve this framework environment is harmonization of institutions dealing with wetland management and climate change adaptation. Appendix 1 shows more than 25 national and local institutions with different roles in wetland management, conservation and climate change adaptation. This is a very large number of institutions that are

not harmonized, which are likely to implement conflicting policies and compete for scarce financial and human resources. While all authority for wetland use rests on NEMA, there are a number of older institutions and local environmental boards and other boards established by acts of parliament that have also been provided with authority. In this environment, it is unlikely that the Nyando wetland ecosystems and indeed other wetlands will be able to obtain coherent strategies for sustainability.

While the principle of Intragenerational equity aspires to protect the rights of all demographic groups in the current generation to exploit wetlands for economic, cultural or other gains, it anticipates involvement of local communities and efforts to promote efficient use of the ecosystem for present but also future economic gain. The current framework places a lot of emphasis on current and foreseeable future economic worth of wetlands and encourages exploitation in accordance with guidelines provided by the relevant minister (GoK, 2013). While this emphasis is understandable, there is insufficient documentation of current wetland use and how existing appropriate technology can be used to efficiently exploit wetlands but still provide the same economic benefits. In addition, the current framework calls for conservation of wetlands for future generations. However, the framework for interpreting anticipated economic, demographic and social changes is not provided. It would be useful to include capacity development so that local institutions have capacity to forecast expected changes through modeling and revision of these models in real time would be a useful way to achieve sustainable use of the wetlands.

The precautionary principle in the current framework is explicit that those who engage in activities that are detrimental to the wetland or are not authorized by the Minister or NEMA are expected to provide for compensation at equal value to the destroyed ecosystem (MEMR 2012b). This is unlikely to be feasible, unless criminal charges are proffered against violators, although this will be punishment rather than compensation of a lost ecosystem segment. It is important to note that some of the prescribed penalties such as the one above cannot be considered in isolation from the wider context of dysfunctional government departments and mismanagement of development funds. These problems trickle down to the grassroots and aggravate poverty to the extent that a violation of aspects of the precautionary principle should strictly not be seen as deliberate destruction of a protected ecosystem rather than a struggle for survival amidst adversity.

Ultimately, for Kenya and other African governments to successfully implement environmental sustainability and climate change adaptation programs, sufficient political will is required in order to transparently allocate resources and embed these programs in the wider context of poverty reduction and provision of pathways towards better livelihoods. Nonetheless, it must be pointed out that rational wetland management is still possible and is being undertaken in other “economically and politically better-off” areas of Kenya like the Lake Naivasha basin. Although devoid of a climate change adaptation component, a comprehensive management plan developed by the Kenyan government and the WWF for Lake Naivasha has been in place since 2012 (GoK 2012). However, it is encouraging to observe evidence of resource mobilization for Nyando wetland ecosystem ; the Star Newspaper, a local Kenyan daily has recently reported disbursement of 2.5 million US dollars to 82 community based non-governmental organizations

for conservation and community education (“Nyando CBO’s Get Sh267m for Wetlands.” 2017). This indicates a level of financial support by both the government and international donors, although coordination between 82 community organizations for an area covering 3600 km² would be a daunting task.

The International Union for Conservation of Nature (IUCN) provides a set of guidelines for application of the precautionary principle in the management of wetlands (Cooney, R 2004). Three of these are relevant for the application of this principle to resource poor settings like the Nyando wetland basin. These are:

- Integration of the Precautionary Principle within other relevant principles and rights including prevention, liability for environmental damage, the right to development, the right to a healthy environment and basic human needs (food, water, health and shelter). It is expected that such an integrated approach is flexible and applied correctly as in some circumstances, these other principles and rights may be subject to the need for precaution while in others, precaution may need to be weighed against them and the greater good upheld.
- Adoption of measures that are proportionate to the potential threats: The correct balance must be struck between the strictness of the precautionary measures and the seriousness and irreversibility of the potential threat. Implementation of precautionary measures will have associated costs and unrealistic measures may not be effective. Through consultation, local communities should retain the right to set their own protection thresholds.

- The social and economic costs and benefits should be taken into consideration when applying the precautionary principle. Where decisions will adversely affect the poor or vulnerable, avoidance or mitigation of adverse effects of such decisions should be given attention. If only a few or powerful or economically advantaged will benefit from the proposed activity, or the benefits *are* only short-lived, and costs are passed on to the public or to poor and vulnerable groups, then increased precaution should be exercised. Threats to biodiversity and living natural resources should be weighed against potential threats to livelihoods and food security and resources to support alternative livelihoods should be provided.

The above principles are important and legislation and policies in the current framework could be improved to incorporate them. Specifically, the correct balance should be made between protection of local community rights to basic human needs as earned from the Nyando wetland ecosystem and the equally important need to conserve the environment for sustainable use. Ultimately, the third principle above is applicable – alternative means should be developed to supplement the needs of the communities living around the Nyando wetland ecosystem to alleviate pressure on the wetland but also to avoid “punishing poverty”. It is not clear in the current framework who should be responsible for these programs and whether there is a coherent approach towards assisting impoverished people to adopt alternative means of livelihood.

With reference to conservation of biological diversity, the current framework and strategies define biodiversity in terms of prevention of introduction of alien species or prohibition of

pollution activities. However, programmes to better document and understand interrelationships between different organisms and their interaction with human activities are not described, although this issue is at the core of wise use of ecosystems since there are real opportunities to enhance certain plants or animals and maybe reduce others in order to achieve the best sustainable result. (Mertz et al. 2007) state that “...exploring biodiversity and ecosystem interactions in the context of the provision of ecosystem services...demonstrates how biodiversity conservation may have added benefits in terms of improved watershed functions and health”. Therefore, the current framework and strategies could be enhanced by inclusion of a plan to conduct an extensive mapping of biodiversity and interrelationships with ecosystem services for better decisions.

To achieve ecologically sustainable development, all the elements described in principles of ecologically sustainable development (See Mollica, 2017) should be taken into consideration and deliberately incorporated in strategy documents. More attention should be given to how to bring together all elements described into a local, focused and effective management and climate change adaptability program for Nyando wetland as well as other wetland ecosystems. Table 1 summarizes the current state of the framework/strategy in the context international principles and highlights of the most critical areas that require attention.

Table 1: Summary of Assessment of Kenya Wetland management and Adaptation in relation to current International Benchmarks

Benchmark/Principle	Adoption in current framework	Opportunities for improvement
Intragenerational equity	Heavily emphasized, forms the core of the framework with economic, especially in the context of Vision 2030	Identification of strategies and activities for efficient exploitation of Nyando wetland ecosystem

Intergenerational equity	Reference is made to sustainable management for future generations with emphasis on conservation of current state of the wetland	Greater emphasis on identification of anticipated economic, social and demographic changes and ecosystem management to respond to these
The precautionary approach	Well-articulated especially the need to depend on scientific evidence and placing the burden of proof on the proponent of change and requirement for payment for unauthorized activity	Practical and economically responsive policies should be applied to the local community for example how would compensation be obtained from individuals who cannot afford it?
Biological diversity	Given emphasis in the context of prevention of alien species and pollution	A framework for better description of biodiversity and interrelationships between different organisms should be developed.
Ecologically Sustainable Development	Intersection between different stakeholders is well described and awareness of complex nature of ecosystem sustainable development is demonstrated	Relevant models describing various development options and potential outcomes should be included in the framework for effective decisions.

5.2 Climate change adaptation

Climate change adaptation is a process, and requires the same kind of attention that would be given to a major long term project. As described above, the IDB defines climate adaptation programs in a similar manner as a project that is time-sensitive and in which different elements come together at the correct time to deliver a beneficial whole (McCarthy et al., 2012). This beneficial whole is the continuous awareness, institutional support and means to protect the lives and livelihoods of local communities as the adverse effects of climate change become more real.

The most important elements that require strengthening in the current framework are enhanced information collection, enhanced capacity to analyze this information and development of sufficient institutional support to implement the programmes.

One of the most serious challenges in environmental adaptation programs is how to link specific environmental changes with climate change in order to understand what elements of ecosystem services will need attention. While the current framework recognizes the need to collect data and

enhance capacity to analyze it, it would be appropriate to assign a specific entity with responsibility for this data. While the Kenya Meteorological Department (<http://www.meteo.go.ke/>) collects all weather-related data, this data remains both sketchy but is also presented in a format that cannot be used in a local environment like the Nyando basin to plan for climate change adaptation. The formation of local authorities to monitor local climate change related events to feed into adaptation programs in real time would be very useful.

Finally, climate change adaptation programs should be coordinated at the local level. There is no clear direction in the frameworks of which level of political authority will be responsible for adaptation programs, except during disaster preparedness and management. It is important to develop competent bodies at the local levels to involve local communities in decision making and implement climate change adaptation programs like a continuous project with continuous learning and refinement. Table 2 summarizes the main areas of concern in current wetland management and climate change adaptation framework and strategies in Kenya.

Table 2: Climate change adaptation in the current framework and opportunities for improvement

Benchmark/Principle	Adoption in current framework	Opportunities for improvement
Collection of Information	The need for systematic collection of information is recognized	Clarity on the level and precision of required information should be improved and custodians of this information should be identified.
Capacity to analyze the information	The need for more trained human capacity is outlined as an important pillar of the framework	Explicit reference to local curriculum revision to include this capacity.
Development of institutional systems to support implementation	A number of institutions are presented in various documents. Some in overlapping roles	There is need for better coherence and streamlining of the various institutions. This area needs the most strengthening

Implementation of the specific project or strategy	How, who and the cost of implementation are described vaguely	More clarity on the implementation program should be developed including some tentative time-lines. Information on local participation and economic/social costs should be strengthened.
---	---	--

5.3 Wetland Governance Framework in Response to Climate Change

Climate change is an issue of social and environmental justice that applies not only at national and regional scales, but also has direct implications for community health and wellbeing outcomes at the local level. The complex dynamics of social–ecological systems in Kenyan national wetlands demand integrated approaches to environmental and human health and wellbeing, which are not yet embedded in national- or state-level policy processes.

Just like the case for sustainable wetland management, the governance framework for climate change adaptation and mitigation has been established but is still not harmonized institutionally and implementation pathways are not clearly defined. Generally, Kenya has produced good documents as a demonstration of intent but much work remains to be done to actualize these documents into actual sustainable programs. Adaptation and mitigation against climate change is a long process that will transcend generations and governments and should be anchored in an environment that is supportive and that can maintain continuity. This involves political goodwill to not only allocate resources for mitigation and adaptation, but also follow through to ensure prudent use. Furthermore, the structural design of Kenya’s science funding frameworks is seen as actively discouraging integrated approaches to social–ecological health research, inhibiting the interdisciplinary applied science that is needed in the dynamic, challenging context of a world undergoing rapid climate change.

Chapter six: Conclusion and recommendations

6.1 Conclusion

This research paper has evaluated the Kenya wetland management and climate change adaptation frameworks against both international standards and the likelihood for successful implementation. Such evaluation is important, especially for LMICs, which suffer the twin problems of increasing populations of poor people, but who will almost certainly bear the brunt of adversity caused by climate change even as they solely depend on exploitation of natural ecosystems for their livelihoods. The focus for the evaluation was the Nyando wetland ecosystem, a wetland in western Kenya that supports a large number of poor and vulnerable people and which is representative of many wetland environments in LMICs. Available Data indicates increased depletion of wetlands due to human use as a result of population increase, which is aggravated by the effects of climate change. Amidst these challenges, findings of this work indicate that Kenya has a number of documents (some are still draft form) that generally meet international standards for wetland management. However, poor institutional harmonization, lack of sufficient human and monetary resources, political intrigue, poor management of funds and an inability to domesticate the documents into local settings may hinder effective management of wetlands.

To improve the effectiveness of the current framework, there is need to streamline governance institutions for coherent implementation. Further, clear mechanisms towards useful and sustainable capacities in wetland management should be devised. This may include the participatory action research among researchers (i.e., wetland ecosystem experts and economists) and capacity building among local people who are direct beneficiaries of these wetland

resources. Rather than being viewed as “subjects to comply to government direction,” local communities should be placed at the center of all wetland management programs and should have greater say in how they would like to ensure sustainability.

There is a general framework for climate change adaptation although it is still in its infancy. Generally, a lot of work needs to be done to distinguish between management and conservation of wetlands and programs that ostensibly focus on climate change adaptation and mitigation. As climate change is a direct impacting factor towards wetland ecosystem, adaptive co-management would help to combat the adverse impacts in future. This may include the local, regional, and national policy and advocacy institutions and NGOs. Finally, climate change adaptation is a long-term project and should involve steps from collection of information for rational decisions as well as resources, capacities and supportive systems. The current wetland climate change adaptation framework is a good beginning point for Kenya but requires both refinement and more realistic implementation plans.

6.2 Recommendations

The following are key recommendations, which if implemented, would greatly strengthen the existing framework for wetland management and climate change adaptation.

- Streamlining of the various institutions involved in wetland management should be undertaken in order to achieve coherent implementation of programs
- Capacity building for modelling and estimation of complex ecosystem relationships should be developed as a basis for informed decision making. This will enable

development of relevant models describing various development options and potential outcomes should be included in the framework for effective decisions

- A comprehensive strategy to develop better identification and descriptions of biodiversity and interrelationships between different organisms should be developed. This will greatly assist in regulation of specific species to maintain biodiversity
- Local communities should be given a stronger voice and practical and economically responsive policies should be applied to them as a means to protecting their rights to decent livelihoods and dignity
- Strategies and activities for efficient exploitation of Nyando wetland ecosystem should be developed and contextualized for the people of Nyando
- Greater political will to efficiently use public resources and ensure equitable distribution of development funds irrespective of political persuasion should be embraced.

Bibliography

- Ajwang' Ondiek, Risper, Nzula Kitaka, and Steve Omondi Oduor. 2016. "Assessment of Provisioning and Cultural Ecosystem Services in Natural Wetlands and Rice Fields in Kano Floodplain, Kenya." *Ecosystem Services* 21, Part A (October): 166–73. doi:10.1016/j.ecoser.2016.08.008.
- Al-Obaid, Sami, Boudjéma Samraoui, Jacob Thomas, Hamed A. El-Serehy, Ahmed H. Alfarhan, Wolfgang Schneider, and Mark O'Connell. 2017. "An Overview of Wetlands of Saudi Arabia: Values, Threats, and Perspectives." *Ambio* 46 (1): 98–108. doi:10.1007/s13280-016-0807-4.
- An, Shuqing, Harbin Li, Baohua Guan, Changfang Zhou, Zhongsheng Wang, Zifa Deng, Yingbiao Zhi, et al. 2007. "China's Natural Wetlands: Past Problems, Current Status, and Future Challenges." *Ambio* 36 (4): 335–42.
- Barros, D. F., A. L. M. Albernaz, D. F. Barros, and A. L. M. Albernaz. 2014. "Possible Impacts of Climate Change on Wetlands and Its Biota in the Brazilian Amazon." *Brazilian Journal of Biology* 74 (4): 810–20. doi:10.1590/1519-6984.04013.
- Bassi, Nitin, M. Dinesh Kumar, Anuradha Sharma, and P. Pardha-Saradhi. 2014. "Status of Wetlands in India: A Review of Extent, Ecosystem Benefits, Threats and Management Strategies." *Journal of Hydrology: Regional Studies* 2 (November): 1–19. doi:10.1016/j.ejrh.2014.07.001.
- Bird, Neil, and Njeru Kirira. 2009. "Government Institutions, Public Expenditure and the Role of Development Partners."
- Burkett, Virginia, and Jon Kusler. 2000. "Climate Change: Potential Impacts and Interactions in Wetlands of the United States¹." *JAWRA Journal of the American Water Resources Association* 36 (2): 313–20. doi:10.1111/j.1752-1688.2000.tb04270.x.
- Clarkson, Beverley R., Anne-Gaëlle E. Ausseil, and Philippe Gerbeaux. 2013. "Wetland Ecosystem Services." *Ecosystem Services in New Zealand: Conditions and Trends. Manaaki Whenua Press, Lincoln*, 192–202.
- Cooney, R. 2004. "The Precautionary Principle in Biodiversity Conservation and Natural Resource Management: An Issues Paper for Policy-Makers, Researchers and Practitioners ." IUCN Publications Services Unit. <https://portals.iucn.org/library/sites/library/files/documents/pgc-002.pdf>.
- Council, National Research. 1995. *Wetlands: Characteristics and Boundaries*. Washington, DC: The National Academies Press. <https://www.nap.edu/catalog/4766/wetlands-characteristics-and-boundaries>.
- Cowardin, Lewis M. 1979. *Classification of Wetlands & Deepwater Habitats of the U. S.* DIANE Publishing.
- Dam, Anne van, Julius Kipkemboi, Fred Zaal, and J. B. Okeyo-owuor. 2011. "The Ecology of Livelihoods in East African Papyrus Wetlands (ECOLIVE)." *Reviews in Environmental Science and Biotechnology; Dordrecht* 10 (4): 291–300. doi:http://dx.doi.org.proxy.bib.uottawa.ca/10.1007/s11157-011-9255-6.

- Dawson, Terry P., Pam M. Berry, and E. Kampa. 2003. "Climate Change Impacts on Freshwater Wetland Habitats." *Journal for Nature Conservation* 11 (1): 25–30. doi:10.1078/1617-1381-00031.
- De Groot, Rudolf S. 1992. *Functions of Nature: Evaluation of Nature in Environmental Planning, Management and Decision Making*. Wolters-Noordhoff BV.
- Dixon, Alan B. 2005. "Wetland Sustainability and the Evolution of Indigenous Knowledge in Ethiopia." *The Geographical Journal* 171 (4): 306–23.
- Ellison, Aaron M. 1994. "Wetlands around the Globe." Edited by D. Whigham, D. Dykyjová, and S. Hejný. *BioScience* 44 (7): 498–99. doi:10.2307/1312303.
- Erwin, Kevin L. 2009. "Wetlands and Global Climate Change: The Role of Wetland Restoration in a Changing World." *Wetlands Ecology and Management* 17 (1): 71. doi:10.1007/s11273-008-9119-1.
- Finlayson, C. 2013. "Climate Change and the Wise Use of Wetlands: Information from Australian Wetlands." *Hydrobiologia* 708 (1): 145–52. doi:10.1007/s10750-013-1474-0.
- Finlayson, S. J. Capon, D. Rissik, J. Pittock, G. Fisk, N. C. Davidson, K. A. Bodmin, et al. 2017. "Policy Considerations for Managing Wetlands under a Changing Climate." *Marine and Freshwater Research*, March. doi:10.1071/MF16244.
- Fleurbaey M., S. Kartha, S. Bolwig, Y., S. Muylaert, R., B. Norgaard, C. Oker, -, eke, and A., and D. Sagar. 2014. "Sustainable Development and Equity. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter4.pdf.
- Friedrich-Ebert-Stiftung. 2012. *Regional Disparities and Marginalisation in Kenya*. <https://books.google.ca/books?id=rsYkjwEACAAJ>.
- Gardner, Royal C., and Nick C. Davidson. 2011. "The Ramsar Convention." In *Wetlands*, edited by Ben A. LePage, 189–203. Springer Netherlands. doi:10.1007/978-94-007-0551-7_11.
- GoK. 2010. "The Constitution of Kenya." Laws of Kenya. <http://www.kenyalaw.org/lex/actview.xql?actid=Const2010>.
- . 2012. "Draft Lake Naivasha Basin Integrated Management Plan 2012-2022."
- . 2013a. "DRAFT NATIONAL WETLANDS CONSERVATION AND MANAGEMENT POLICY." MEMR. <http://www.environment.go.ke/wp-content/uploads/2013/06/DRAFT-WETLANDS-POLICY-June-2013.pdf>.
- . 2013b. "National Environment Policy." Ministry of Environment, Water and Natural Resources. [www:environment.go.ke](http://www.environment.go.ke).
- Grimm, Nancy B, Michelle D Staudinger, Amanda Staudt, Shawn L Carter, F Stuart Chapin, Peter Kareiva, Mary Ruckelshaus, and Bruce A Stein. 2013. "Climate-Change Impacts on Ecological Systems: Introduction to a US Assessment." *Frontiers in Ecology and the Environment* 11 (9): 456–64.
- ICRAF. 2017. "World Agroforestry Centre | Transforming Lives and Landscapes with Trees." <http://www.worldagroforestry.org/>.
- IPCC. 2007. "Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change." Geneva Switzerland. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_full_report.pdf.

- . 2013. "Long-Term Climate Change: Projections, Commitments and Irreversibility."
- Junk, Wolfgang. 2013. "Current State of Knowledge Regarding the World's Wetlands and Their Future under Global Climate Change: A Synthesis." *Aquatic Sciences* 75 (1): 151–67.
- Kabii, Tom. 1996. "An Overview of African Wetlands."
- Kairu, J. K. 2001. "Wetland Use and Impact on Lake Victoria, Kenya Region." *Lakes & Reservoirs: Research & Management* 6 (2): 117–25.
- Kangalawe, Richard Y.M., and Emma T. Liwenga. 2005. "Livelihoods in the Wetlands of Kilombero Valley in Tanzania: Opportunities and Challenges to Integrated Water Resource Management." *Physics & Chemistry of the Earth - Parts A/B/C* 30 (11–16): 968–75. doi:10.1016/j.pce.2005.08.044.
- Kebede, Abiy S., Robert J. Nicholls, Susan Hanson, and Mustafa Mokrech. 2012. "Impacts of Climate Change and Sea-Level Rise: A Preliminary Case Study of Mombasa, Kenya." *Journal of Coastal Research* 28 (1A): 8–19.
- Keddy, Paul A., Lauchlan H. Fraser, Ayzik I. Solomeshch, Wolfgang J. Junk, Daniel R. Campbell, Mary T. K. Arroyo, and Cleber J. R. Alho. 2009. "Wet and Wonderful: The World's Largest Wetlands Are Conservation Priorities." *BioScience* 59 (1): 39–51. doi:10.1525/bio.2009.59.1.8.
- Kerry Turner. 1991. "Economics and Wetland Management." *Ambio* 20 (2): 59–63.
- Khisa, P. S., S. Uhlenbrook, A. A. van Dam, J. Wenninger, A. van Griensven, and M. Abira. 2013. "Ecohydrological Characterization of the Nyando Wetland, Lake Victoria, Kenya: A State of System (SoS) Analysis." *African Journal of Environmental Science and Technology* 7 (6): 417–34. doi:10.5897/AJEST13.1426.
- Kinyangi, James, John Recha, P. Kimeli, and V. Atakos. 2015. "Climate-Smart Villages and the Hope of Food Secure Households," April. <https://cgspace.cgiar.org/handle/10568/65144>.
- Klemas, Victor. 2011. "Remote Sensing of Wetlands: Case Studies Comparing Practical Techniques." *Journal of Coastal Research* 27 (3): 418–27.
- Kumar, Ritesh, Pierre Horwitz, G. Randy Milton, Sonali S. Sellamuttu, Sebastian T. Buckton, Nick C. Davidson, Ajit K. Pattnaik, Monica Zavagli, and Chris Baker. 2011. "Assessing Wetland Ecosystem Services and Poverty Interlinkages: A General Framework and Case Study." *Hydrological Sciences Journal* 56 (8): 1602–21. doi:10.1080/02626667.2011.631496.
- Lynch, A. Jasmyn J., Elikana Kalumanga, and Guillermo A. Ospina. 2016. "Socio-Ecological Aspects of Sustaining Ramsar Wetlands in Three Biodiverse Developing Countries." *Marine and Freshwater Research* 67 (6): 850–68. doi:10.1071/MF15419.
- Macharia, Geoffrey, Paul Lekapana, Griffms Ochieng, and Aron Keche. 2007. "Status of Wetlands in Kenya and Implications for Sustainable Development." In . School of Environmental Studies and Human Science, Kenyatta University. <http://ir-library.ku.ac.ke/handle/123456789/12617>.
- Maclean, Ilya M. D., Rosalind R. Boar, and Charles Lugo. 2011. "A Review of the Relative Merits of Conserving, Using, or Draining Papyrus Swamps." *Environmental Management* 47 (2): 218–29. doi:10.1007/s00267-010-9592-1.
- Malatinszky, Ákos. 2013. "Climate Change Related Land Use Problems in Protected Wetlands: A Study in a Seriously Affected Hungarian Area." *Climatic Change* 118 (3–4): 671–82.

- Maltby, E. 1991. "Wetland Management Goals: Wise Use and Conservation." *Landscape and Urban Planning* 20 (1–3): 9–18. doi:10.1016/0169-2046(91)90085-Z.
- Marambanyika, T., H. Beckedahl, and N.S. Ngetar. 2016. "Community Strategies to Promote Sustainable Wetland-Based Food Security in Rural Areas of Zimbabwe." Article in Press. Scopus. doi:10.1007/s10708-016-9724-0.
- Martin Kernan, Richard W. Battarbee, and Brian R. Moss, eds. 2010. "Climate Change Impacts on Freshwater Ecosystems." In *Climate Change Impacts on Freshwater Ecosystems*, 60. <http://ca.wiley.com/WileyCDA/WileyTitle/productCd-1405179139.html>.
- McCartney, M. P., and B. Van Koppen. 2004. "Sustainable Development and Management of Wetlands. Wetland Contributions to Livelihoods in United Republic of Tanzania."
- McClain, Michael. 2013. "Balancing Water Resources Development and Environmental Sustainability in Africa: A Review of Recent Research Findings and Applications." *AMBIO - A Journal of the Human Environment* 42 (5): 549–65. doi:10.1007/s13280-012-0359-1.
- MEA. 2003. "Ecosystem and Human Well-Being: A Framework for Assessment World Resource Institute." Washington, DC.
- . 2005. "Ecosystems & Human Well-Being: Synthesis (Millennium Ecosystem Assessment)." Island press, Washington DC.
- MEMR. 2012a. "Kenya Wetland Atlas." Ministry of Environment and Mineral Resources. https://na.unep.net/siouxfalls/publications/Kenya_Wetlands.pdf.
- . 2012b. "MASTER PLAN FOR THE CONSERVATION AND SUSTAINABLE MANAGEMENT OF WATER CATCHMENT AREAS IN KENYA." MINISTRY OF ENVIRONMENT AND MINERAL RESOURCES.
- Meng, Lei, Nigel Roulet, Qianlai Zhuang, Torben R. Christensen, and Steve Frohling. 2016. "Focus on the Impact of Climate Change on Wetland Ecosystems and Carbon Dynamics." *Environmental Research Letters* 11 (10): 100201. doi:10.1088/1748-9326/11/10/100201.
- Mitchell, Stephen. 2013. "The Status of Wetlands, Threats and the Predicted Effect of Global Climate Change: The Situation in Sub-Saharan Africa." *Aquatic Sciences* 75 (1): 95–112.
- Mitsch, William J., Blanca Bernal, Amanda M. Nahlik, Ülo Mander, Li Zhang, Christopher J. Anderson, Sven E. Jørgensen, and Hans Brix. 2013. "Wetlands, Carbon, and Climate Change." *Landscape Ecology* 28 (4): 583–97. doi:10.1007/s10980-012-9758-8.
- Mollica, David. 2017. *Sustainability*. Routledge.
- Nasongo, F. Zaal, A. J. Dietz, and J. B. Okeyo-Owuor. 2015. "Institutional Pluralism, Access and Use of Wetland Resources in the Nyando Papyrus Wetland, Kenya." *Journal of Ecology and the Natural Environment* 7 (3): 56–71.
- Nath, Arun Jyoti, Biplab Brahma, Karabi Pathak, and Ashesh Kumar Das. 2016. "Why Should We Preserve Wetlands?" *Current Science (00113891)* 110 (9): 1619–20.
- Njuguna, Steven G., and Geoffrey W. Howard. 1992. *Wetlands of Kenya: Proceedings of the KWWG Seminar on Wetlands of Kenya, National Museums of Kenya, Nairobi, Kenya, 3-5 July 1991*. IUCN.
- "Nyando CBO's Get Sh267m for Wetlands." 2017. *The Star, Kenya*. Accessed August 1. http://www.the-star.co.ke/news/2013/03/25/nyando-cbos-get-sh267m-for-wetlands_c753860.
- Obiero, K. O., P. O. Raburu, P. O. Wa'Munga, and J. B. Okeyo-Owuor. 2012. "The People of Nyando Wetland: Socioeconomics, Gender and Cultural Issues.," 32.

- Oduor, Francis O., Phillip O. Raburu, and Samuel Mwakubo. 2015. "To Conserve or Convert Wetlands: Evidence from Nyando Wetlands, Kenya." *Journal of Development and Agricultural Economics* 7 (2): 48–54. doi:10.5897/JDAE2014.0617.
- Okayo, Joyce, Peter Odera, and Stanley Omuterema. 2015. "Socio-Economic Characteristics of the Community That Determine Ability to Uptake Precautionary Measures to Mitigate Flood Disaster in Kano Plains, Kisumu County, Kenya." *Geoenvironmental Disasters* 2 (November): 26. doi:10.1186/s40677-015-0034-5.
- Okotto-Okotto, Joseph, Phillip O. Raburu, Kevin O. Obiero, Gilbert O. Obwoyere, John M. Mironga, Lorna G. Okotto, and Elizabeth A. Raburu. 2016. "Spatio-Temporal Impacts of Lake Victoria Water Level Recession on the Fringing Nyando Wetland, Kenya." *Wetlands*, 1–13. doi:10.1007/s13157-016-0831-y.
- Opere, A. O., and B. N. Okello. 2011. "Hydrologic Analysis for River Nyando Using SWAT." *Hydrology and Earth System Sciences Discussions* 8 (1): 1765–97.
- Overton, John. 1987. "The Colonial State and Spatial Differentiation: Kenya, 1895–1920." *Journal of Historical Geography* 13 (3): 267–82. doi:10.1016/S0305-7488(87)80115-9.
- Raburu, P. O., J. B. Okeyo-Owuor, and F. Kwena. 2012. *Community Based Approach to the Management of Nyando Wetland, Lake Victoria Basin, Kenya*. Mcpowl Media Ltd. http://www.undp.org/content/dam/kenya/docs/energy_and_environment/Nyando%20Book%20-%20FINAL%20MOST-internet.pdf.
- Rahman, M. M. 2010. "Balancing Ecosystem Services and Livelihoods: A Study of Nyando Wetland, Kenya Using a Bayesian Probability Network." Unesco-IHE.
- RAMSAR. 1971. "Convention on Wetlands of International Importance Especially as Waterfowl Habitat." In . UN Treaty 14583. Iran.
- Ramsar, Ramsar. 2016. "An Introduction to the Convention on Wetlands, Ramsar Secretariat, Gland, Switzerland." Ramsar. http://www.ramsar.org/sites/default/files/documents/library/handbook1_5ed_introductiontoconvention_e.pdf.
- Rongoei, P. J. K., J. Kipkemboi, J. B. Okeyo-Owuor, and AA van Dam. 2013. "Ecosystem Services and Drivers of Change in Nyando Floodplain Wetland, Kenya." *African Journal of Environmental Science and Technology* 7 (5): 274–91.
- Rono, Joseph Kipkemboi. 2002. "The Impact of the Structural Adjustment." *Journal of Social Development in Africa* 17 (1). doi:10.4314/jsda.v17i1.23847.
- Russi, Daniela. 2013. "Paper Citation: Russi D., Ten Brink P., Farmer A., Badura T., Coates D., Förster J., Kumar R. and Davidson N.(2013) The Economics of Ecosystems and Biodiversity for Water and Wetlands. IEEP, London and Brussels; Ramsar Secretariat, Gland."
- S. Businge. 2011. "Kenya, State of the Environment and Outlook 2010." National Environment Management Authority (NEMA),Kenya. <http://www.environmentalmigration.iom.int/kenya-state-environment-and-outlook-2010>.
- Sang, Joseph Kipyegon. 2005. "Modeling the Impact of Changes in Land Use, Climate and Reservoir Storage on Flooding in the Nyando Basin." Masters thesis submitted to Biomechanical and Environmental Engineering Department, Jomo Kenyatta University of Agriculture and Technology, Kenya.

- Serdeczny, Olivia, Sophie Adams, Florent Baarsch, Dim Coumou, Alexander Robinson, William Hare, Michiel Schaeffer, Mahé Perrette, and Julia Reinhardt. 2017. "Climate Change Impacts in Sub-Saharan Africa: From Physical Changes to Their Social Repercussions." *Regional Environmental Change* 17 (6): 1585–1600.
- Siuta, M., C. E. Nedelciu, D. Zadorozhna, R. Nagy Sangumani, and Sobekova AA. 2016. "Report on Socio-Economic Benefits of Wetland." *Does Not Represent the Views of Michael Otto Foundation for Environmental*.
- Swallow, Brent, Leah Onyango, and Ruth Meinzen-Dick. 2003. "Catchment Property Rights and the Case of Kenya's Nyando Basin." In *Preparing for the next Generation of Watershed Management Programmes and Projects. Proceedings of the African Workshop, Nairobi*, 8–10.
- Turner, B. L., Roger E. Kasperson, Pamela A. Matson, James J. McCarthy, Robert W. Corell, Lindsey Christensen, Noelle Eckley, et al. 2003. "A Framework for Vulnerability Analysis in Sustainability Science." *Proceedings of the National Academy of Sciences of the United States of America* 100 (14): 8074–79. doi:10.1073/pnas.1231335100.
- Verhoeven, Jos T. A., and Tim L. Setter. 2010. "Agricultural Use of Wetlands: Opportunities and Limitations." *Annals of Botany* 105 (1): 155–63. doi:10.1093/aob/mcp172.
- Wood, Adrian. 2013. *Wetland Management and Sustainable Livelihoods in Africa*. Routledge.
- World Resource Institute. 2005. "World Resource Institute."

Links.

<http://ramsar.rgis.ch/pdf/cop12/nr/COP12NRFKenya.pdf>

<http://www.meteo.go.ke/>

http://www.the-star.co.ke/news/2013/03/25/nyando-cbos-get-sh267m-for-wetlands_c753860

Appendix 1

List of institutions involved in wetland management in Kenya

Ministry/ institution	Main roles and responsibilities	Legislative framework
Ministry of Water and Irrigation	Formulate water and irrigation policies, initiate and oversee drafting of relevant legislation, sector coordination and guidance, monitoring and evaluation	Water Act (No. 8 of 2002).
Water Resources Management Authority (WRMA)	Develop procedures for water allocation; reassess the national water strategy; issue water permits; protect water resources quality from adverse impacts; manage and protect water catchments; gather and maintain water information; liaise with other actors for better management of water resources	Water Act (No. 8 of 2002).
Catchment Area Advisory Committees (CAACs)	Advise WRMA on water conservation, use and apportionment; issue water permits at catchment level.	Water Act (No. 8 of 2002).
Water Resources Users Associations (WRUAs)	Ensure cooperative management of water resources at the catchment level; conflict resolution.	Water Act No. 8 of 2002).
Water Services Regulatory Board (WASREB)	Promote water conservation and demand management; periodically reassess water management strategy; issue licenses and determine water standards	Water Act (No. 8 of 2002).
Water Services Boards (WSBs)	Ensure efficient and economical provision of water and sewerage services.	Water Act (No. 8 of 2002)
Water Service Providers (WSPs)	These local bodies are set up for the provision of water and sewerage services under license from WSBs	Water Act (No. 8 of 2002).
Water Services Trust Fund (WSTF)	Finance provision of water and sanitation to disadvantaged groups.	Water Act (No. 8 of 2002)
Water Appeal Board (WAB)	Determine disputes in the water sector	Water Act (No. 8 of 2002)

National Water Conservation and Pipeline Corporation (NWCPC)	Construct dams and drill boreholes	State Corporations Act (Cap.446)
Kenya Water Institute (KEWI)	Carry out training, research and consultancies in the water sector	Kenya Water Institute Act (No. 11 of 2001).
National Irrigation Board (NIB)	Develop irrigation infrastructure and manage irrigation schemes.	Irrigation Act (Cap 347).
Ministry of Forestry and Wildlife	Formulate forestry and wildlife policies, initiate and oversee drafting of relevant legislation, sector coordination and guidance, monitoring and evaluation	Forests Act (No. 7 of 2005)
Kenya Wildlife Service (KWS)	Conserve wildlife and their ecosystems; National Ramsar administrative authority	Wildlife Conservation and Management) Act (Cap 376).
Kenya Forestry Service (KFS)	Conserve, develop and sustainably manage Kenya's forest resources for the country's social-economic development	Forests Act (No. 7 of 2005).
Kenya Forestry Research Institute (KEFRI)	Carry out research in forestry and related natural resources	Science and Technology Act (Cap. 250).
Ministry of Environment and Mineral Resources	Formulate environmental laws and policies, monitor, protect, conserve and manage the environment and natural resources by ensuring sustainable utilization	Environmental Management and Coordination Act (No. 8 of 1999)
National Environment Management Authority (NEMA)	Coordinate environmental management; provide guidance on the development of wetland management plans; ensure compliance of environmental laws	Environmental Management and Coordination Act (No. 8 of 1999).
Department of Resource Surveys and Remote Sensing (DRSRS)	Collect, store, analyse and disseminate geo-spatial information on natural resources to facilitate informed decision-making for sustainable management of these resources	Environmental Management and Coordination Act (No. 8 of 1999)
Ministry of Fisheries Development	Formulate policies, oversee drafting of relevant legislation, policy formulation, sector coordination and guidance, monitoring and evaluation	Fisheries Act (Cap 378).

Kenya Marine and Fisheries Research Institute (KMFRI)	Conduct aquatic research in the country's waters and the corresponding riparian areas including the Exclusive Economic Zone	Science and Technology Act (Cap. 250).
National Museums of Kenya (NMK)	Promote Kenya's heritage by collecting and preserving artefacts and research. National Museums and Heritage	Act (No. 6 of 2006).
Ministry of Public Health and Sanitation	Develop and implement public health and sanitation policies and establish primary health care interventions at individual, household, community and primary health facility levels in order to make the country free from preventable diseases and ill health.	Public Health Act (Cap. 242).
Ministry of Lands	Formulate and implement the national land policy, oversee drafting of land laws, register land transactions, undertake physical planning, land surveys and mapping, land adjudication and settlement, land valuation and administration of state and trust land	Land Registration Act (No. 3 of 2012); The Land Act (No 6 of 2012).
District Environmental Committees (DECs)	Provide technical support for environmental management including all ecosystems and integrate wetland protection into district development plans	Environmental Management and Coordination Act (No. 8 of 1999).
Civil Society Organizations (CSOs)	Implement community and government projects and programmes; lobby for policy and legal reform; mobilize technical and financial support for programmes	NGO Coordination Act (No. 19 of 1990).
Development partners	Mobilize resources for implementation of various projects in priority sites and implement activities through counterparts and local partners	