UNIVERSITY OF NAIROBI

LINKING ECONOMIC VALUES OF MANGROVE ECOSYSTEMS WITH THE GOVERNING INSTITUTIONAL FRAMEWORK FOR SUSTAINABLE MANAGEMENT OF THE TANA DELTA, KENYA

By

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Declaration

This thesis is my original work and has not been submitted or presented in any other university for examination either in part, or as a whole. All sources of information cited herein have been acknowledged.

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Disclaimer

All views and opinion expressed in this report describe work submitted as part of study at the Centre for Advanced Studies in Environmental Law and Policy (CASELAP), University of Nairobi, are those of the author, and do not necessarily represent those of CASELAP or University of Nairobi.

Abstract

Mangroves provide a host of ecosystem goods and services such as nursery and spawning ground for fish, shoreline and storm protection, carbon sequestration, ground water recharge, flood control, tourism and recreation, fishing; water transport; herbal medicines, honey, timber/poles, fuel wood among others. However, they face a continued threat to their existence from conversion into aquaculture, over harvesting, pollution, upstream developments that threaten the availability of freshwater flooding, etc. This is due to lack of acknowledgement of the values of the goods and services that mangroves provide, particularly in economic terms. This study determined the economic value of the mangrove ecosystem goods and services in Tana River delta; and assessed the role of the integrated river basin management (IRBM) framework in safeguarding them. Out of a population of 3,743 households in Kipini, 605 were surveyed using market price method, choice experiment questionnaires and content analysis. The results show that the total economic values of the mangroves is US$ 1053.92/ha/year and that the legal architecture of the institutional arrangements does not fully capture the principles of IRBM. It is therefore recommended that in order to harness the economic benefits of mangroves, there is need to establish the Tana River reserve flow to guide in allocation of water resources equitably among the competing needs. A review of the Water Act 2002 will be necessary to address the gaps identified.

Keywords: Economic valuation, Choice experiment, Market price, Mangroves, Wetlands, Forests, Institutional Analysis for Development Framework, Integrated River Basin Management

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Abbreviations

ANOVA	Analysis of Variance
ASAL	Arid and Semi-Arid Lands
ASCU	Agricultural Sector Coordination Unit
ASDS	Agricultural Sector Development Strategy
CASELAP	Centre for Advanced Studies in Environmental Law and Policy
CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity
CE	Choice Experiment
CFAs	Community Forest Associations
CMS	Catchment Management Strategy
CPR	Common Pool Resources
CS	Cabinet Secretary
CWSB	Coast Water Services Board
DUV	Direct Use Values
EA	Environmental Audit
EAWS	East African Wildlife Society
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
ERC	Energy Regulatory Commission
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
GIS	Geographic Information System
GWP	Global Water Partnership
IAD	Institutional Analysis for Development
ICZM	Integrated Coastal Zone Management
IIA	Independence from Irrelevant Alternatives
IoS	Institutions of Sustainability

IRBM	Integrated River Basin Management
IUCN	International Union for Conservation of Nature
IUV	Indirect Use Values
IWRM	Integrated Water Resource Management
KenGen	Kenya Electricity Generating Company
KFS	Kenya Forest Service
KNBS	Kenya National Bureau of Statistics
KNCHR	Kenya National Commission on Human Rights
KWS	Kenya Wildlife Service
LAPSSET	Lamu Port-South Sudan-Ethiopia Transport
MDGs	Millennium Development Goals
MEMR	Ministry of Environment and Mineral Resources
MEWNR	Ministry of Environment, Water and Natural Resources
MNL	Multinomial Logit
MOA	Ministry of Agriculture
MOE	Ministry of Energy
MWI	Ministry of Water and Irrigation
n.d	Not dated
NEMA	National Environment Management Authority
NIB	National Irrigation Board
NTPs	Non Timber forest Products
PES	Payment for Ecosystem Services
PPM	Parts Per Million
PPT	Parts Per Thousand
PSU	Practical Salinity Unit
SAS	Statistical Analysis System
SCMP	Sub Catchment Management Plan
SEA	Strategic Environment Assessment
SES	Social-Ecological Systems
SIA	Social Impact Assessment

SPSS	Statistical Package for the Social Sciences
TARDA	Tana and Athi Rivers Development Authority
TEEB	The Economics of Ecosystems and Biodiversity
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Science and Cultural Organisation
WAP	Water Allocation Plan
WASREB	Water Services Regulatory Board
WESCOORD	Water and Environmental Sanitation Coordination
WRMA	Water Resources Management Authority
WRUAs	Water Resource Users Association
WSB	Water Service Board
WTP	Willingness To Pay

CHAPTER 1: INTRODUCTION

1.1. Background

An ecosystem is a dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit (Butler et al, 2003), example of ecosystems include forest, wetlands, grasslands among others. Ecosystems provide a number of goods and services which are of great value to human well-being. The Millennium Ecosystem Assessment (Butler et al, 2003) has classified ecosystem services along functional lines using categories of: 1. provisioning services such as food, timber, fibre, and fuelwood; 2. supporting services such as soil formation, nutrient cycling among others; 3. regulating services such as water regulation, climate regulation among other; 4, cultural services such as educational, recreation, aesthetic, among others.

Mangroves are a forested wetland ecosystem commonly found along the coast in the intertidal area between the land and the sea (Hunter, 1999). Landward, mangroves are found adjacent to coastal terrestrial forests, while seaward, they coexist with sea grass beds and coral reefs (NEMA, 2010). They are globally important since they provide wood, act as nursery for fish, offer storm protection among others (CBD 2010). The global mangrove cover was at 15.2 million hectares in 2005 down from 18.8 million hectares in 1980 (FAO 2010). In Kenya, mangroves are concentrated on the northern coast around the Lamu archipelago and the permanent Tana/Sabaki River estuaries, with smaller wetlands in the mouths of semi-perennial and seasonal coastal rivers on the South Coast, at Shimoni-Vanga, Funzi and Gazi Bays, and Port-Reitz, Tudor, Mtwapa, Kilifi and Mida Creeks. The total area of mangroves in Kenya has been estimated at between 53,000 to 61,000 ha, with 67 percent occurring in Lamu County, and

10 percent each in Kilifi and Kwale Counties (NEMA, 2010). The Tana delta has mangroves along the main river course between Ozi and Kipini (Tana River Delta, 2004).

Owing to the ecosystem services that mangroves provide to humanity, it is imperative that such services are utilised in a manner that guarantees their perpetuity through sustainable management. In this study, sustainable management of mangroves in the Tana delta was presented to be dependent on the appreciation of their economic contribution to the communities that depend on them and also on the realisation that the success in sustainable management of the mangroves does not depend on looking at their ecosystem in isolation but rather holistically from a basin wide perspective through integrated river basin management to be able to deal with externalities that threatens the tenets of such ecosystem in which case. The ecosystem values of the mangroves were assessed though economic valuation of their ecosystem goods and services. Economic valuation of ecosystem goods and services is a process of expressing a value for a particular good or service in a certain context in monetary terms (UNEP, 2010) and integrated river basin management entails coordinated planning, development, management and use of land, water and related natural resources within hydrologic boundaries (Watson, 2004). The objective is the integration of water planning and management with environmental, social and economic development concerns, in order to promote sustainable development (McNally & Tognetti, 2002; Toriman et al, 2012). The study was therefore primarily focused on the economic values of the mangrove ecosystem goods and services and how institutional arrangements through integrated river basin management as a broader goal of avoiding silo approaches to sub sets of basin ecosystems of interest which in this case is the mangrove ecosystem in Kipini for their sustainable management.

1.2.Statement of the Research Problem

Despite the importance of mangrove ecosystems, there is continued threat to their existence; they face great threat from conversion into aquaculture, over harvesting, pollution among others (FAO, 2010). It is estimated that 10,310 ha of mangrove forest in Kenya have been lost due to conversion to other land uses, overexploitation and pollution (NEMA, 2010). The conversion of mangroves into aquaculture, other unsustainable use and upstream developments that threaten the availability of freshwater flooding downstream is due to lack of acknowledgement of the values of the goods and services that they provide, particularly in economic terms (Pascual et al, 2012; De Groot et al , 2012). There is therefore need to assess the economic values of these ecosystem goods and services of mangroves, for instance, the economic value of the mangroves in the Tana delta has not been studied yet. This will provide information on the ecosystem services that benefit society and the economy.

In a situation where ecosystem values are appreciated, there is a need to ensure that such values are safeguarded. One way of ensuring this is the practice of integrated river basin management through a responsive institutional arrangement that ensures that a balance is stuck between the entire various social, economic and environmental flow requirements. Whereas the water sector has developed an integrated water resource management plan, there is no evidence that its implementation is actually securing the three tenets of integration of economic, social and environmental sustainability.

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1.3. Research Questions

The central research question of the study was what are the economic values of the mangrove ecosystem goods and services in Tana River and how can the integrated river basin institutional arrangements help safeguard them?

The sub questions were:

1. What are the ecosystem goods and services provided by the mangroves in Tana River delta?
2. What are the economic values of the ecosystem goods and services provided by the mangroves in Tana River delta Kipini area?
3. How are the institutional arrangements for the Tana River basin management suitable for advancing an integrated river basin management approach?

1.4. Research Purpose and Objectives

1.4.1. Research Purpose

The purpose of study was to estimate the economic values of the mangrove ecosystem goods and services and investigate the suitability of the existing institutional arrangements to harness the values within a broader integrated river basin management framework.

1.4.2. Research Objectives

The main research objective was to identify and estimate the economic values of the mangrove ecosystem goods and services and to investigate how institutional arrangements can be designed to enhance the ability of the ecosystem to continue providing the goods and services within an integrated river basin management framework.

The specific objectives of the study were:

1. To identify the ecosystem goods and services provided by the mangroves of the Tana river delta
2. To estimate the economic value of the ecosystem goods and services provided by the Mangroves in Kipini area of the Tana River delta
3. To investigate the Tana River basin institutional arrangements suitability for an integrated river basin management framework

1.5.Justification of the study

Mangroves form part of important natural resources around the world including Kenya, where studies have shown that they provide a range of ecosystem based goods and services such as protection of coastal shoreline, carbon sequestration, nursery for both offshore and on-shore fisheries, purification of water and timber for various uses by local communities such charcoal, building among others. Mangroves also constitute a significant habitat for various plants and animals such as hippos, reptiles like snakes and crocodiles, various bird species and several invertebrates. Despite, the importance of the mangroves to humanity and the biological community in general, they face a great threat on their existence ranging from conversion into other economic ventures such as aquaculture, diversion and abstraction of upstream river waters for agriculture and flood mitigation measures. All these activities are generally targeted at improving the socio economic well-being of humanity. However, hardly do the values of ecosystem goods and services to the society assessed against such development initiatives before decision on possible trade-offs, or redesigning to optimise on both development and safeguarding the services without diminishing either is conducted.

This valuation study will be useful for policy makers, investors and local communities in understanding how the mangrove ecosystem contributes to the society, and the benefits and costs interventions that have the potential to alter the mangrove ecosystem have Despite the importance of mangrove ecosystems, there is continued threat to their existence; they face great threat from conversion into aquaculture, over harvesting, pollution among others (FAO, 2010). It is estimated that 10,310 ha of mangrove forest in Kenya have been lost due to conversion to other land uses, overexploitation and pollution (NEMA, 2010). The conversion of mangroves into aquaculture, other unsustainable use and upstream developments that threaten the availability of freshwater flooding downstream is due to lack of acknowledgement of the values of the goods and services that they provide, particularly in economic terms. There is therefore need to assess the economic values of these ecosystem goods and services of mangroves to provide information on the ecosystem services that benefit society and the economy. For instance, the economic value of the mangroves in the Tana delta has not been studied yet. In a situation where the values are appreciated, there is a need to ensure that such values are safeguarded and one way of ensuring this is the practice of integrated river basin management through a responsive institutional arrangement that ensures that a balance is stuck between all the various social, economic and environmental flow requirements. There are a host of organisations with mandate of carrying various activities at the Tana River Basin drawn from varied legal instruments. Whereas the water sector has developed an integrated water resource management plan, there is no evidence that it is implemented or whether its implementation is actually securing the three tenets of integration of economic, social and environmental sustainability. This study therefore proposed that the current institutional arrangements be investigated to assess its suitability to provide an integrated river basin management approach in the Tana delta.

1.6. Limitations of the study

The role played by mangroves in carbon sequestration is widely appreciated. However, in this study, carbon measurements was not conducted because direct field measurements are more laborious and finance resource intensive making it difficult to conduct within the scope of this study. The study however, covered other equally invaluable values of the mangroves such as the direct use values which include fuel wood, building materials, traditional herbal medicine, honey, and fish and in direct use values such as nursery and breeding ground for fish, tourism and recreation, flood control and shoreline protection. These values were chosen in order of priority or perceived significance by the community members.

CHAPTER 2: LITERATURE REVIEW

2.1. Overview of Mangrove Ecosystem goods and services

Mangroves have duality in their ecosystem type classifications. On one hand they are forests and on the other hand they are wetlands (Olson et al., 2001; Schmitt et al., 2009). The significance of this duality is that mangroves therefore are able to provide a wide range of ecosystem goods and services attributable to both forests and wetlands. Some of the documented ecosystem goods and services include: sustaining highly productive fisheries through acting as a nursery for spawning; supporting a significant biodiversity such as many species of birds, reptiles including crocodiles, mammals (pigs and monkeys) and insects, terrestrial flora -mainly comprises fungi, lichens and mistletoe, aquatic species include many prawn and shrimp, crab, mollusc, and oyster species. Common fish species include striped catfish, *Plotosus lineatus*, gobies, common silver biddy, *Gerres oyena*, and the two-finned round herring, *Spratellomorpha bianalis* (Ravilious et al, 2003). Mangroves play a vital role in protecting riverbanks and shorelines against erosion and storms such as hurricanes. It has been suggested that the large loss of life (300,000 to 500,000 lives) in Bangladesh during the 1970 typhoon was partly due to the fact that many of the mangrove swamps protecting those populated coastal regions had been removed and replaced by rice paddies (Feller and Sitnik, 1996).

Mangroves are also a significant resource for Carbon sequestration: a study conducted by Donato et al. (2011) on indo pacific mangroves found that the below-ground carbon storage in soils accounted for 71-98% and 49-90% of total storage in estuarine and oceanic mangrove sites, respectively. The study also found that the below-ground carbon storage was positively but

weakly correlated to above-ground storage (R2D 0:21 and 0.50 in estuarine and oceanic sites, respectively).

Ground water recharge is another significant ecosystem service that mangroves provide, water which moves from the mangrove to an aquifer can remain as part of the shallow groundwater system, which may supply water to surrounding areas and sustain the water table, or it may eventually move into the deep groundwater system, providing a long term water resource. This is of value to communities and industries that rely on medium/deep wells as a source of water (Bann, 1998; Field, 1995). Tourism and recreation is also another service that mangroves provide, others include fishing; water transport; forestry products such as herbal medicines, honey, timber and poles selling and for among others building huts, furniture, fuel wood, charcoal, fencing, boat making and boat traps and are valuable in sustaining the needs and livelihoods of many coastal communities (Bann, 1998; Field, 1995).

2.2 Ecology of the mangrove ecosystem

Key significant interrelationship of the mangroves and their environment include characteristics such as zonation, forest structure, trophic levels which are influenced by physicochemical elements like salinity, tidal currents, winds, high temperatures, and muddy anaerobic soil (Kathiresan, 2008; Feller and Sitnik, 1996). Mangroves occur in low lying, broad coastal plains where the topographic gradients are small and the tidal amplitude large. Repeatedly getting flooded, but well drained soil supports a rich growth of mangrove plants. They normally grow poorly in stagnant waters and have luxuriant growth in the alluvial soil substrates with fine-textured loose mud or silt, rich in humus and sulphides. They can also be found in substrates

other than muddy soil such as coastal reefs and oceanic islands. In such areas, the mangrove plants grow on peat, which is derived from decayed vegetation (Kathiresan and Bingham, 2001).

The occurrence of individual mangrove species within the forest is related to environmental factors such as salinity, nutrient availability, oxygen levels in the soil and wave energy. As mangrove species are variable in their tolerance of these factors, a pattern of species distribution known as zonation occurs (Semesi, 1986; Kairo, 1997). The forest structure of the mangroves are characterized by attributes such as species richness, canopy height, basal area, tree density, age/size class distribution, and understory development. Species richness appears to be influenced by temperature, tidal amplitude, rainfall, catchment area, freshwater seepage (Tomlinson, 1986; Lugo & Snedaker, 1974). Another structural characteristic of mangrove forests is the frequent absence of understory species, which are usually found in other forest systems (Janzen 1985). Shrubs, grasses, lianas, and other herbaceous plant species do not usually occur under the closed canopy in the mangrove forests. The lack of understory is probably related to the combination of salinity and flooding stresses and low light levels, which exceeds the tolerance limits of plants (Lugo, 1986). Two groups of mangroves can be identified based on salinity tolerance data; one has a very broad range (0-80%) and the other has a narrower range (<40%) of tolerance (Robertson and Alongi, 1992).

2.3 Threats to the mangroves

Mangrove forests around the world are under significant and increasing threats from degradation, pollution, conversion to other land uses, and various other anthropological impacts (Kathiresan and Bingham, 2001). Pollution from oil or gas exploration, petroleum production, and accidents by large oil tankers cause significant damage to mangrove ecosystems. Oil tanker accidents in

the Gulf of Mexico and in the Caribbean areas resulted in oil spillage that severely damages the coastal systems. As a result, the entire mangrove ecosystem got affected, causing defoliation of trees, mortality of all sessile and benthic organisms and contamination of many water fowls. In Kenya, between 1983 and 1993 Mombasa port and surrounding waters experienced 391,680 tonnes of oil pollution from spills. Mangroves in Makupa Creek were badly affected as a reservoir of oil sunk into sediments causing frequent re-oiling (Kathiresan, 2007; Ravilious et al. 2003). Once the mangrove forest is affected by oil pollution, it will take a long time of at least 10 years for recovery of the forest (Kathiresan, 2007).

Mangroves in many areas are facing the threat of being lost due to salt production. A study conducted by Ravilious et al in 2003 revealed that six salt works between Ngomeni and Karawa had produced 71,400 tonnes of salt, which causes underground seepage of saline water from salt pans that kill neighbouring mangroves (Ravilious et al., 2003). Altered water flow such as changes to fresh water inflows arising from upstream dams and irrigation also impact mangroves, altering salinity and often leading to mangrove losses. For example, in the Indus Delta in Pakistan, there has been a 90% reduction in freshwater inflow, leading to increase in coastal erosion due to the lack of new sediment input (Van Lavieren, 2012). Lake Cahora Basa which is a human made reservoir in the middle of the Zambezi River in Mozambique is primarily used for the production of hydroelectricity. Created in 1974, its water level held constant for 19 years, resulting in a near-constant release of 847 m^3 (1,108 cubic yards) of water over the same period. Observations before and 20 years after the dam's impoundment, however, reveal the following negative impacts some of which may also have been caused by other dams on the river (e.g. Kariba), as well as the effects of the country's 20-year civil war —but nearly all of which have been directly influenced by the over-regulation of a major river system: 1) many of the

mangroves in the delta have dried out and died back; 2) the community structure of the floodplain vegetation has changed, with a substantial increase in trees; 3) meanders and oxbows, once a major feature of the floodplain, have become clogged with reeds and trees; 4) productive, flood-dependent grasslands have been depleted of grasses, the favoured food of herbivorous mammals; 5) large mammals, including the once abundant buffalo, have almost disappeared from the delta; 6) the abundance of waterfowl has declined significantly; 7) floodplain 'recession agriculture' has declined significantly; 8) vast vegetated islands have appeared in the river channel, many of which have been inhabited by people; 9) dense reeds have lined the sides of the river channels; 10) Erosion of the coastal zone has increased, probably more as a result of the release of sediment-hungry water from Cahora Basa Dam than of changed flow patterns (Singh, Diop & M'mayi, 2006; Chenje and Jonson, 2002).

2.4 Economic valuation of mangrove ecosystem goods and services

Costanza (2000), defined value to mean the contribution of an action or object to user-specified goals, objectives or conditions, while Goulder and Donald (1997) made a distinction between intrinsic and instrumental value. Some individuals might maintain a value system in which ecosystems or species have intrinsic rights to a healthful, sustaining condition that is at par with human rights to satisfaction (Farbes, Costanza & Wilsonl, 2002). The value of any action or object is measured by its contribution to maintaining the health and integrity of an ecosystem or species, per se, irrespective of human satisfaction ((Farbes et al, 2002). Some interpret Leopold and Aldo (1949) land ethic as constituting an intrinsic value system, where something is 'right when it tends to preserve the integrity, stability and beauty of the biotic community and it is wrong when it tends otherwise (Farbes et al, 2002). Instrumental values are based on usefulness

to humans, and are commonly measured in terms of economic or service value, and may be divided into three basic categories namely, goods, services and information. Policies toward the environment will always tend to be based on a mix of intrinsic and instrumental values (Farbes et al, 2002; Callicott, 1997; Trombulak et al, 2004).

Economic value refers to the value of an asset, which lies in its role in attaining human goals, be it spiritual enlightenment, aesthetic pleasure or the production of some marketed commodity (Barbier et al., 2009).Valuation is useful since existing market signals often lack appropriate consideration of the value of, the damage to, and incentives for the sustainable use of biodiversity (TEEB, 2010). Understanding the values of ecosystem services can help to: 1) generate better information about the value of nature's services; 2) identify 'true' costs of business as usual; 3) improve decision making when trade-offs are necessary and useful information is lacking; 4) provide a basis for policy formulation and analysis; and 5) set incentives and regulating use (TEEB, 2010).

The quantitative valuation of ecosystem goods and services can be based on the concept of total economic value which distinguishes between *use* values and *non-use* values, the latter referring to those current or future (potential) values associated with an environmental resource which rely merely on its continued existence and are unrelated to use (Pearce and Warford, 1993; Barbier, et al, 1997; Garcia et al, 2003). The use value refers to value arising from an actual use made of a given resource, such as the use of mangrove forest for timber. Use values are further divided into direct use values (DUV), which refer to actual uses such as fishing, timber extraction among others; indirect use values (IUV), which refer to the benefits derived from ecosystem functions such as a shoreline protection by mangroves; and option values (OV), which is a value approximating an individual's willingness to pay to safeguard an asset for the option of using it at

a future date (Pearce and Moran, 1994). There are various methods that are used to estimate the total economic value of ecosystem goods and services and are based on three approaches, which are: stated preference, revealed preferences and costs based approaches (JNCC, 2013).

Stated preference approaches simulate a market and demand for ecosystem services by means of surveys on hypothetical (policy-induced) changes in the provision of ecosystem services. Stated preference methods can be used to estimate both use and non-use values of ecosystems and/or when no surrogate market exists from which the value of ecosystems can be deduced (TEEB, 2010). It is classified into contingent valuation and choice modelling techniques. The former seek measures of willingness to pay through direct questions such as 'What are you willing to pay?' and 'Are you willing to pay £X'? The latter seeks to secure rankings and ratings of alternatives from which WTP can be inferred. Choice modelling is further divided into various forms namely: choice experiments, contingent ranking, paired comparisons and contingent rating (Oezdemiroglu, Pearce, & Department for Transport, Local Government and the Regions (DTLR), [London], (2002). Both Contingent Valuation and Choice Modelling methods have their merits but choice modelling methods appear to be in the ascendancy as they provide a more direct route to the valuation of the characteristics or attributes of a good, and of marginal changes in these characteristics, rather than the value of the good as a whole (Accent, 2010). Choice modelling was initially developed in the marketing and transport literature by Louviere and Hensher (1982) and has since been applied in valuation of dozens of ecosystem goods and services. The disadvantage of stated preference is that there may be cognitive limitations. People may not fully understand, for example, very small changes in risk, or highly complex goods such as biological diversity. Whether or not these limitations exist can be tested by (a) reference to the available literature and (b) use of focus groups (Oezdemiroglu et al, 2002).

The revealed preference techniques are based on the observation of individual choices in existing markets that are related to the ecosystem service that is subject of valuation. In this case it is said that economic agents "reveal" their preferences through their choices (TEEB, 2010). The main methods within this approach include use of existing markets where market price method is applied; and surrogate markets where hedonic, travel cost and production function methods are used (Pearce and Moran, 1994). The market price method use prevailing prices for goods and services traded in domestic or international markets and its main advantage is that market prices reflect the private willingness to pay for ecosystem goods and services that are traded such as fish, timber, fuel wood, and recreation; price, quantity and cost data are relatively easy to obtain for established markets; and the method uses standard, accepted economic techniques (Barbier et al., 1997; King and Mazotta, 2014). The approach's disadvantage is that market data may only be available for a limited number of goods and services provided by an ecological resource and may not reflect the value of all productive uses of a resource; the true economic value of goods or services may not be fully reflected in market transactions, due to market imperfections and/or policy failures; seasonal variations and other effects on price must be considered; the method cannot be easily used to measure the value of larger scale changes that are likely to affect the supply of or demand for a good or service; usually, the market price method does not deduct the market value of other resources used to bring ecosystem products to market, and thus may overstate benefits (King and Mazotta, 2014). An economic analysis of Mangrove forest in Gazi Bay, Kenya by UNEP in 2011 used market valuation for capturing values of direct ecosystem goods and services. In particular, fishery, building poles, fuel wood, research, eco-tourism, apiculture and aquaculture were valued to yield a total of $ 1092.30/ha/year.

Cost-based approaches are based on estimations of the costs that would be incurred if ecosystem service benefits needed to be recreated through artificial means. The methods under this approach include: the damage avoided method, which relates to the costs that would have been incurred in the absence of ecosystem services; replacement cost method, which estimates the costs incurred by replacing ecosystem services with artificial technologies; and mitigation or restoration cost method, which refers to the cost of mitigating the effects caused by to the loss of ecosystem services or the cost of getting those services restored (Garrod and Willis, 1999; De Groot, Fisher & Christie, 2010). The advantage of cost based approaches is that it is easier to measure costs of producing benefits themselves, when goods, services and benefits are non-marked, and also this approach is less data and resource intensive. On the hand its disadvantage the approach assumes that expenditure provides positive benefits and net benefits generated by expenditure match the original level of benefits. Even when these conditions are met, costs are usually not an accurate measure of benefits. So long as it's not clear whether it's worth it to replace a lost or damaged asset, the cost of doing so is an inadequate measuring of damage (De Groot et al, 2010).

Ecosystem services can be considered as contributing to different elements of Total Economic Value of an ecosystem, which comprises both use values (direct and indirect use) and non-use values categories; each subsequently disaggregated into different value components (Brander et al. 2010). Figure 1 shows a TEV diagram that shows the different values of ecosystem services.

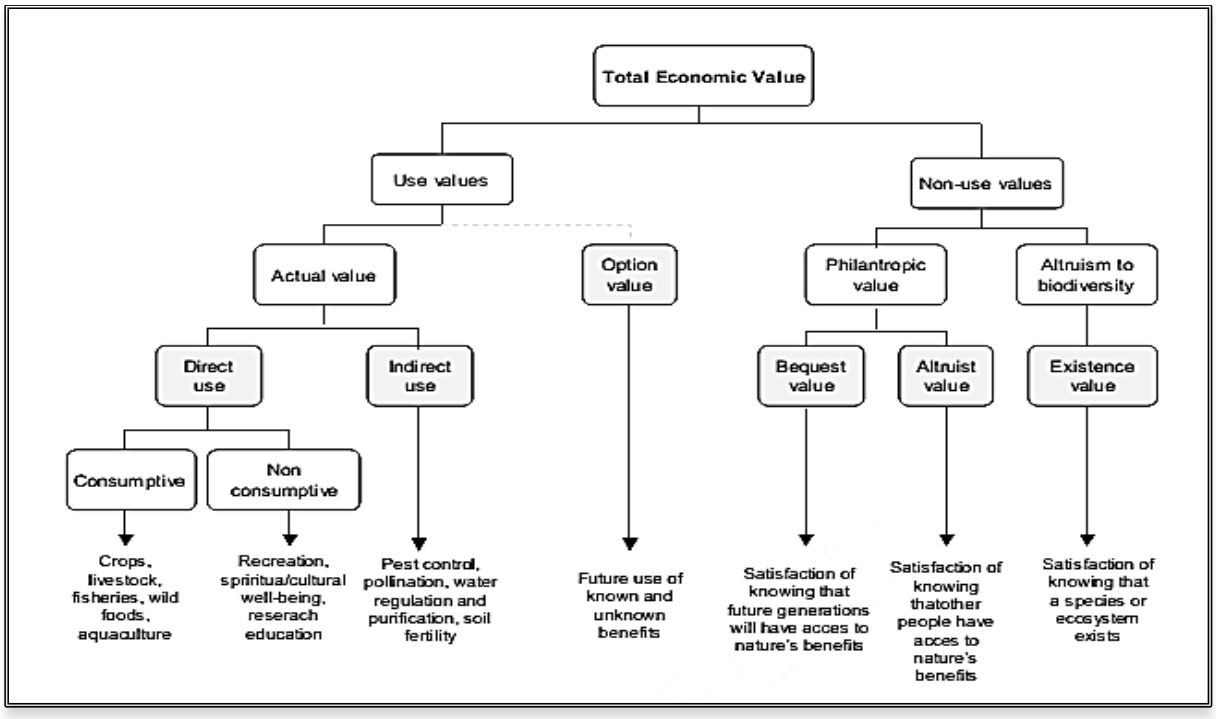


Figure 1: Value types within TEV Approach

Source: Brander et al. (2010)

A number of methods have been used in estimating values of mangrove ecosystem services. Some of these are discussed. Sathirathai and Barbier (2001) conducted valuation of mangrove conservation in southern Thailand on a 400ha mangrove forest in the village of Po in Surat Province, which had a population of 652 people. Three key economic benefits were measured: the value to the villagers of their direct use of wood and non- timber products from the forest and the ecological values of the mangrove area in terms of off-shore fishery linkages and coastline protection. These values of the mangrove forest were estimated to obtain the net benefits of protecting the mangrove area, which in turn were compared to the returns of the alternative use of the mangroves which was conversion to shrimp farming. Market Price Method was used to measure the direct use value of mangrove resources, which was assumed to be equivalent to the

net income generated from the forests in terms of various wood and nonfood products. If the extracted products were sold, market prices were used to calculate the net income generated (gross income is minus the cost of extraction). Based on a conservative estimate of village use rates, the aggregate annual value of the 400 ha of mangrove forest was estimated to be US $35,135, or approximately US$88 per ha.

In a study aimed at exploring the role of mangrove ecosystem in providing livelihoods, ecosystem services and the protective role against extreme weather events based on the experience of Tsunami in Panama Village in south Eastern Sri Lanka (IUCN, 2007), market price method was used in valuing direct use values (Shell Fish, fish, timber and poles, herbs and vegetables, fuel-wood etc.). The mangrove products collected from the mangrove ecosystem by the households and the related market prices were collected. Then the actual market values of each good were determined by multiplying the price by the quantity, there by generating the gross benefits. Based on the results using the market value method, the collective mangrove products represented a total gross value of US$ 1,171 per household per year for a household that collects mangrove products.

The Use and Management of Mangrove Ecosystems in Pakistan was conducted by Adhikari et al. (2010) in the Village of Damb spread over 200 acres. This analysis revealed that the minimum value per household per year was USD 179, while the maximum was USD 76,779. Further, the average net value per household per year in US Dollars was 5,699.9. Per hectare estimates were derived by first extrapolating the total sample net value per year to account for all the 366 households who were engaged at the village level in onsite exploitation of fishery products. The direct benefits in per hectare terms of the mangroves ecosystem in Miani Hor were

calculated to be USD 1,287, while the total value for the Village was calculated to be USD 4,419,935.

Kuenzer & Tuan (2013) conducted an assessment of the ecosystem services value of Can Gio Mangrove Biosphere Reserve in Vietnam through combining earth observation and household survey based analyses. A socio-economic household survey was performed in Can Gio district in November 2011, interviewing 289 households. The fish caught inside mangrove area (primary source) was valued at USD 14,780,000 per year for an area of 38,293ha, and the value of Marine fish catch culturally related to mangrove area (secondary source) was valued at USD 81.34 million per year for an area of 38,293 ha. Mangrove wood for construction wood and firewood was valued at USD 12, 727,623 per year for an area of 38,293ha.

Seenprachawong, (2002) estimated the total economic value of mangrove and coral reef ecosystems in Phang Nga Bay, Thailand. Both use and non-use values were calculated using the choice experiment method. The sample size for this research was 300 individuals. Random sampling was used to select the people who were living and travelling to Phang Nga Bay area. The total economic value was calculated to be US$ 5,784 million/year and the suggested entrance fee for locals and foreigners was $1.00 and $10.00 respectively (Akhter and Yew, 2013).

Garber-Yonts, Kerkvliet & Johnson (2004) used a choice experiment framework to study public values for biodiversity conservation policies in the Oregon Coast Range to estimate willingness to pay (WTP) for changes in levels of biodiversity protection under different conservation programs in the Oregon Coast Range. The attributes chosen were presented as conservation programmes which included: Salmon stream which involved protection and restoration of salmon habitat in coastal range stream; forest age management which focused on changing the

average age of the working forest of the Oregon Coast Range; Biodiversity reserves which focused on reserving land patches of land from most human uses in order to protect whole ecosystem and retain natural processes; endangered species which focused on protection of most severely threatened species. On average, respondents indicated an annual household WTP of $380 to increase old-growth forests from 5% to 35% of the age-class distribution, and the WTP for increasing conservation reserves peaks at $45 annually to double then current level to 20% of the landscape, whereas WTP was negative for any increase over 32%. The researchers also found resistance to any change in conservation policy, which substantially offset WTP for increases in all four conservation programs.

Birol et al. (2006) used Choice Experiment to account for preference heterogeneity in wetland attributes in Cheimaditida wetland in Greece. Significant wetland management attributes pertaining to the Cheimaditida wetland were identified in consultation with ecologists and hydrologists. The attributes that were considered included biodiversity, open water surface area, research and education, and re-training of local farmers in environmentally friendly employment such as eco-tourism, and the payment vehicle was a one off payment taxes for the year 2006-2007 to be channelled to a 'Cheimaditida Wetland Management Fund', which would be managed by a trustworthy and independent body. In the analysis of the results, the best-fit LCM, mean WTP for the *Low impact scenario* was €107.56, whereas greater improvements in ecological, social and economic conditions in the wetland under the *Medium impact scenario* increased mean WTP to €116.49, and under the *High impact scenario* to as high as €134.46

Christies and Matt (2012) used choice experiment to assess the economic value of ecosystem services delivered by Sites of Special Scientific Interest (SSSI) in their study on economic assessment of the ecosystem service benefits derived from the SSSI biodiversity conservation

policy in England and Wales. Seven ecosystem services attributes were examined, Nature's gift, research and education, climate regulation, water regulation, sense of experience, charismatic species, non-charismatic species and the payment vehicle was in form of taxes per year for a period of ten years. Choice experiment study was administered through a series of 10 deliberative evaluation workshops comprising total of 153 participants who were recruited from five locations across England and Wales. People were willing to pay an extra £2.49 for a 1% increase in the populations and ranges of Charismatic species, and an extra £1.70 for a 1% increase in Research and education benefits. Respondents were also willing to pay an extra £0.89 for 1000 more tonnes of CO_2 absorbed and £1.02 if 1000 more people became at risk of flooding.

2.5 Institutional Arrangements under Integrated River Basin Management

There are various definitions of what institutions are and consequently what institutional arrangements may mean. In his publication, 'The Varieties of Comparative Institutional Analysis', Cole (2013) notes that the term "institution" seems to have nearly as many definitions as definers. Sometimes, the term is defined only implicitly and some definitions are not compatible with others. Ostrom, the author of the common pool resource theory, defines institutional arrangements as sets of working rules that are used to determine who is eligible to make decisions in some arena, and what actions are allowed or constrained. Further, the rules describe what procedures must be followed, what information must or must not be provided and what payoffs will be assigned to affected individuals (Ostrom, 1990). Saleh and Dinar (1999) consider institutions to have three dimensions which are policy, law and administration. Ostrom definition however, excludes organisations from institutions (Cole, 2013). In this study of assessing the water resource management institutional arrangements, and investigating its suitability in implementation of an integrated river basin management as a way of harnessing the

economic values of mangroves, I have included organisations as part of institutions. Integrated River Basin Management (IRBM) is a subset of Integrated Water Resource Management (Mokhtar et al. 2011). Integrated Water Resource Management (IWRM) emerged around the 1980s in response to increasing pressures on water resources from competition amongst various users for a limited resource, the recognition of ecosystem requirements, pollution and the risk of declining water availability due to climate change. A central goal of IWRM at the river basin level is to achieve water security for all purposes, as well as manage risks while responding to, and mitigating disasters. The path towards water security requires resolving trade-offs to maintain a proper balance between meeting various sectors' needs, and establishing adaptable governance mechanisms to cope with evolving environmental, economic and social circumstances (Khan and Malano, 2009). Integrated River Basin Management has three main sectors which include water users such as agricultural sector, domestic water supply, industrial water sector, hydro power sector, sewerage (sanitation) and drainage sector; environmental sector; and flood management sector and an overall coordination (UNESCO, 2009).

Institutional arrangements in an integrated river basin management framework are necessary to enable; for the functioning of a platform for stakeholders involved in decision making, water resources management on hydrological boundaries, an organisational set-up in river basin and sub-basin authorities with their respective by-laws to incorporate decision making at the lowest appropriate level, a planning system oriented at the production of integrated river basin plans, the introduction of a system of water pricing and cost recovery (Jaspers, 2011). The key pillars that should be a feature of an institutional arrangement in an integrated river basin management are; stakeholder participation, decentralisation and subsidiarity, management on hydrological boundaries, institutional frameworks, and integrated planning system (ibid).

Some of the commonly known institutional arrangements that have been applied in common pool resources such as river basins, fisheries etc. have been documented by Imperial and Yandle (2005) and they include: (1) the ‘‘leviathan’’ or centralized bureaucratic arrangement based on government regulation; (2) market based arrangements; (3) community-based arrangements that rely on self-regulation by communities and user groups (Charles 1992) and (4) Co-management that has emerged as a fourth hybrid arrangement that relies on shared management between government agencies and user groups (Yandle, 2003).

Institutional analysis identifies institutional challenges through the processes of analysing design and performance of institutional arrangements which includes policy, rules, laws and organizations. These institutional arrangements form the governance structure of a river basin (Saleth and Dinar 2005; Mahktar et al, 211). There are various frameworks that have been used in institutional analysis studies. Institutional Analysis for Development Framework (IAD) which was formulated by Ostrom and her colleagues at Indiana University Workshop in Political Theory and Policy Analysis (Blomquist & Leon, 2011; Elinor Ostrom 1986; 1990; 1999. Ostrom et al. 1993; 1994; Kiser and Ostrom1982) is one such framework that is compatible with theories of public and common resource pools like river basins, and forest that has been widely used in institutional analysis (Ostrom, 2011). The IAD is a systematic method for organizing policy analysis activities. The researcher first defines a policy question or problem, and then focuses on behaviour in the action arena--which includes the action situation, and the individuals (or groups of individuals) who are routinely involved in the situation, who are referred to as "actors” (Ostrom, 2007; Poslki and Ostrom, 1999). One objective is to identify factors in each of the three prior areas that influence the behaviour of the actors: physical and material conditions, community attributes (e.g. cultural determinants), and rules-in-use. Two other "downstream"

objectives are to identify and then evaluate the patterns of interaction that emerge from the action arena and the outcomes from these interactions (ibid).

Institutions of Sustainability (IoS) by Hagedorn (2008) and Hagedorn, Arzt, and Peters (2002) is another framework said to have be inspired by IAD (Prager, 2010). It has been developed as an analytical framework for analysing institutions and governance structures that regularize interaction between ecological and social systems. It provides the function of a research heuristic which relates four key elements of institutional innovation and institutional performance in social-ecological systems (SES) to each other: transactions, actors, institutions and governance structures. According to the IoS-Framework, the properties of the respective transactions and the characteristics of the involved actors determine which institutions (sets of rules) develop and through which governance structures (organisational forms) these institutions will in practice be implemented (Hagedorn, 2014). However, whereas Prager (2010) sought to show how this analytical framework can be operationalised, action arenas unpacked and a methodology developed to carry out a systematic institutional analysis. He also acknowledges that scholars do not find the operational framework straight forward, particularly in relation to choices regarding the relevant transaction (s), the definition of action arena (s) and a suitable methodology (Prager, 2010).

Mokhtar, et al (2011) in their study of institutional challenges for integrated river basin management in Langat River Basin, Malaysia, applied Institutional Analysis Development Framework to define action arena, rules-in-use and action situation for IRBM in Langat River Basin. Thus, it disclosed factors affecting policy processes and outcomes of IRBM in the basin. For the empirical study to identify institutional challenges, 181 stakeholders were randomly selected from three different locations – upstream, middle stream and downstream of the Basin –

to be interviewed using a semi structured questionnaire and field observations were also carried out to cross check training sites for GIS-based land use map preparation, fragmented forest areas, wetlands, head water zones and interacted with the community members to conduct the stakeholder interviews. It also contributed to the field assessment of the policy outcomes in the basin. A total of three categories of action arenas were identified for the Basin i.e. interactions among the secondary stakeholders, interactions between primary stakeholders and secondary stakeholders, interactions among primary stakeholders. where primary stakeholders refer to stakeholders who enjoy products and services from the river basin but not formally engaged/employed with agency (ies) responsible for managing products and services of the river basin and its associated resources or (b) secondary stakeholders who might or might not be getting products and services but were formally engaged/employed with agency (ies) responsible for managing products and services of the river basin and its associated resources. The levels of rules-in-use and action situation were also defined from literature review and field observation. After defining action arenas, attributes of contextual factors were analysed i.e. biophysical setting, attributes of the community and the rules in use. The study revealed that polycentric institutional arrangements under the Federal administration are likely capable of coordinating and integrating river basin management by extending the scope of an iterative learning through participation of individual stakeholder at the lowest appropriate level.

2.6 Theoretical framework

To undertake the study, there were two theories that the research relied upon and these included the random utility theory to guide in economic valuation of the ecosystem goods and services,

and the common pool resource theory that guided the institutional analysis for integrated river basin management framework.

2.6.1. Random Utility Theory

Choice Experiment method that was used to value non- marketed direct use values and the indirect use values of the mangrove ecosystem services has its theoretical grounding in Lancastrian characteristics theory of value (Lancaster, 1966) and its econometric basis in the random utility theory (Luce, 1959; Mcfadden, 1973). The random utility theory assumes that the utility U that individual i gains from the consumption of a good j is made up of an observable deterministic component V (the utility function) and a random component ε.

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (1)$$

Lancaster proposed that consumers derive satisfaction not from the good per se, but from the attributes of the good. In case of an environmental good, this can be represented as;

$$V_{ij} = \alpha_{ij} + \beta(Bid_j) + \gamma X_j + \mu Z_i \qquad (2)$$

Where X represents environmental attributes and Z are respondents' characteristics. Bid represents the price attached to a certain choice of good j, while α, β, γ and μ are constants. The error component ε is independent of the deterministic part and follows a predetermined distribution. This implies that predictions cannot be made with certainty. The choice made among alternatives will be a function of the probability that the utility associated with a particular option is higher than that associated with other alternatives (Luce, 1959). To illustrate the basic model behind the choice modelling, specifically, the Choice Experiment (CE) presented

here, consider a respondent's choice of a mangrove forest management option. As illustrated by Hanley *et al*. (1998), assume that utility depends on choices made from some set, C of alternative mangrove forest management options. The representative individual is assumed to have a utility function of the form:

$$U_{ij} = V(X_j, Z_i) \qquad (3)$$

Where, for any individual$i$, a given level of utility will be associated with any alternative mangrove forest management option$j$. Alternative j will be chosen over some other option k *iff* $U_j > U_k$. Utility derived from any mangrove forest management option is assumed to depend on the attributes of the management option X_j (Lancaster, 1966). These attributes may be viewed differently by different agents, whose socioeconomic characteristics, Z_i will also affect utility. However, a consumer may not choose what seems to the analyst to be the preferred alternative. To explain such variations in choice, a random element, ε is included as a component of the consumer's utility function. Equation 3 can then be re-written as:

$$U_{ij} = V(X_j, Z_i) + \varepsilon(X_j, Z_i) \qquad (4)$$

and the probability that individual $i$will choose option j over other options k is given by:

$$Pr[i|C] = Pr[U_j > U_k], \quad \forall j \in C \qquad (5)$$

$$= Pr[(V_j + \varepsilon_j) > (V_k + \varepsilon_k)]$$

$$= Pr[(V_j - V_k) > \xi]$$

where C is the complete choice set. In order to estimate equation 5, assumptions must be made over the distributions of the error terms. A typical assumption is that the errors are Gumbel-

distributed and independently and identically distributed (McFadden, 1973). This leads to the use of multinomial logit (MNL) model to determine the probability of choosing j:

$$Pr[i|C] = \frac{\exp(\mu V_j)}{\sum_{j \epsilon C} \exp(\mu V_k)} \qquad (6)$$

Here, μ is a scale parameter, which is usually assumed to be equal to 1 (implying constant error variance). As μ tends to infinity, the model becomes deterministic. An important implication (Hanley *et al.*, 2001) of this specification is that selections from the choice set must obey the Independence from Irrelevant Alternatives (IIA) property (Luce, 1959). IIA, also known as the Luce's choice axiom, states that relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives.

Each respondent's multinomial responses that were obtained from the choice sets were interpreted as the choice results from the respondents' utility maximization problem. In this study, each respondent was given 4 choice sets and asked to choose among 3 alternatives including the status quo. The choice results for alternative j of respondent i was either 'yes' or 'no'. The log-likelihood function can be written as:

$$ln = \sum_{i=1}^{N} \sum_{j=1}^{3} \left[y_{ij} \, ln \, Pr[i|C] \right] \qquad (7)$$

Where y_{ij} is a binary variable (1 when respondent i chooses alternative j among 3 alternatives and 0 otherwise) and N is the total number of respondents. The parameters of this log-likelihood function are estimated by maximum likelihood estimation.

2.6.2. Common Pool Resource Theory

Common-pool resources are systems that generate finite quantities of resource units so that one person's use subtracts from the quantity of resource units available to others and efforts to exclude potential beneficiaries are costly (Ostrom, Gardner and Walker, 1994; Ostrom, 2002). The water system in a river basin can be characterized as one large common pool resource consisting of asymmetrically linked smaller common pool resources (van Oel, Krol and Hoekstra, 2007; Wagerich, 2002), such smaller common pool resources within a river basin include forests, wetlands, fisheries among others (Ratner, 2011; Mvula and Haller, 2009). The characteristics of the common pool resources can lead to different dilemmas. The first category of common pool resource problems is that of appropriation or demand. Demand dilemmas are related to the non-excludability characteristics of common pool resources because they typically result when too many users have un-limited access to a shared resource (Ostrom, Gardner and Walker, 1994). The second category of common pool resource dilemmas is that of provision or supply. Supply problems are related to the characteristics of common pool resources subtractability, which arise when common pool resource users do not maintain or conserve supplies adequately leading to less than optimal productivity levels of the resource.

Common Pool Resource theory (Ostrom 1990) suggests that individuals can overcome the dilemmas, and cooperate to protect a common pool resource, by designing and following rules that most closely suit the environmental and socio-economic needs of the common pool resource (Ostrom, 1990; Ostrom et al, 1993; 1994; Keohane and Ostrom, 1995; Wade, 1988a;1988b; 1992; Mearns, 1996a; 1996b; 1996c; Swift, 1994; Devereux, 1996). The theory of Common Pool Resources (CPR) helps researchers understand both why individuals engage in collective action arrangements to devise institutions to cope with CPR problems, as well as what types of rules

make such institutions successful (Ostrom, 1990). The theory is made up of ten (10) variables in two groups (the attributes of common pool resources which are supportive of cooperative behaviour and appropriators that support the emergence of cooperation) and eight (8) institutional arrangement design principles that are likely to make appropriators to commit themselves to monitor institutional arrangements across many generations (Schalger, 2004). The attributes of the common pool resources include (1) feasible improvement, (2) indicators, (3) predictability, and (4) spatial extent. And the attributes of the appropriators are (1) salience (2) common understanding, (3) low discount rate, (4) trust and reciprocity, (5) autonomy, and (6) prior organisational experience and local leadership (Ibid). The institutional arrangement design principles of the theory are shown in the Table 2.

Table 1: The institutional arrangement design principles of the Common Pool Resource Theory

Design Principle	Description
Clearly defined boundaries	Individuals or households who have rights to withdraw resource units from the common pool resource must be clearly defined as the boundaries of the common pool resource itself
Congruence	a. The distribution of benefits from appropriation rules is roughly proportionate to the costs imposed by provision rules. b. Appropriation rules restricting time, place, technology and/or quantity of resource units are related to local conditions.
Collective choice arrangements	Most individuals affected by the operational rules can participate in modifying them

Monitoring	Monitors who actively audit common pool resource conditions and appropriators behaviour, are accountable to the appropriators or are the appropriators
Use of graduated sanctions	Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offence) by other appropriators, by officials accountable to these appropriators, or by both.
Conflict resolution mechanism	Appropriators and their officials have rapid access to low cost local arenas to resolve conflicts among appropriators or between appropriators officials
Minimal recognition of rights to organise	The rights of users to devise their own institutions are not challenged by external governmental authorities
Nested enterprise	Appropriators, provision, monitoring, enforcement, conflict resolution, and governance activities, are organized in multiple layers of nested enterprise.

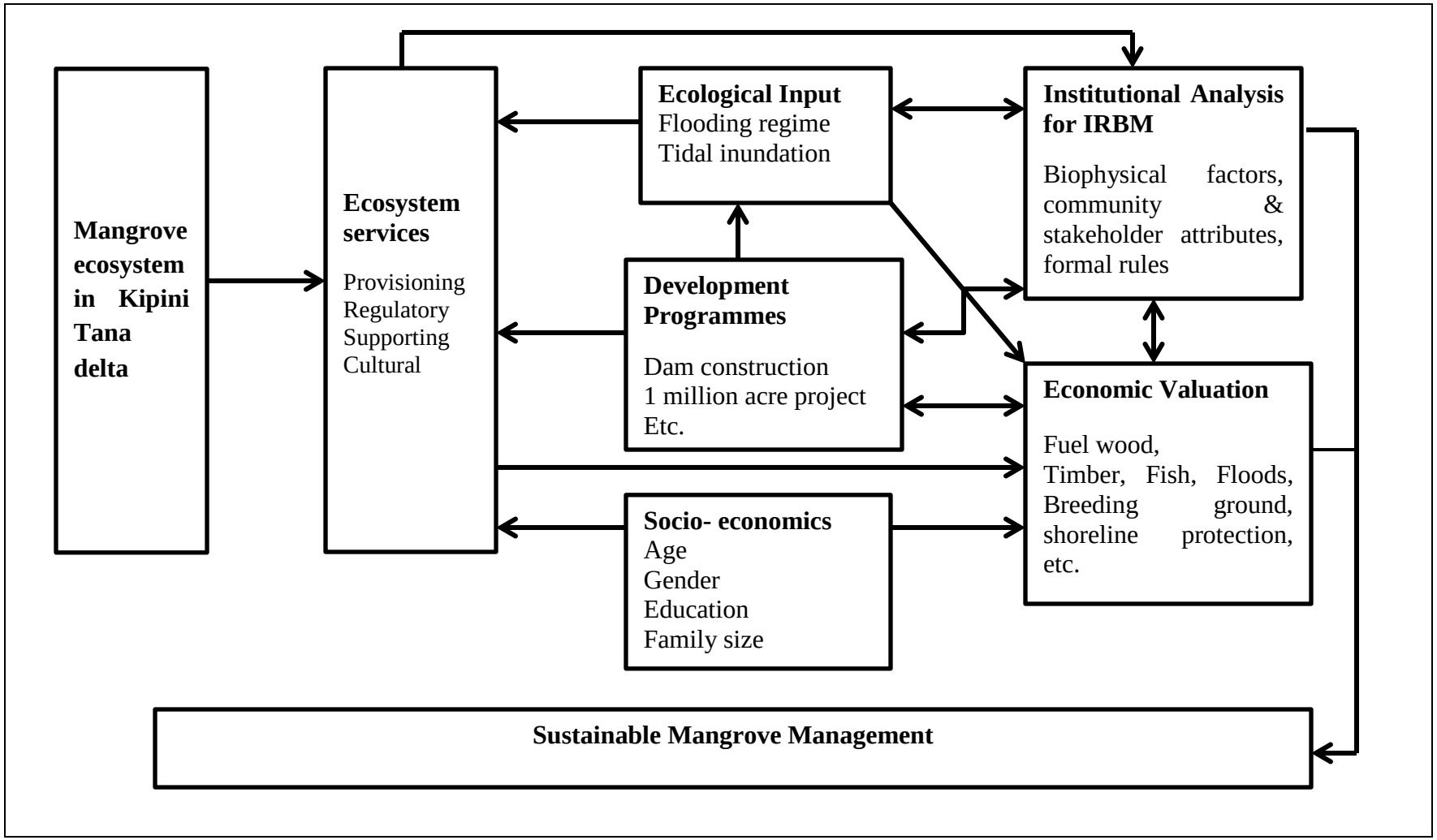
Source: adapted from: E. Ostrom, 1990: 90; Sanders, 2011; Schlager, 2004)

The attributes of common pool resources and appropriators should not be considered necessary or sufficient for appropriators to engage in collective action to create or change institutional arrangements. Rather the attributes should be thought of as conditions positively related to the emergence of collective action (Schalger, 2004). One framework that has much of its theoretical and empirical work under the rubrics of Common Resource Pool Theory and a key tool in analysis of institutional arrangements within the common pool resource realms is the Institutional Analysis for Development Framework (University of Colorado Denver, 2014).

The Tana River Basin has been earmarked for major development initiatives both upstream and downstream in the form of irrigation, dam construction, traditional livelihoods and

environmental conservation. The common pool resource dilemma is eminent particularly in maintenance of mangrove ecosystem flows due to flood mitigation. The Common Pool Resource Theory through Institutional Analysis Development Framework was used to investigate the suitability of the existing institutional arrangement to provide an integrated river basin management framework that can guarantee a win-win situation among all the stakeholders including mangrove dependent communities, the pro- environmentalism, irrigators, domestic and industrial water suppliers and consumers, hydropower generators among others.

2.7 Conceptual framework showing ecosystem values and institutional framework for sustainable management of mangroves



Source: Modified from Butler et al, 2003; Ostrom, 1995; GWP, 2013)

In the framework, the continued supply of the mangrove ecosystem goods and services depend on three factors: 1. the local community who directly interacts with mangroves and exploit it by harvesting the goods and also derive benefits from the services too. The local community would therefore have an impact on the perpetuity of the mangroves depending on whether they harvest its resources sustainably or overharvests it to exhaustion, or if they do not necessarily attach any value to the mangroves such that any measure or action that would replace the ecosystem would mean nothing to them or even be beneficial; 2. Given that mangroves depend on flooding to moderate salt levels, that is despite them being generally tolerant to saline environment, there are optimal salt levels beyond which their productivity would be compromised, it is therefore imperative that flooding at the delta is permitted at the required levels by this ecosystem. In the event that activities taking place upstream would not permit flooding then mangroves future would be compromised; 3. Who speaks for the mangroves? The ability of the mangroves to enjoy their needed ecological input and its harvesting is carried out sustainably would depend on the institutional arrangements that ensures that these two conditions are enforced. To achieve sustainable management of the mangroves through harnessing its ecosystem values, a framework which would ensure that all the competing needs for water, including needs of the mangroves, would be an integrated river basin management. The values of the mangroves were therefore assessed, and the ability of the existing institutional framework to deliver IRBM was investigated.

2.8 Chapter Summary

There is a large body of literature on the ecosystem goods and services that mangroves provide to communities and nations. However, these uses are many and varied and differ from one area to the other (Bandaranayake, 1998; de Lacerda, 2002), it is therefore imperative to assess the

particular goods and services that a given community derives from the mangrove ecosystem in their locality.

A review of the literature on valuation research on mangroves show that only five (5) studies have been conducted in East Africa (Tibor Vegh, et al, 2014.), and three in Kenya (Kairo et al., 2009; UNEP, 2011 and Mwangi, 2004), yet there are over ten (10) mangrove sites in the country. These studies however, did not employ choice experiment technique which has been regarded to be more superior to contingent valuation. The Tana delta mangroves in general, is not well studied and has not been valued. The significance of valuation is that it can lead to the understanding of the contribution that an ecosystem like the mangroves make to an area and the dependencies between the different ecosystem services arising from it and also the costs and benefits for different stakeholders from how an ecosystem is managed (Parliament, 2011), this is particularly important for the Tana delta which has attracted a lot of development interests Table 2 shows the various valuation approaches and methods that have been used in this study and the type of values that each method applies to best.

Table 2: Approaches and Methods for Economic Valuation of Ecosystem Values

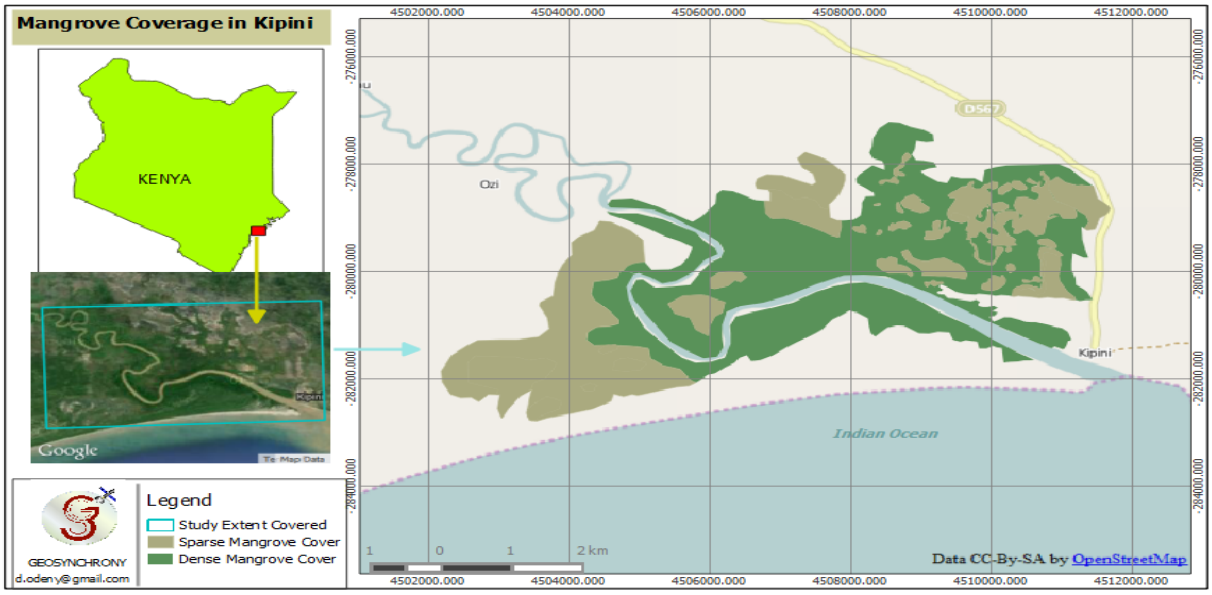
Approach	Method	Use	Example
Revealed preference	Market prices	Direct use	Food, timber, fuel wood
Stated preference valuation	Choice modelling-choice experiment	Indirect use	Nursery for fishery, tourism, shoreline protection, flood protection.

Kenya embraced the integrated water resource management through developing an integrated water management and efficiency plan in 2009. However, there has been no feedback or assessment on how the plan is being implemented or whether integration is actually working and the intended goals being actualised, this study therefore reviews the functions of water sector and related sector institutions and the enabling frameworks to assess if they are fit for purpose in providing integrated water resource management with special focus on Tana River Basin.

CHAPTER 3: STUDY METHODOLOGY

3.1.Study Area

The research was conducted in Tana River delta, with economic valuation component covering specifically mangrove habitats located within former Kipini division and institutional analysis extending to the entire delta. The formerly known as Kipini division which was the area of study focus has a population of over 19,635 people and households number of 3,743 (KNBS, 2009), and the main socio economic activities of the local people include; pastoralism, livestock keeping, farming, business, and fishing (ibid). The mangrove at the study site covers a total of 2350ha. There are nine species of mangroves found in the delta and these include; *Lumnitzera racemosa*, *Heriteria littoralis*, *Avicennia marina*, *Rhizophora mucronata*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, *Xylocarpus granatum*, *Sonneratia alba and Xylocarpus muluccensis* (Tana River Delta, 2004).



Map 1: GIS map showing status of mangrove forest

Tana River Delta is located in Tana River Delta sub-county and Lamu West Sub-county in Tana River County and Lamu County respectively and it is found between 02°30'S, 40°20'E. The delta measures 130,000 ha (Mireri, 2010). A study conducted in 1986, however, showed that it had a size of 3000 km^2 or 300,000 ha **(**Beck et al, 1986).

The biophysical factors relevant to water management could be broadly categorized into climatic, hydrological, topographic, soil, vegetation and environmental factors (Bekele et al, 2012).

Climatic conditions: The mean annual temperature of the delta is 30℃, ranging between 20.6°C and 38°C (Mireri,2010) and the Delta area along the Indian Ocean is normally hot and humid with little variations in temperature (Bucx et al, 2014). The annual rainfall in the delta is varied, with Kipini and Witu receiving an annual rainfall of above 1000 mm (Makenzi et al., 2013), Garsen receiving an average of 580mm, ranging between 500 and 700mm, and Tarasaa receiving between 600 to 800mm (Makenzi et al., 2013; MOA, 2012). The evaporation rates is relatively high at 150–210 mm month−1 (Bucx et al, 2014) and the average humidity is 85 (Mireri, 2010). The average annual wind speed in the delta is about 2.5 m/s and varies during the different months between from 1.7 m/s in December to 3.1 m/s in August.

Topography: The altitude of the Delta is in the range of 0–37 m above sea level with the vast majority of it comprising undulating plains, although other areas rise up to 140 m above sea level with the main hill being Minjila in Garsen (Mireri, 2010; NEMA, 2009). There are also a number of ox bow lakes in the Tana Delta namely: Lakes Vukoni, Pongi, Pacha, Lango La Shimba, Bilisa, Idsowe, Harakisa, Moa, Shakababo, Kongolola, Kitumbuini, and Dida Warede (Oyugi & Thieme, 2008).

Soil: Soils at the Tana River Delta are generally classified as Fluvisols being divided into two subgroups: eutric and vertic Fluvisols. The floodplain consists of chromic Vertisols, i.e. silt clay with no salinity or alkalinity. In the meander belt (*river levee land*) taking into consideration old and new river courses, the soils are yellowish – brown, often stratified, sand to clay rich in Micas (Mireri,2010).

Biodiversity: The delta is crowned by a wide variety of habitats, including riverine forest, grassland, woodland, bushland, lakes, mangroves, dunes, beaches, estuaries and coastal waters. Small fragments of riverine forest, not nearly as extensive as the forests north of Garsen, occur along the present or former river courses (Mireri, Onjala & Oguge, 2008). A total of 300 plant taxa have been recorded in the delta (BirdLife International, 2015). The delta has a rich diversity of animal species comprising more than 345 species of birds including the threatened Basra reed warbler and Tana River cisticola; other important biodiversity resources found in the Delta are: hippos, crocodile (Mireri, Onjala & Oguge, 2008)

Hydrology: The entire length of the Tana River is around 1000 km long (Okazawa et al, 2009). The river discharges on average, 4,000 million m^3 of freshwater and discharges sediments estimated at 3.1 to 6.8 3 x10^9 kg /yr (Mireri, 2010; Syvitski et al. 2005; Kitheka et al. 2005) and the delta is formed by the Tana and Ozi rivers and their numerous tributaries which range across the vast swamp plains (Samoilys, Osuk, & Maina, 2011). The input of water is almost exclusively from the river itself because of the net outward flow of water, except in situations where invasions of saltwater occur. The delta maintains high levels of productivity in a dynamic balance which revolves around the frequency, extent and duration of flooding (UNEP, 1998). Water circulation transports nutrients, influences a wide variety of habitat types, flushes away wastes, controls salinity and disperses and nurtures larval stages of a number of coastal

organisms (UNEP, 1998). The annual flooding of the Tana delta has experienced some disturbances in which the peak river discharge of the Tana before the construction of the dams was almost double that following construction (Pickaver & Sadacharan, 2007). The Mean monthly discharges for the December–March period are now 17–44% higher in the post-dam period than in the pre-dam period (Maingi & Marsh, 2002). Peak flow months of April–May and November–December have been affected differently by dam construction. May floods have seen declines of up to 22%, while November flows remained virtually unchanged (Maingi & Marsh, 2002).

Salinity: An assessment of salinity levels in Tana River by Mwatha in 2002 showed that it ranges from about 32 PSU (Practical Salinity Unit) at the mouth of the estuary to 0.6 PSU inside the estuary. The highest salinity of about 32 PSU occurred in the frontal region located between the mouth and the bridge. During high tide, the ocean water penetrated up to about 12 km into the estuary thus raising the salinity in the estuarine region to values between 25 and 35 PSU. Salinity in the Tana delta is an important part of the ecological resource for the Mangrove which was the focus of this research. Table 23 below shows levels of salt tolerance for some of the mangrove species found in the delta.

Table 3: Salinity level tolerance by mangrove species

Species	Optimal salinity for growth
Avicennia marina	Maximum pore water salinity of 85 ppt; Optimal growth occurs at a salinity of 0-30 ppt
Ceriops tagal	It can tolerate soil salinity up to 45 ppt but optimum salinity range is between 0 and 15 ppt
Bruguiera gymnorrhiza	It tolerates up to 50 ppt of soil salinity but optimal salinity range is reported to be between 8 and 26 ppt.
Rhizophora mucronata	species tolerates a maximum salinity of 40 ppt and a salinity of optimal growth of 8-33 ppt.
Lumnitzera racemosa	a maximum pore water salinity of 78 ppt**,** in experimental settings**,** germination rate decreases with increasing salinity and no germination will be seen if the salinity increases beyond 25 ppt.
Sonneratia alba	Grows in salinities ranging from freshwater to sea water with growth maximal in 5-50% sea water
Xylocarpus granatum, Xylocarpus molucensis	It tolerates a salinity of 0.1–3%.
Heriteria littoralis.	It grows well in the landward edge of mangroves where soil salinity is low

Sources: Roberts & Alongi, 1992; Selvam, 2007; Pessarakli, 1999; Jansen, 2005

The major communities living in Tana delta are the Pokomo, Orma, Wardei, Bajuni, Malakote, Somali, Munyoyaya, Mijikenda, and the Waata, others include; Luos, Kambas, Taitas, Giriamas, and Kikuyus (KNBS, 2009; Ng'weno, 2012), and the main socio-economic activities include farming, pastoralism, fishing, and hunting and gathering.

Farmers: The farming community in Tana delta are predominantly members of the Pokomo ethnic community. Others include the Mijikenda. Pokomos from Ngao to Oda villages are predominantly Christians while those further East are majorly Muslims (KNCHR, 2012). It is the cultural practice of the Pokomo who live along the Tana River that land is theirs (Andres, 2013), this puts them at loggerheads with Orma who also holds that water belong to them.

Pastoralists: The pastoral communities in the delta are the Orma, Wardei, and Somali ethnic Communities (Pickmeier, 2011)). Both Orma and Wardei are almost exclusively Muslims (KNCHR, 2012). In the interactions with their neighbours' the Orma have a long tradition of claiming the waters which they use to water their livestock (Andres, 2013).

Fisher folk: The fishing communities in the Tana delta are the Malakote, Bajuni and Luo ethnic Communities (EAWS, n.d). Fishing is mainly done in the ocean (Ungwana bays), the mangroves, along the Tana River and in the numerous lakes found in the delta.

Hunters and Gatherers: The Boni, and Wasanye ethnic communities are the traditional hunters and gatherers mainly in the delta and Boni forest (SIF, 2013). However, the delta and Boni forest are shrinking, with consequently less wildlife; moreover hunting became illegal and controlled by the Kenyan Wildlife Service. As hunting & gathering becomes an obsolete livelihood, they are trying to adopt other livelihoods such as farming and livestock keeping without much success so far (SIF, 2013).

3.2.Study Design and Sampling Procedures

The necessary data for this study was collected using Market Price Method and Choice Experiment Techniques and Content Analysis. For market price method, random sampling was used to collect prices of the forest products. The sampling unit was households within Kipini division which has 3743 households according to population census of 2009 and using the Slovins's formula;

$$n = \frac{N}{1 + Ne^2}$$

Where n = sample size, N= total number of households in the area (3743), and e = design margin of error (7 percent error assigned), a sample size of 200 households was identified.

The above framework assumes that there is a linear relationship between the area of wetland that contributes to a certain function and the use value delivered by that function. This is an approximation of, rather complex relationships, however, its validity will vary for different wetland functions.

In choice experiment, individuals are asked to choose their preferred alternative from several options in a choice set, and they are usually asked to respond to a sequence of such choices. Each alternative is described with a number of attributes or characteristics, where the levels of the attributes change from one alternative to the other. A monetary value is included, as are other significant attributes, when presenting each alternative. Thus, when individuals make their choices, they implicitly make trade-offs between the levels of the attributes in the different

alternatives presented in a choice set (Alpízar et al. 2003). There are four steps involved in the design of a choice experiment: (i) definition of attributes, attribute levels and customisation, (ii) experimental design, (iii) experimental context and questionnaire development and (iv) choice of sample and sampling strategy (Martinsson et al., 2001).

3.2.1. Definition of Attributes and their levels for Choice Experiment

The attributes identified in the study included; shoreline protection, storm protection, nursery and breeding ground for fish, ground water recharge, flood control, tourism and recreation, cultural values, and the payment vehicle was volunteer time (instead of real money because of the high poverty levels among the study population that could have made liquid cash a put off) for mangrove conservation. The attributes were, however, reduced to four i.e. nursery and breeding ground for fish, shoreline protection, flood control and tourism and recreation after consultation with practitioners and a cross-section of the community resident at the study site. Three levels of attributes were chosen, with the business as usual levels arrived at through review of data on the attributes and consultations with community population, two management options A and B are proposed within the ecosystem and predicted impacts the upstream development will likely have on the future productivity of the mangroves. The levels therefore included ‘high’ and ‘moderate’ for increased returns from mangroves services. The monetary attribute level was based on the volunteer time (being from useful time that they use for gainful activity) that community members were willing to offer for conservation of mangroves to ensure the flow of the services.

Table 4: Attributes and their assigned levels

Attributes	Description	Levels assigned	
			Business as usual
Nursery and breeding ground for fish	Total number of catches both in the River and nearby ocean waters of fish that breed in the mangroves	6000T, 4000T	2000T
Tourism and Recreation	Numbers of tourists visiting the delta for bird, crocodile and hippo watching among others	600, 400 tourists	200 tourists
Shoreline protection	Extent of damaged coastline/ avoided coastline erosion	1 metre width of coastline loss, 5metres of width of coastline loss	15 metres width of coastline loss
Flood control	Frequency of settlements being flooded and the attendant damages avoided	2 times in 10 years, 4 times in 10 years, 8 times in 10 years	Every year
Volunteer time for conservation	Cost to respondents in terms of Labour that they will provide towards restoration and sustainable use of mangroves	3hrs/month, 5hrs/month, 10hrs/month, 15hrs/month 20hrs/month, 30hrs/month	1hr/month

3.2.2. Experimental design for Choice Experiment

Experimental design refers to the process of generating specific combinations of attributes and levels that respondents evaluate in choice questions (Carías Vega & Alpízar, 2011). In choice experiments, design techniques used for linear models were popular in the past. Orthogonality in particular has often been used as the main component of an efficient design. More recently, researchers have developed design techniques based on D-optimal criteria for nonlinear models in a choice experiment context (ibid). Huber and Zwerina (1996) identified four principles for an efficient design of a choice experiment based on a nonlinear model: 1) orthogonality, where attribute levels within each choice set are not correlated; 2) level balance, where attribute levels occur the same number of times within a choice set; 3) minimal overlap, where attribute levels are not repeated within a choice set; and 4) utility balance, where each alternative within a choice set has approximately the same utility (Carías Vega & Alpízar, 2011). There are a number of conjoint analysis softwares that can be used to generate efficient designs, including SAS, SPSS and Sawtooth (Ryan et al, 2012). In this study, sawtooth software was used to generate efficient cards.

3.2.3. Experimental Context and Questionnaire Development for Choice Experiment

The components of the questionnaire included knowledge about the mangroves, the benefits derived from the mangrove ecosystem services, the choice sets for the choice experiment which also had pictograms to aid in presentation of the attributes; the pictograms were fish, tourists, clock, flooded huts, eroded shorelines all of which were altered to show the different levels. Two pre-tests were conducted in which the first did not have pictograms while the second pre-test had

them; analysis showed that cognitive ability of the respondents was greatly enhanced by the use of pictograms. Also, a contingent valuation question section was included in the questionnaire; the choice set exercise was preceded by an explanatory text to introduce the respondents to the task. The questionnaire was closed by demographic and socioeconomic characteristic questions. In some cases, the demographic questions appear in the initial stages of a questionnaire, however, it was deemed important that questions that sought personal information such as demographic questions, be avoided until the confidence of the respondents are fully won, this explains why such information was collected last, respondents' names were not recorded to ensure that data collection remained faithful to its anonymous nature. Initially, the highest volunteer time was 15 hours in a month, however, pretesting showed that respondents appeared not to have taken volunteer time seriously, and this payment vehicle was revised upward to include 20, and 30 hours in a month.

3.2.4. Choice of sample and sampling strategy

Five sub-locations namely Kipini, Matangeni, Kau, Kilelengwani, Ozi and Mpeketoni were chosen as sample locations given that they are the areas that border the mangrove forest and thus the residents have direct access to and benefit from the mangroves. Households were the sampling unit. Simple random sampling was used, and the formula provided by Louviere et al. (2000) aided in calculation of the minimum sample size. According to the formula, the size of the sample, *n*, is determined by the desired level of accuracy. In order to estimate the true proportion within *a* per cent of the true value *p* with probability α or greater, then the required minimum sample size must satisfy the requirement that $Prob(\mid p_n - p \mid \geq ap) \geq \alpha$. Given this, the minimum sample size is defined as:

$$n \geq \frac{1-p}{rpa^2}\, \Phi^{-1}\left(\frac{1+\alpha}{2}\right)$$

where $\Phi^{-1}(.)$ is the inverse cumulative normal distribution function. Note that *n* refers to the size of the sample and not the number of observations. Since each individual makes *r* succession of choices in a choice experiment, the number of observations is much larger. The formula above is only valid for a simple random sample and with independency between the choices.

With p set at 0.25, r set at 6, $\propto$ was set at 95%, and a set at 5% he sample size that was obtained was 405. The recommended standard sample size of practice in stated preference studies like choice experiment is 400.

3.3.Primary Data Collection

To collect data for Market Price analysis survey, a questionnaire was developed and the ecosystem goods whose data were collected included firewood, charcoal, timber, poles for fencing, building huts, boat traps, and boat construction, Tannins and dyes, medicinal values, fodder, furniture, honey, and fish. Prior to actual data collection, focus group discussion (FGD) was held to determine the actual products that the community draws from the forest; this was then flowed by pretesting to determine the effectiveness of the questionnaire. During the actual data survey though, little information was collected on the use of the mangrove forest for charcoal burning and furniture making. Choice experiment was used to collect data on the following attributes: volunteer community time for mangrove conservation as the payment vehicle, nursery and breeding ground for fish, Tourism and recreation, shoreline protection, and flood control. The choice experiment design generated a total of 48 cards, and each respondent was required to answer six (6) choice sets (cards), which is the recommended standard practice in choice experiment that does not cause fatigue to respondents (Bateman et al 2002), this led to

creation of eight (8) sub samples resulting into around fifty (50) questionnaires per sub sample, which were administered according to the population in each sub location (table 4) and strategic significance in relation to the identified mangrove ecosystem services.

Table 4: Number of Questionnaires Administered

Sub-location	Number of questionnaires
Kipini	117
Matangeni	99
Ozi	71
Mpeketoni	73
Kau	45
Total	**405**

Experienced enumerators with knowledge of the area were recruited and trained together, and each one of them was personally guided by the researcher during a mock exercise in Kipini before pretesting, this was not only aimed at making sure that they understood the assignment but also minimise cases where data collected may vary according to enumerators. Stratified simple random sampling was employed in which the number of households to be interviewed was selected based on the population per sub location, proximity to the mangroves, and the potential to receive particular flows of certain mangrove ecosystem services over other locations for instance, residents of Ozi are more likely to be affected by flooding more than other locations. The extent of data collection was within the five kilometre radius of the mangrove forest, data was then collected using random sampling in which enumerators were required to conduct interviews in every tenth household except in Ozi location where they carried interviews after every third household, this was to ensure fidelity to probability sampling where every household in the area stood as a chance of being selected to participate in the survey.

3.4.Secondary Data

Data for institutional analysis was largely obtained from content analysis of various reports (research studies, government and development agencies reports, plans and strategies, sessional and policy papers, statute and subsidiary laws) on: the biophysical information of the Tana delta; communities and the various organisations with mandate on the management and utilisation of natural resources in and affecting the delta; policies and legal instruments on water and other sectors that affect water resource; and the principles of integrated river basin management and integrated water resource management frameworks. In addition, secondary information was useful in literature review to identify the wealth of inform about the research subject, identification of gaps, uses of mangrove ecosystem goods and services, generation of the attributes levels, data on population, and the exchange rate among others, and for comparative analysis to help explain the findings of the study. Such sources were obtained from official government publications such as census reports, consultancy reports and other reports from various development agencies.

3.5. Data Analysis

Descriptive statistics was used to summarise and describe the primary data collected from the household survey through graphs, tables and discussion of the results using Stata 11 and excel 2010. Analytical statistics were also used to identify relationships between variables, and compare various variables, such as: a one-way ANOVA was conducted to determine if mean age was different for among the sub locations; an independent t test was also run to determine if there were differences in levels of education based on gender. The total direct use value of a wetland may be expressed as follows:

$$TDUV = \sum_{i=1}^{n} MV_i \text{ x } A_i$$

Where *i* denotes the wetland function,

TDUV: Total direct use value (US$/year),

MV: Marginal value of a product or a service derived from a wetland function (US$/Ha/year),

A: Area of the wetland that contributes to the wetland function under consideration (ha).

The total indirect use value was obtained by estimation of the probability that an individual will choose improvement in a certain mangrove ecosystem service, and was conducted using Multinomial Logit Model (MNL). The variable definitions and their coding are provided in shown in table 5 and all coefficients were statistically significant at 1% level.

Table 5: Definitions and coding of variables for choice experiment results

Nursery fish	Attribute, fish per 1,000 ton
Tourists	Attribute, number of tourist per 100
Shoreline erosion	Attribute, width of eroded shoreline in meter
Flood probability	Attribute, flood probability in a probability metric
Volunteer time	Attribute, volunteer community time in hour per month
Membership	Dummy variable, 1=member of….., 0=otherwise
Distance mangrove	Continuous variable of distance of the respondent's village to the nearest mangrove in km
Age	Continuous variable of age in years
Number of children	Continuous variable of the number of children in a household

3.6.Ethical Considerations

During the interviews, respondents were assured of their individual privacy and confidentiality through use of aggregate results only, and the study being conducted in anonymity, in which case the respondents were not required to give their contacts or names. In addition, they were

informed that the research was for academic purposes only, and that there were no personal benefits or risks involved. They were also informed that they reserved the right to terminate the interview at any stage should need to do so arise. Furthermore, their consent was always being sought before commencement of interviews. The research was designed to be as objective as possible and respondents were allowed to make informed choices without any influence.

CHAPTER 4: RESULTS

4.1. Household, Socio-Economic and Demographic Characteristics

This section considers the following socio- economic and demographic characteristics: age, gender and household sizes; education levels; membership to environmental and social groups; main sources of income; and income levels. In the survey female comprised 127 respondents, whereas the male were 277, thus female constitute a third of the respondents.

4.1.1. Age, Gender and Household Size

Among the respondents interviewed, 68% were male while 32% were female. The average household size was seven (7) of three (3) adults (above 18 years) and four (4) children (below 18 years). The mean age of the respondents was around 39 years and was similar in the different sub-locations (*F = 1.40, p= 0.2347).*

Table 6: Mean ages of respondents by sub location

	Name of sub location					
	Kipini	**Matangeni**	**Ozi**	**Mpeketoni**	**Kau**	**Total**
Mean	**40.41**	**39.11**	**40.04**	**36.01**	**37.82**	**38.94**
Standard deviation	11.64	10.21	16.77	11.63	13.49	12.7
Minimum	19	20	19	19	18	18
Maximum	75	65	78	70	70	78

4.1.2. Education levels

Most (58%) respondents had primary school level education, 22% had secondary, 5 % post-secondary and 15% had no formal education. Results showed that women had statistically

significantly low levels of education (5.93± 3.93 years in education) compared to men (7.15 ± 3.87 years in education), (t = 2.940, $p = 0.003$).

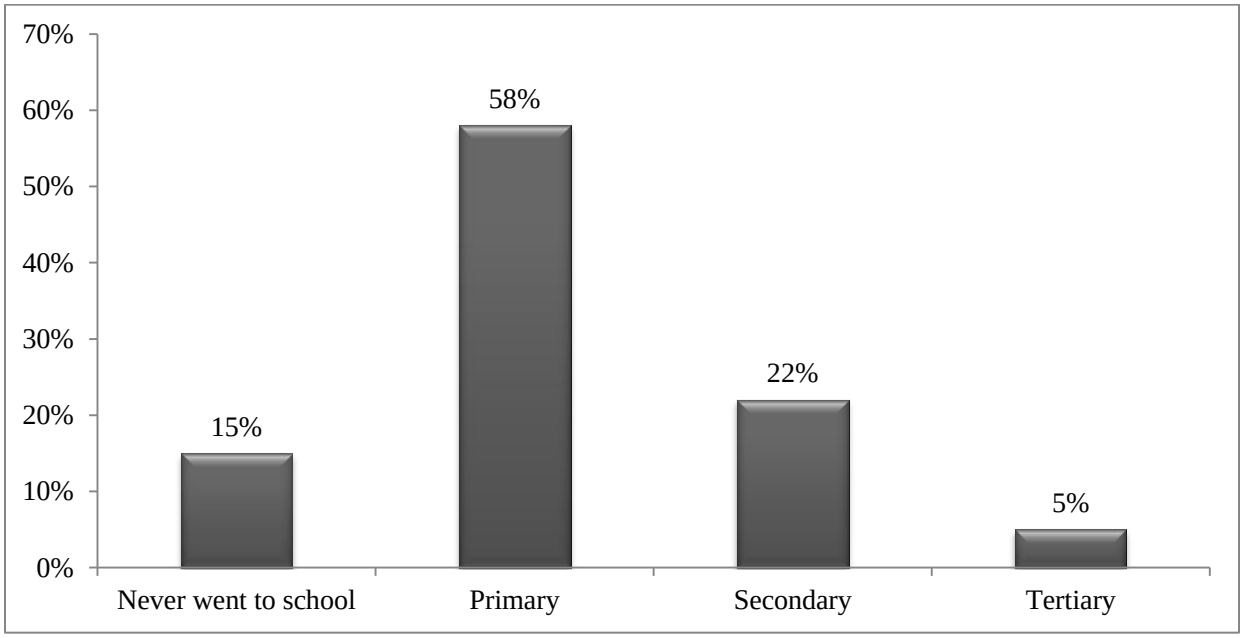


Figure 2 : Percent levels of education of respondents

4.1.3. Membership to environmental or social group

Respondents were asked if they belonged to a social or an environmental group and 25% reported not to belong any group. Majority of the respondents who reported to belong to any group were members of environmental groups (30%), followed by those belonging to the fishing industry 14%. Respondents did not necessarily belong to one group only though.

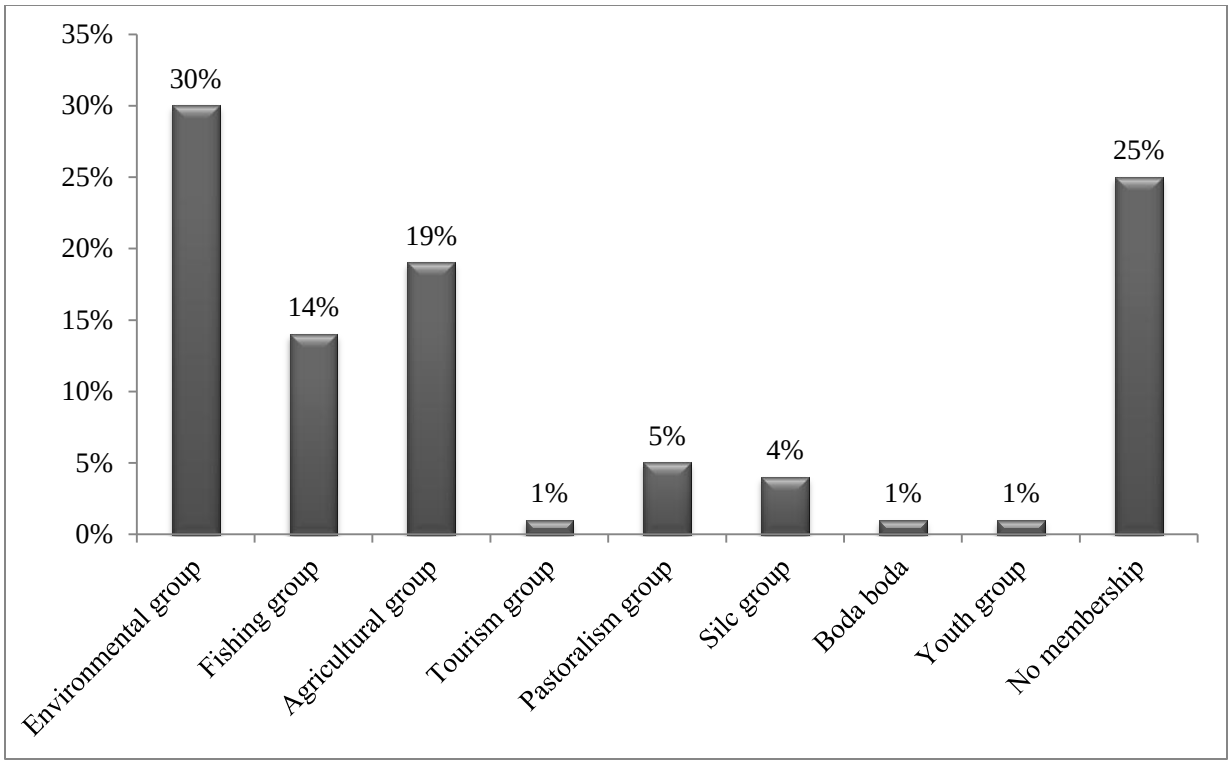


Figure 3: Percent respondents' membership to groups

Membership to groups appeared to be characteristic of specific sub locations and also along major occupations of the respondents. For instance, majority of those who belonged to fisheries were found in Kipini and Ozi (21% each) and environmental groups were mostly found in Mpeketoni (54%), Kipini (37%), and Ozi (34%), while those belonging to agricultural groups were mostly found in Matangeni (30%) and Kau (32%) sub locations..

Table 7: Membership to groups by sub location

Membership to environmental or social group	Name of sub location					Total
	Kipini	Matangeni	Ozi	Mpeketoni	Kau	
Environmental group	37%	10%	34%	54%	7%	20%
Fishing group	21%	5%	21%	10%	12%	14%
Tourism group	1%			2%		1%
pastoralists group	4%	6%		1%	16%	5%
Agriculture group	14%	30%	14%	8%	32%	19%
Silc (lending) group	1%	17%				4%
Bodaboda group		3%				1%
Youth group	1%	2%				1%
No membership	21%	27%	31%	25%	33%	25%
Total	100%	100%	100%	100%	100%	100%

4.1.4. Main source of income

The main sources of income in the three locations of Kipini division were crop farming (58%) and fishing (16%). Other sources of income included pastoralism, businesses, and salaries through formal employment, wages, and *boda boda*[1] operations.

[1] Taxy business conducted using motorcycles

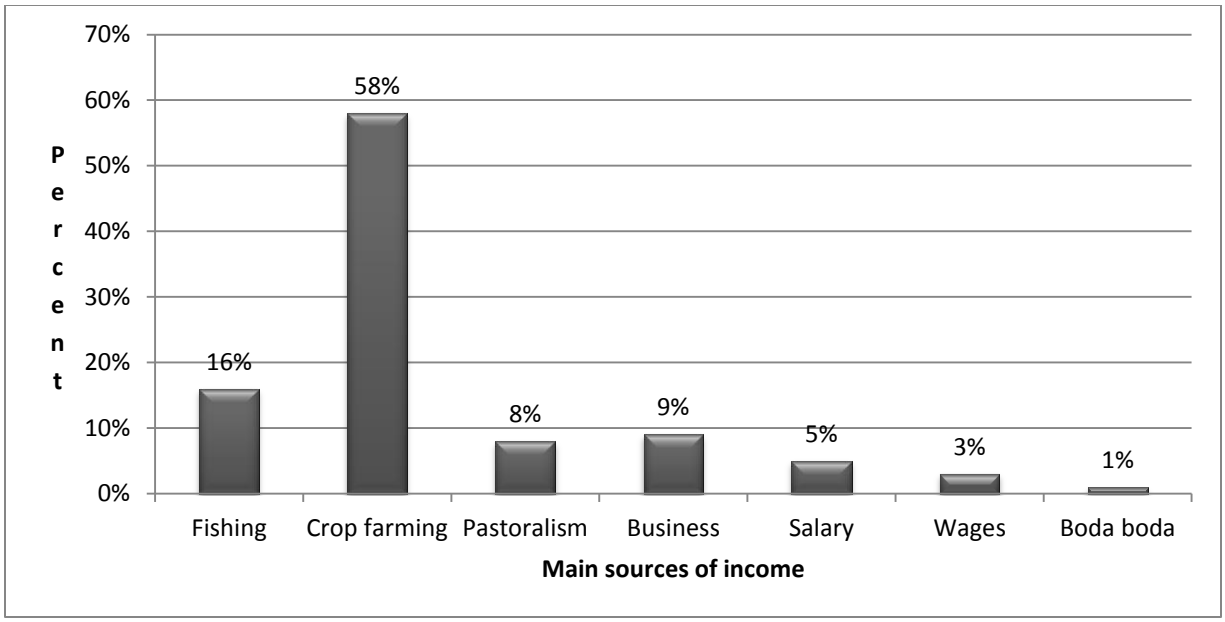


Figure 4: Percent respondents by main source of income

There were, however, some differences on the main sources of income by sub locations, for example in Kipini sub location; it was fishing which was the main source of income.

Table 8: Main source of income by sub location

Main source of income	**Name of sub location**					**Total**
	Kipini	Matangeni	Ozi	Mpeketoni	Kau	
Fishing	34%	7%	14%	8%	2%	16%
Crop farming	19%	58%	86%	92%	60%	58%
Pastoralism	7%	13%			22%	8%
Business	22%	10%			7%	9%
Salary	13%	5%				5%
Wages	4%	4%			4%	3%
Boda boda	1%	3%			5%	1%
Total	100%	100%	100%	100%	100%	100%

4.1.5. Income Levels

About 67% of the respondents earned a cumulative annual income of between 28,801 to 180,000 shillings. Those who earned less than Ksh. 28,800 per annum comprised 16% of the population.

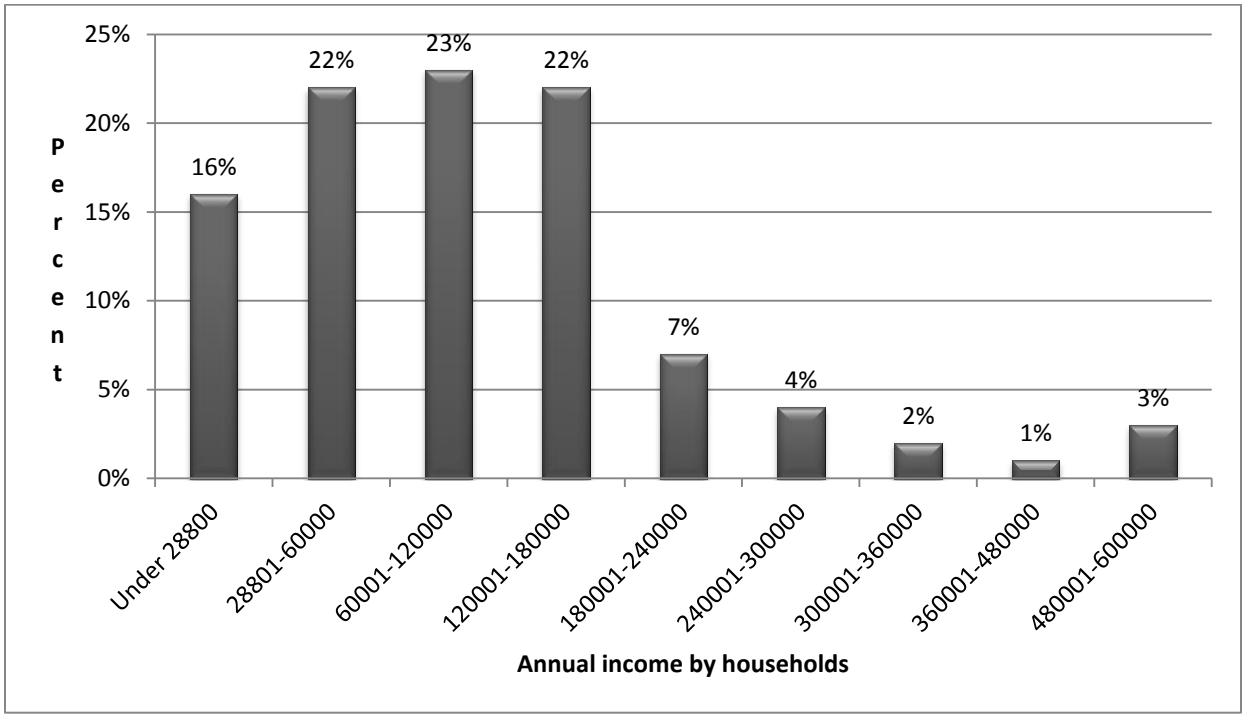


Figure 5: Percent household annual household income levels

Annual income levels/earnings by sub locations showed that in Kipini, people who earned less than Kshs. 28,800 per annum were 3% of the population; in Matangeni they comprised 4% while in Ozi they constituted 31% of the population. In Mpeketoni the respondents under this category constituted 36% while in Kau they constituted 16%.

Table 9: Annual household income levels by sub location

Annual income by sub location	Name of sub location					Total
	Kipini	Matangeni	Ozi	Mpeketoni	Kau	
under 28800	3%	4%	31%	36%	16%	16%
28801-60000	8%	33%	24%	31%	18%	22%
60001-120000	26%	19%	20%	22%	27%	23%
120001-180000	29%	24%	14%	8%	33%	22%
180001-240000	7%	13%	10%		4%	7%
240001-300000	10%	2%	1%	3%	2%	4%
300001-360000	8%	1%				2%
360001-480000	2%	1%				1%
480001-600000	7%	3%				3%
Total	100%	100%	100%	100%	100%	100%

4.2.Ecosystem Goods and Services Provided by Mangroves in Kipini

4.2.1. Mangrove Ecosystem Goods

The ecosystem goods provided respresent direct use values (DUV) of the mangroves and include: biomass fuel (firewood); poles for fencing, poles for building houses, poles for boat traps and boat construction; dyes; medicinal herbs; fodder; honey; and fish. Respondents were presented with a list of twelve (12) mangrove ecosystem products and were asked if they visited the forest to harvest the products for subsistence or for sale, buy and sell the products or were just consumers who bought from those who harvested the products. Among those who were considered as producers by virture that they harvested the products, 47% said that they visited the forest to collect firewood, and another 42% said that they visited the forest to harvest fish. Non of the respondents mentioned that they ever used the forest products to make furniture. Figure 6 shows the products that the local community derive from the mangrove ecosystem.

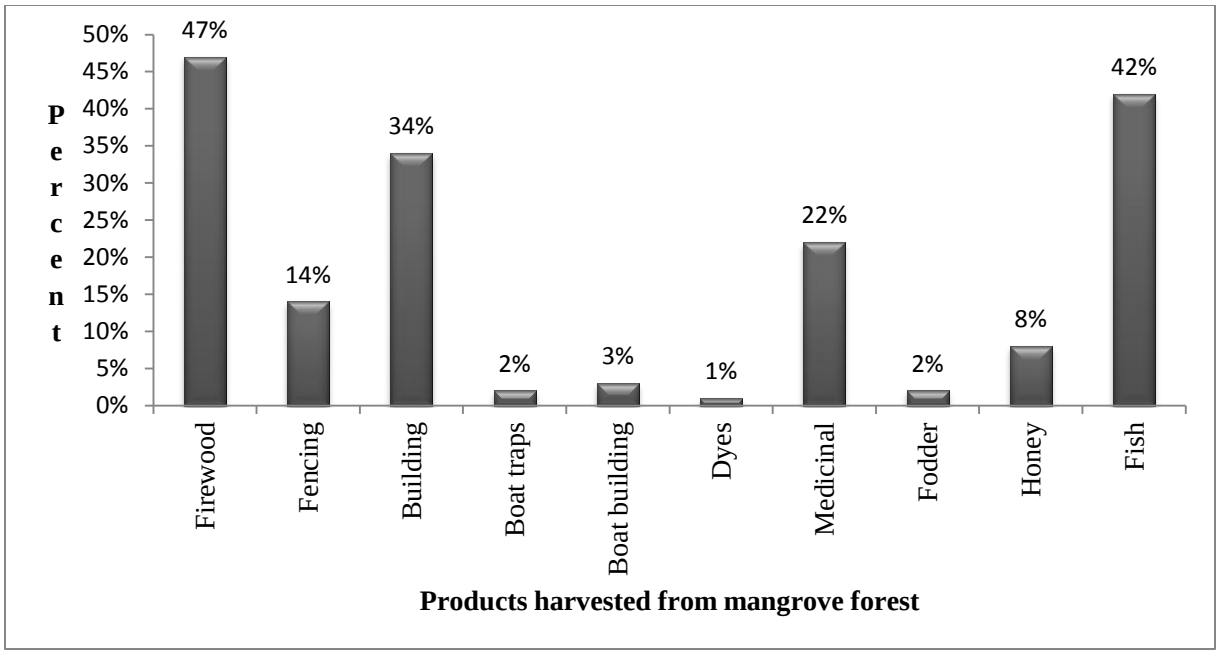


Figure 6: Products that are harvested/ made from the mangroves of the Tana Delta

Among the respondents identified as only consumers of already collected mangrove forest products; 30% used firewood collected from the mangrove forest, 53 % used fish harvested from the mangroves, 47% used building materials obtained from the mangroves, 27% used honey obtained from mangroves, and 20% used mangroves for herbal medicine.

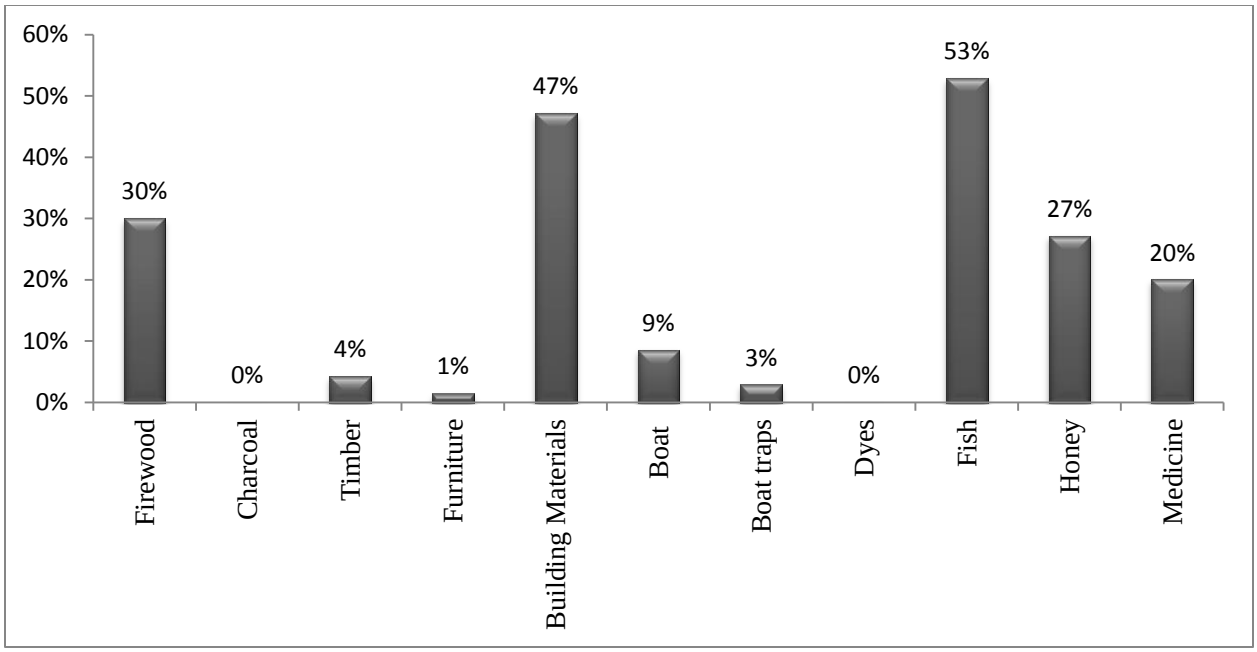


Figure 7: Proportion of consumers of the Mangrove Products

4.2.2. Mangrove Ecosystem Services

The services present indirect use values (IUV) of the mangorove and include provision of nursery and breeding ground for fish, shoreline protection, flood control and a source of tourism and recreational attraction.

Respondents were asked to grade (on a likert scale of 1 to 5) if they agreed that mangroves provided ecosystem services. The values in the Likert scale were represented as: 1-fully disagree, 2-disagee, 3-somewhat agree, 4-agree and, 5-fully agree.

Nursery and breeding ground services

Among the respondents interviewed, 87.65% agreed that mangroves provide nursery and breeding grounds for fish, and only 4.45 % of the respondents disagreed, with a further 7.9% somewhat agreeing that mangroves did actually provide the service. Some of the fish species that

were found to use mangroves as a breeding ground and nursery include: catfish; prawns such as Coctail, Jumbo, Tiger, Red sniper, Banana, Pilipili; Tilapia; and Mudfish.

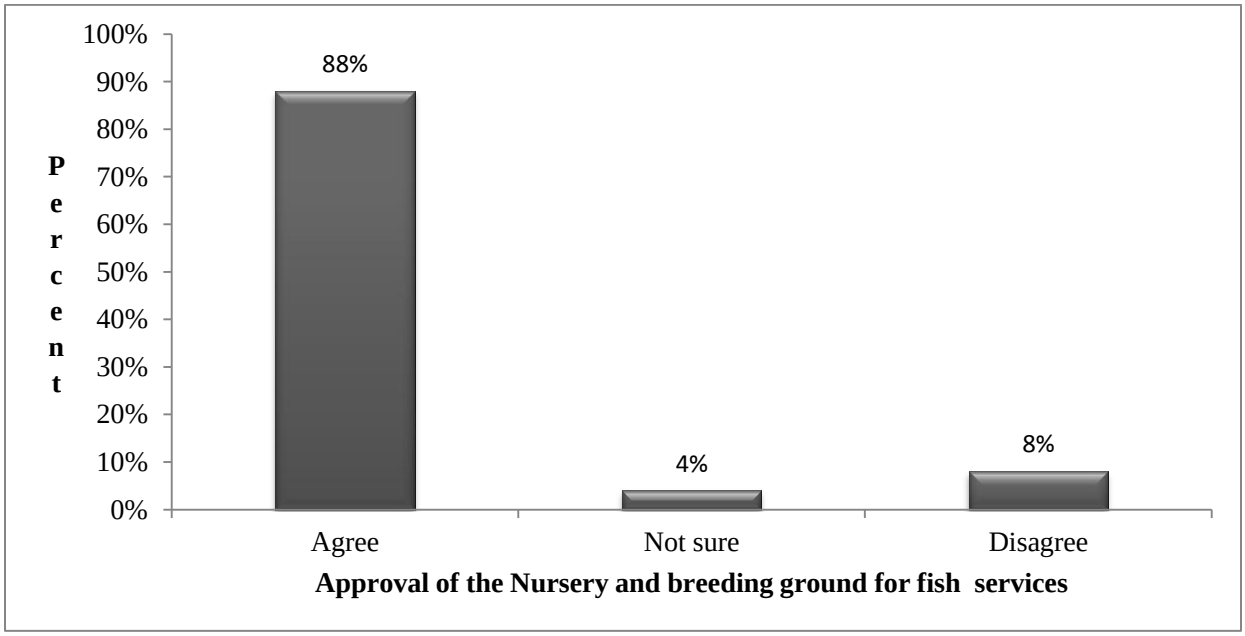


Figure 8: Proportion of respondents who approve nursery and breeding ground for fish services

Residents of Ozi sublocation had the greatest approval of mangroves acting as a nursery and breeding ground for fish, 80% fully agreed and only 3% disagreed that mangroves provide this service. Only Matangeni recorded less than one third (21%) of the respondents who fully agreed that mangroves provide nursery and breeding ground for fish. Overall, in all the villages 88% agreed that mangroves provide the service.

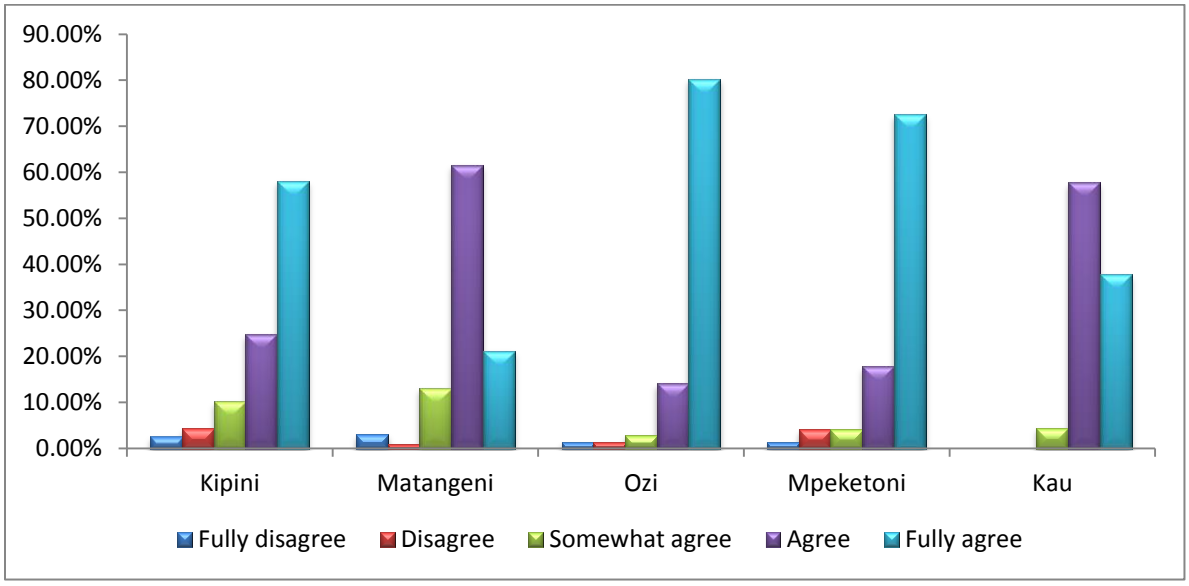


Figure 9: Percent respondents by sub location who agree that mangroves provide nursery and breeding ground for fish

Shoreline protection services

Asked whether they agreed that mangroves protected shoreline from erosion, 79% of the respondents affirmed, while 13% were not sure. Only 8% disagreed and disagreed, respectively.

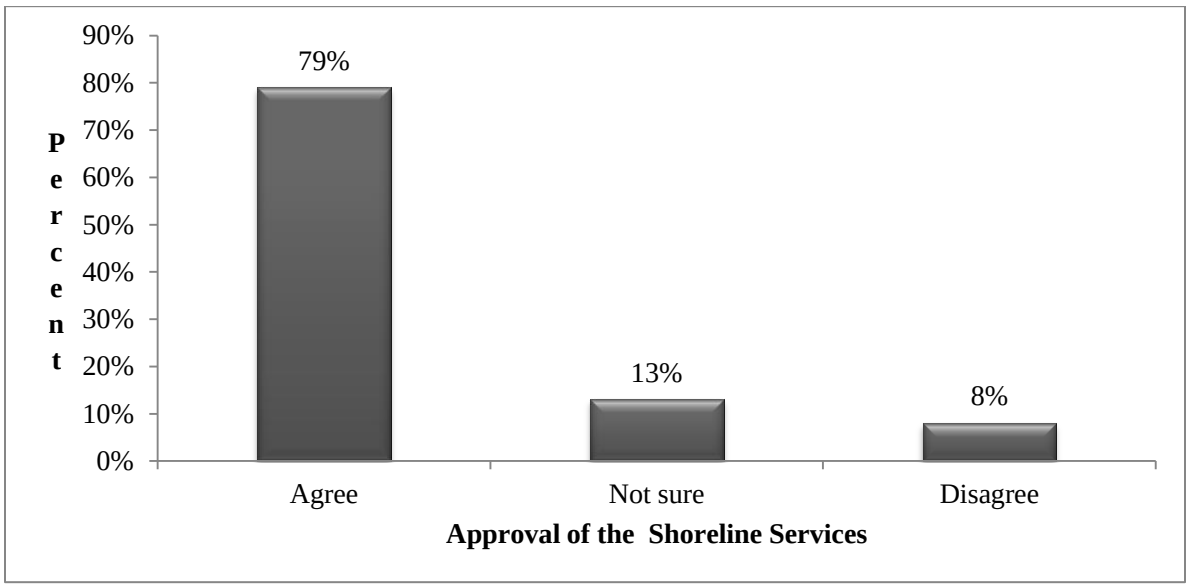


Figure 10: Percent respondents who agree that mangroves provide shoreline protection services

Respondents from Ozi had the strongest approval of mangroves offering shoreline protection, 82% of them fully agreed and a further 14% agreed, giving a total of 96% approval. The lowest approval was seen in Matangeni in which only 19% fully agreed and a further 43% agreed, thus giving a 63% approval.

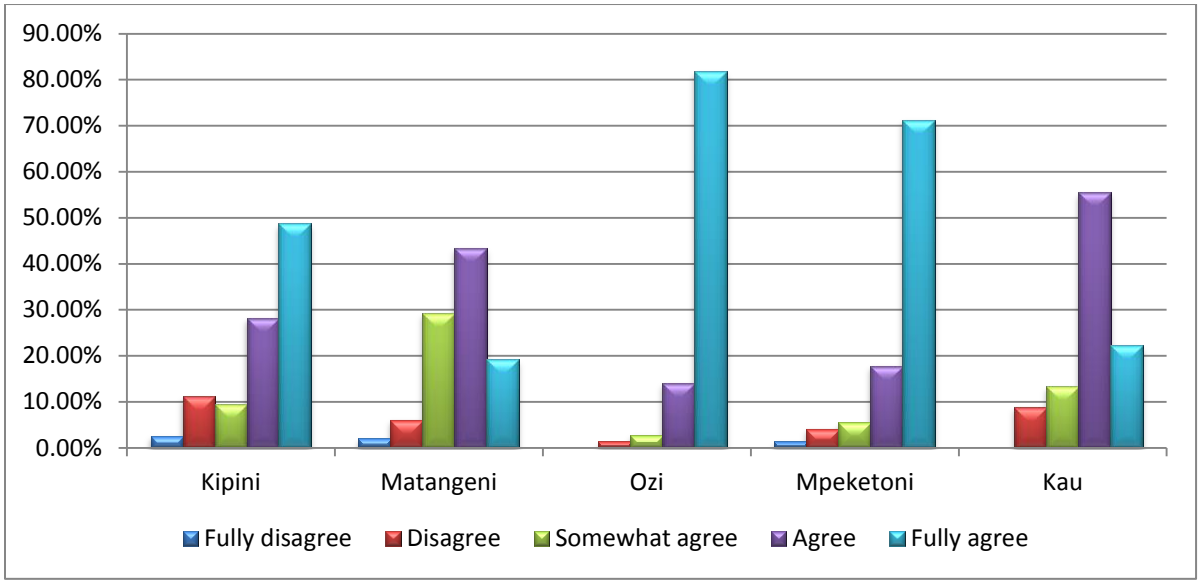


Figure 11: Percent of respondents by sub location who agree that mangroves provide shoreline protection services

Flood control services

For flood control services, 77% of the respondents gave an approval that in mangroves do offer flood regulation servicesfully, whereas 11% were not sure if indeed mangroves do offer such services, and 12% of the respondents disagreed.

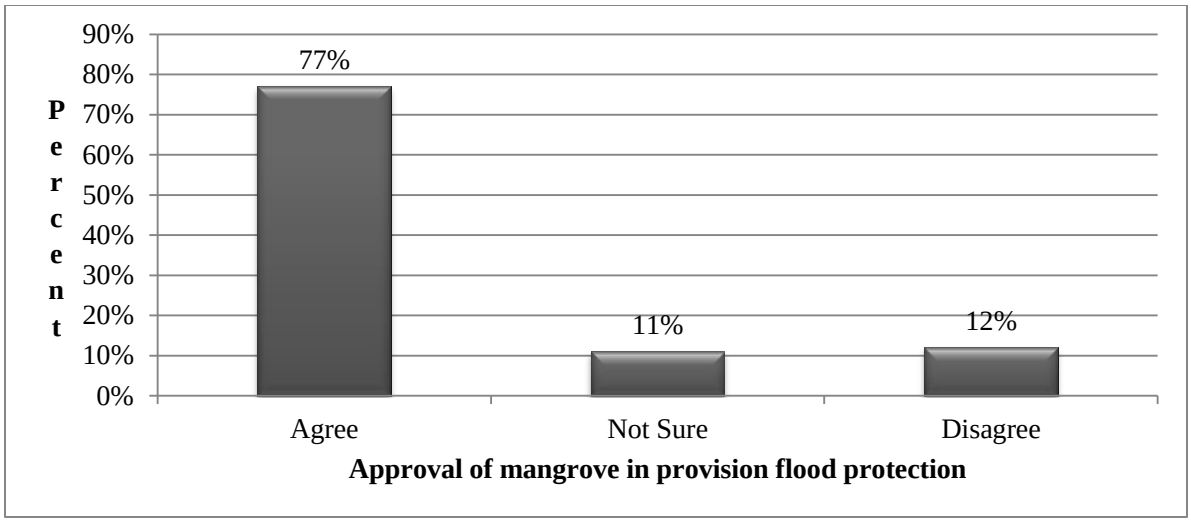


Figure 12: Percent respondents who agree that mangroves provide flood control services

Approval of flood control was highest in Ozi and Mpeketoni where 82% and 70% of the respondents respectively fully agreed that mangroves control flooding. The lowest approval was in Matangeni where only 20% fully agreed and and other 41% agreed.

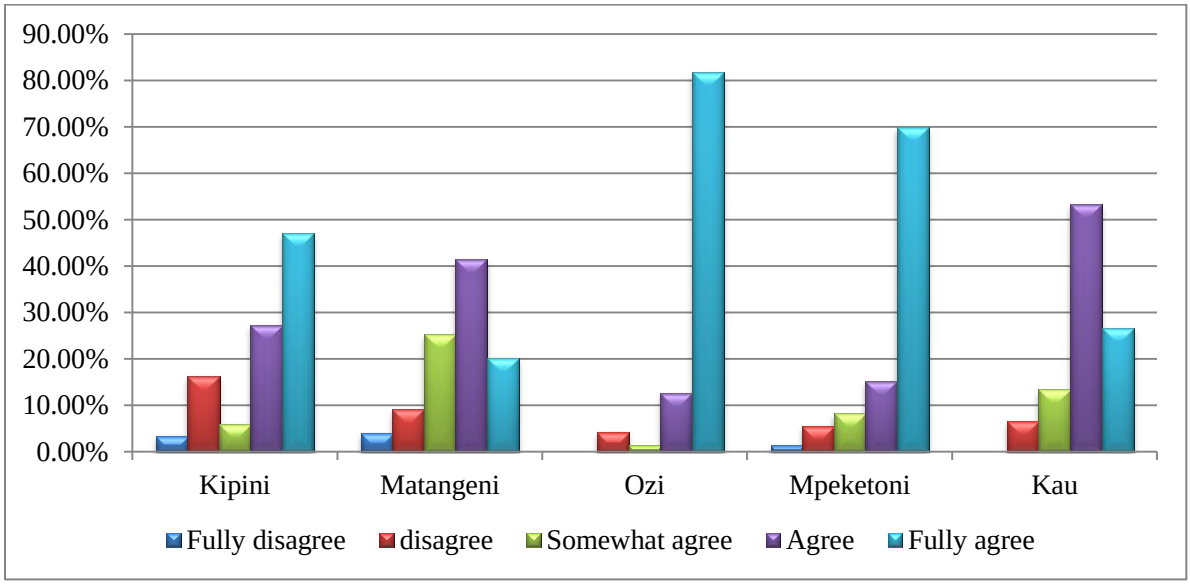


Figure 13: Percentage of respondents by sub location who agree that mangroves provide flood control services

Tourism and Recreation services

Respondents were asked to rank the mangrove services of tourism and recreation and 84% agreed that mangals do provide the service while 9% were not sure and 7% disagreed.

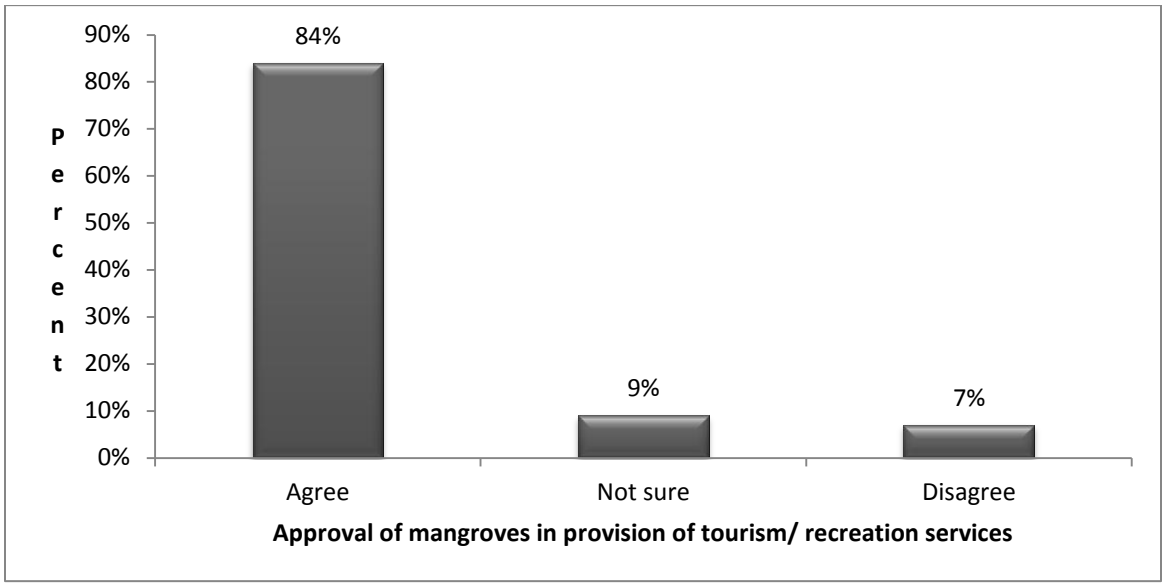


Figure 14: Percentage of respondents who agree that mangroves are sources of tourism and recreational attractions

Respondents from Ozi had the greatest concurrence that mangroves were a source of tourism and recreation, 82% fully agreed and 13% agreed. Respondents from Matangeni had the least number who fully agreed (26%) and 40% agreed.

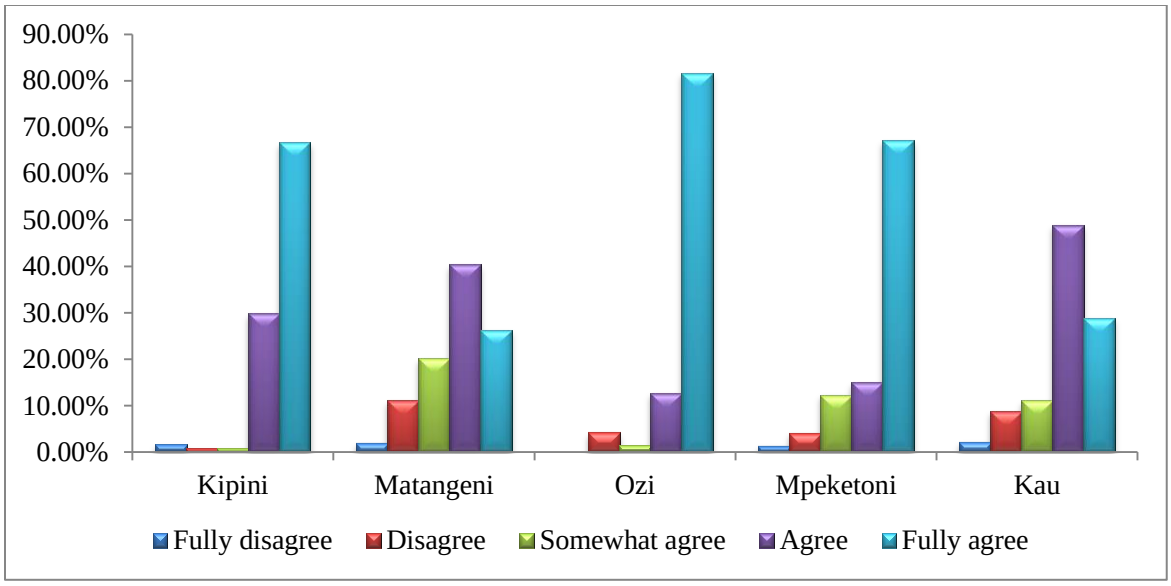


Figure 15: Percent of respondents by sub location who agree that mangroves provide tourism and recreational attractions

The Mangrove Degradation Status

On a scale of 1 to 4 respondents were asked to state the condition of the mangrove forest in terms of degradation and 52% said that the forest was in good state while 5% were of the view that it was heavily degraded.

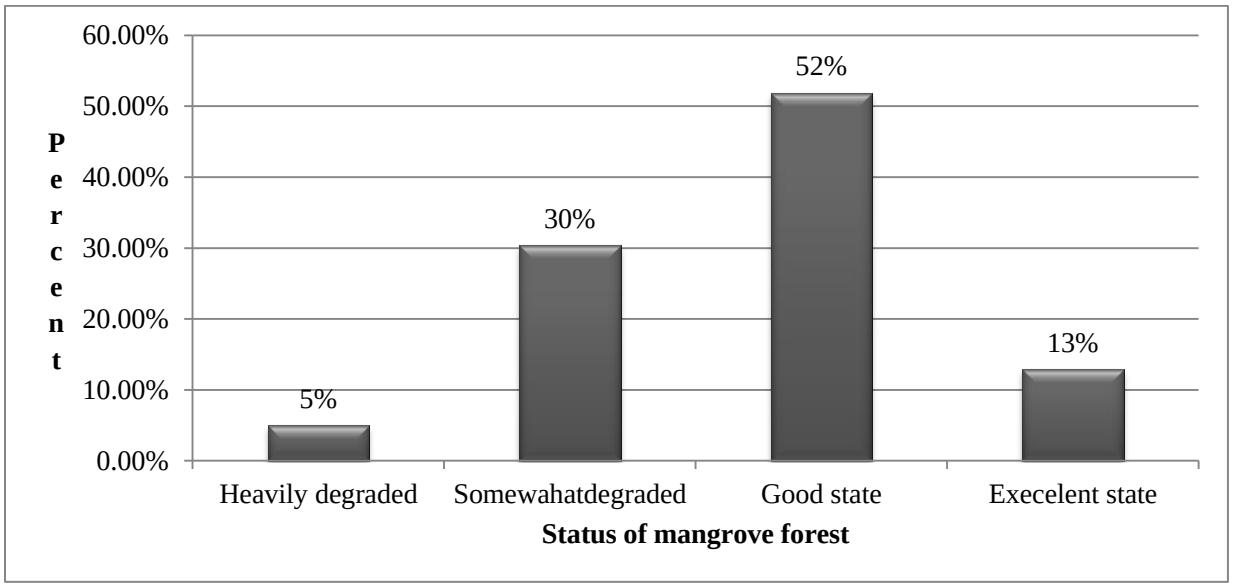


Figure 16: Percent respondents who view the mangrove forest to be degraded

Awareness of development projects on the Tana River

Awareness of High Grand Falls Dam Project: As part of vision 2030, the Government of Kenya planned to construct 165 square kilometre dam at the middle stream of River Tana aimed at generating electricity, supply of domestic and irrigation waters. Respondents were asked about their awareness and knowledge about the project, and 60% said that they had never heard about the project, 36% said to have heard about it and only 4% stated that they were well informed of the project.

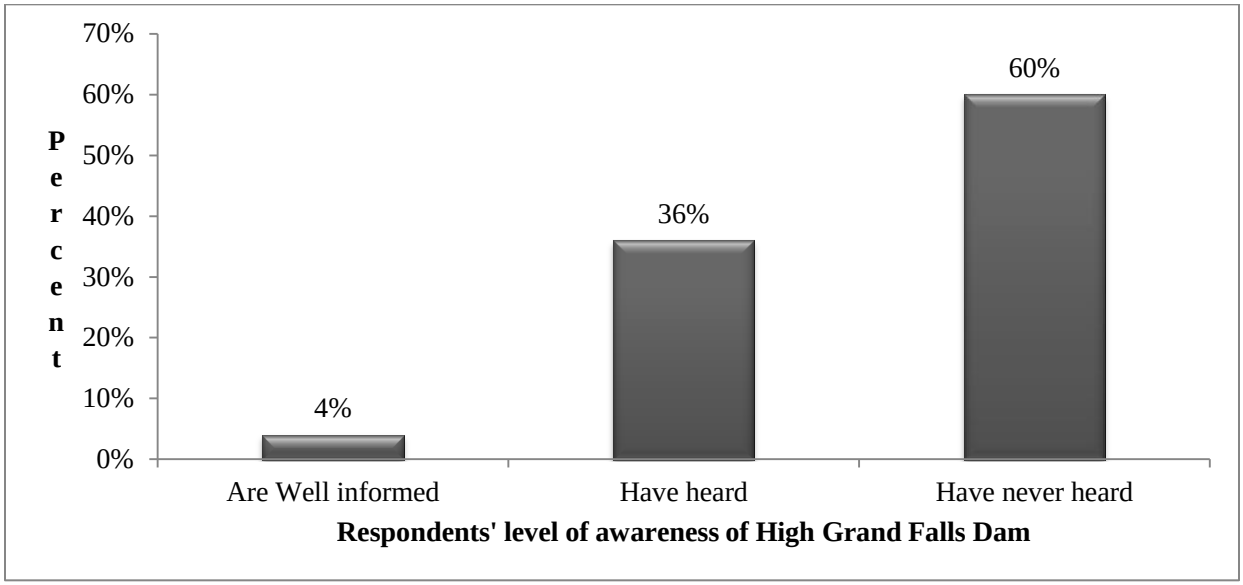


Figure 17: Percent respondents' level of awareness of High Grand Falls Dam Project

Awareness of the one million acres irrigation project: The government had a plan to establish one million acre irrigation project at the Galana/Kulalu, located in Kilifi and Tana River counties. The project will draw some of the water needed for irrigating the land from the Tana River. Respondents were asked if they were aware of the proposed irrigation project and 60% said that they had never heard of the project. About 39% had heard about the project and only 1% of the respondents said that they were well informed about the project..

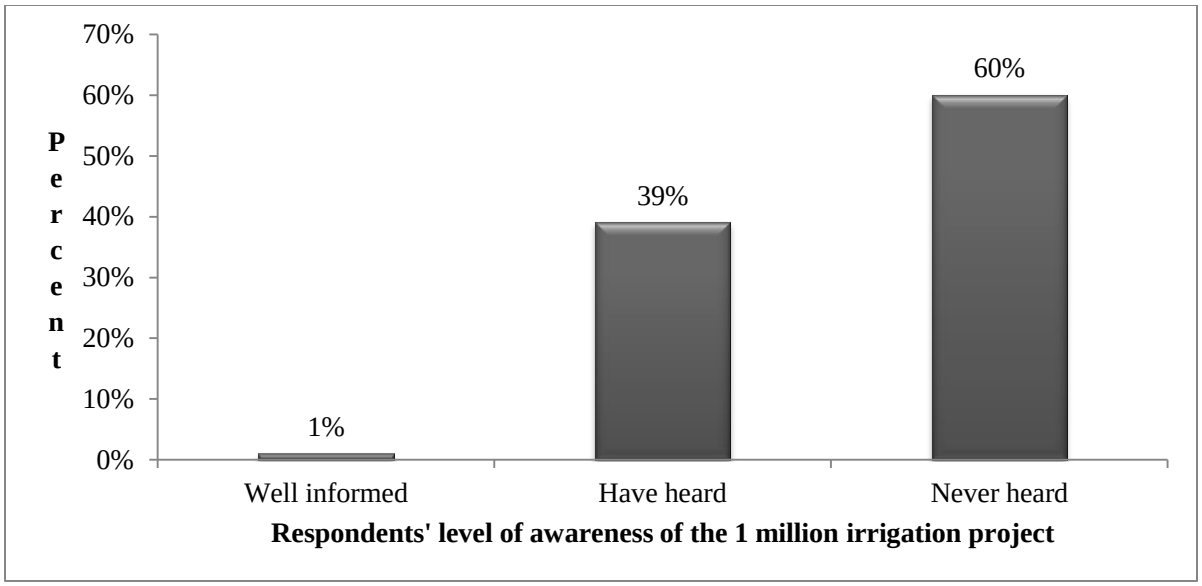


Figure 18: Proportion of the respondents who are aware of the a million acre irrigation project

Awareness of Lamu port project: Lamu port project is part of the Lamu Port-South Sudan-Ethiopia Transport (LAPSSET) project and it will benefit from the waters of the High Grand Falls dam that will be constructed on the Tana River. Only 5% of the respondents said they had never heard of the project. 93% of the respondents said that they had heard of the project and 2% of the respondents said that they were well informed of the project.

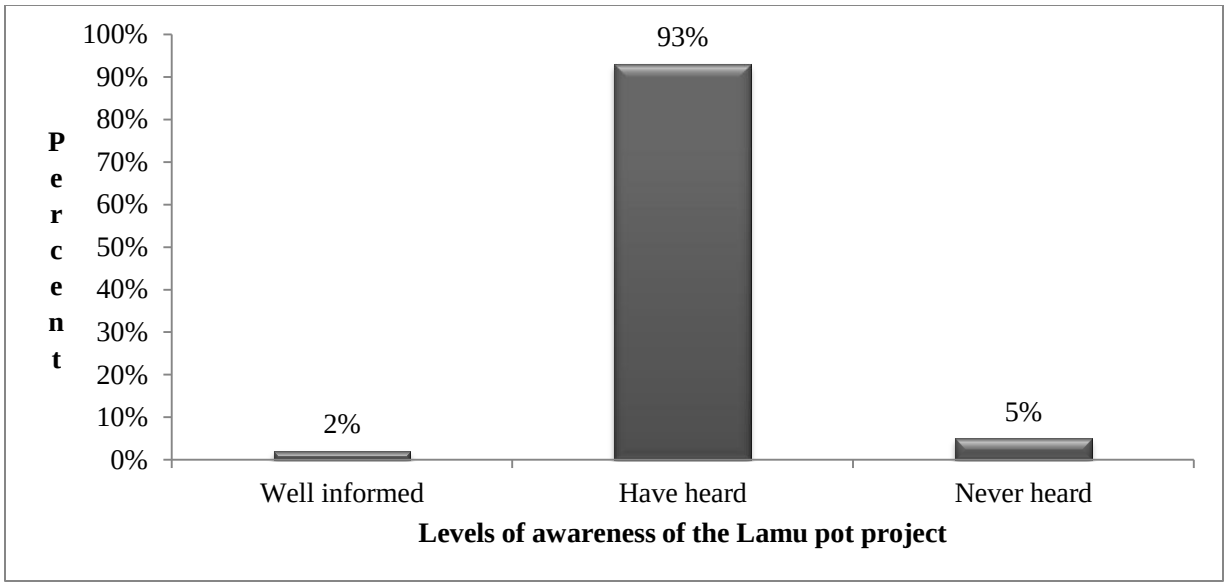


Figure 19: Proportion of respondents who are aware of the Lamu port project

Perception of the effects of upstream projects on Mangrove ecosystem services

Majority of the respondents were of the view that upstream development projects would have a negative impact on the future availability of the mangrove ecosystem services. About 88% of the respondents felt that the availability of the habitat and nursery breeding ground for fish offered by the mangroves would be reduced with the upstream developments on the Tana River. A further 79% felt that shoreline protection offered by mangroves would decline, while 77% felt the flooding control role would also be reduced. Finally, 84% of the respondents felt that the tourism and recreation potential would be greatly reduced.

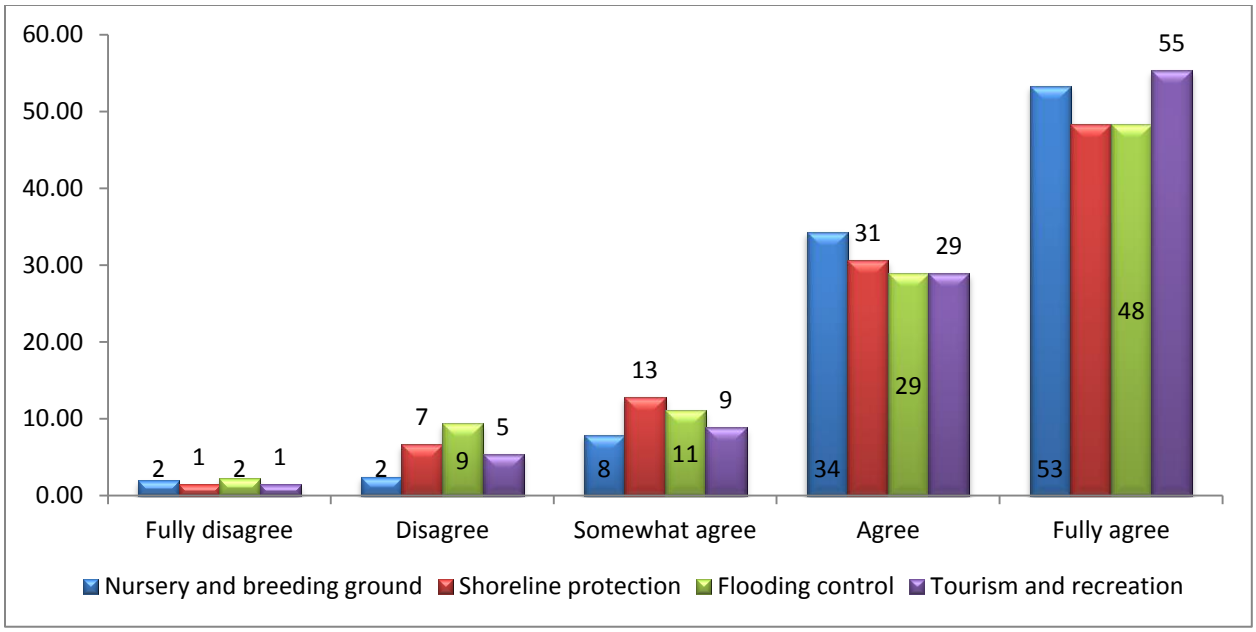


Figure 20: Perception of the respondents on future availability of mangrove services with the planned development projects

Dependence on Fish that breed at the Mangroves

Among the respondents interviewed, 75% reported that they depended on fish that breed at the mangroves either for domestic use or both domestic and commercial use. With 41 % of those interviewed reporting to be involved in fishing. The total monthly catch of such fish was reported to be 65,944 Kilogrammes.

Shoreline Protection

The average length of stay at the location by respondents was 29.6 years with the minimum length of stay reported being 2 years and the maximum was 78 years. Seventy six percent (76%) of the respondents had witnessed shoreline getting eroded with the lowest level of erosion being 1 metre and the maximum erosion reported being 700m. The average shoreline erosion was 95 metres, with a standard deviation of 106. 5.

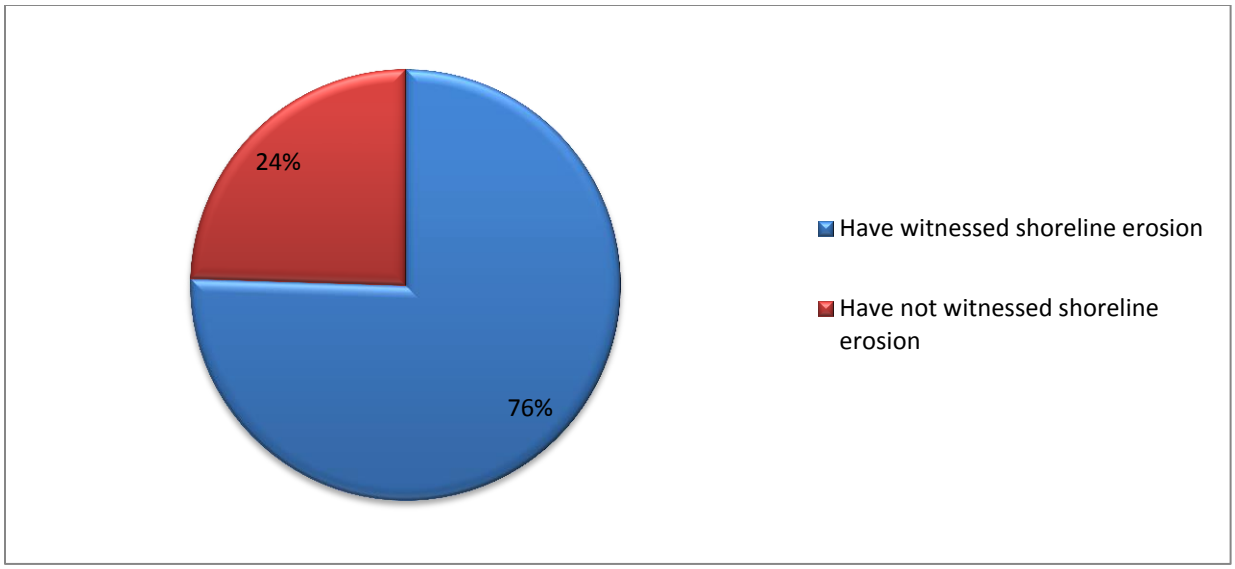


Figure 21: Percent respondents who have witnessed shoreline erosion

About 18% of the respondents indicated that there had been intervention efforts to address the shoreline erosion while 82% said that they had not seen any form of intervention either from community, government agencies or Non-governmental organisations.

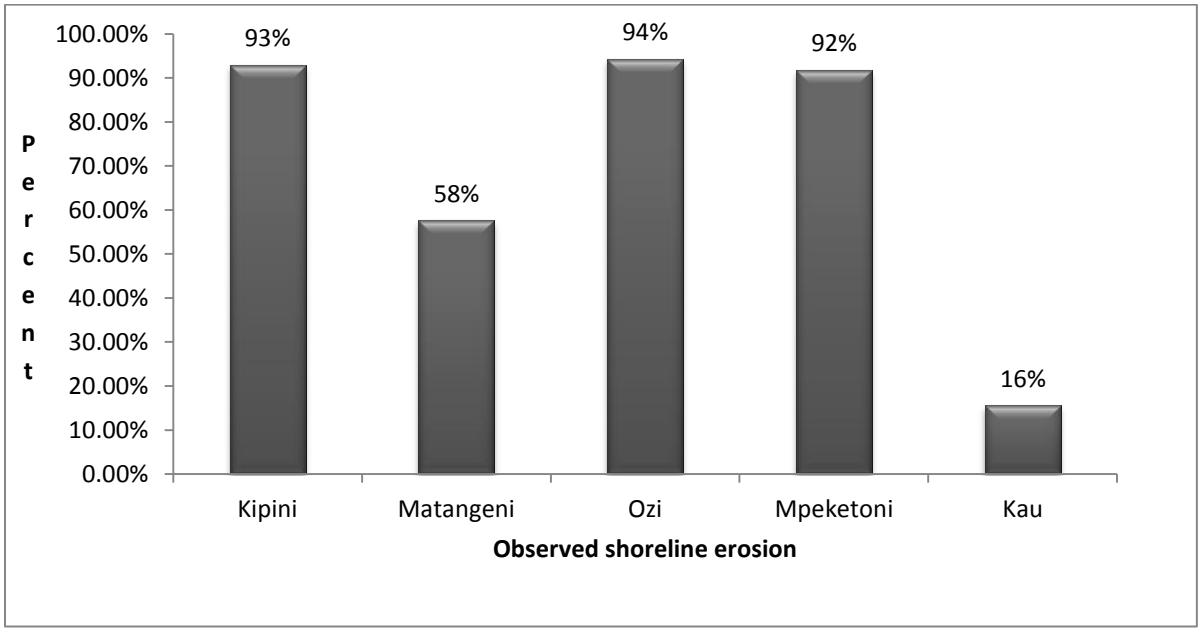


Figure 22: Percent respondents by sub location who have observed shoreline erosion

Flood Control

Flooding was a common phenomenon in Kipini division, 36% of the respondents reported to have encountered floods every year and 14% said that they experienced floods twice in a year. Those who reported to having never experienced floods constituted 16% of the respondents.

Table 10: Percent respondents by sub location who have experienced flooding in the delta

Frequency of Flooding	Name of sub location					Total
	Kipini	Matangeni	Ozi	Mpeketoni	Kau	
Elnino	77%	31%			14%	31.51%
Every year	9%	24%	56%	61%	60%	35.98%
Twice in a year			42%	29%	13%	13.90%
No Floods	14%	41%	1%	4%	7%	15.63%
Twice in five years		2%				0.50%
Once in five years		1%			2%	0.50%
Three years ago		1%				0.24%
Twice in ten years			1%	6%		1.24%
Once in two years					2%	0.25%
Twice in 3 years					2%	0.25%
Total	100%	100%	100%	100%	100%	100%

Asked about severity of flooding, 26% of the respondents affirmed that in deed flooding was very severe, while 19% of them stated that flooding was never severe, those who said that flooding was moderate were 32% of the respondents and a further 24% of the respondents said that flooding was severe. Residents of Ozi and Mpeketoni sub locations were the most impacted by flooding, 41% and 41%, respectively reported that flooding was very severe. In Kipini and Matangeni, only 16% and 12% of the respondents respectively reported flooding to be very severe.

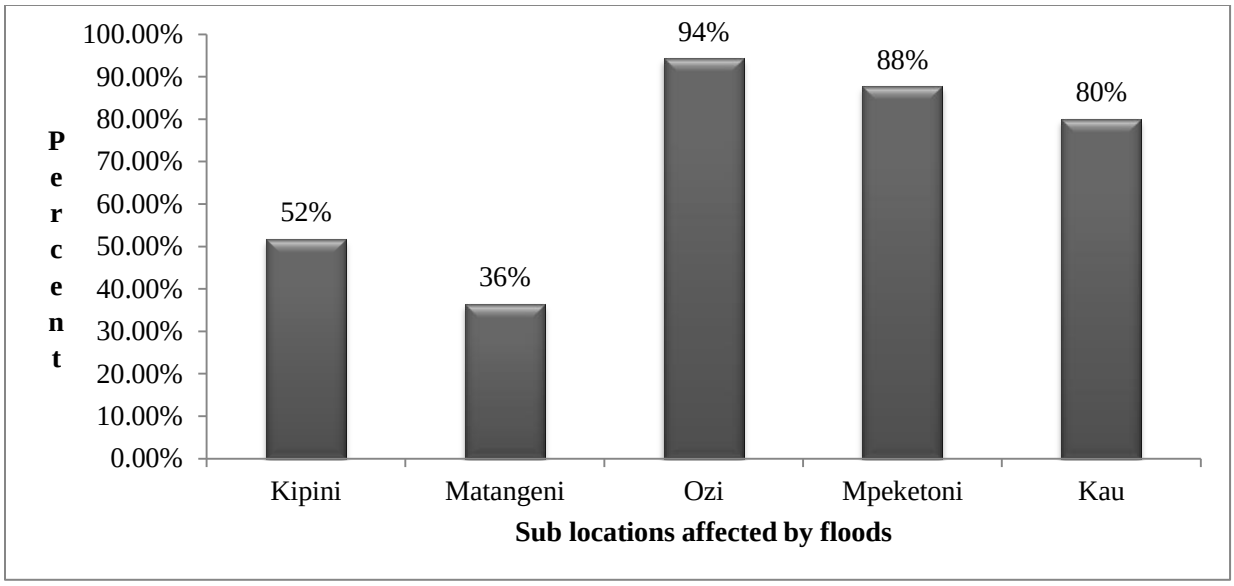


Figure 23: Percent respondents by sub location who have been affected by floods

Ozi and Mpeketoni reported the highest number among those who had experienced total loss from flooding. Among those who reported to had been personally affected by floods, 41% were from Ozi and 45% from Mpeketoni. In Matangeni, 19% of the respondents had experienced total loss from floods, while in Kipini only 17% of those who had been personally affected by floods had incurred a total loss.

Tourism and recreation

Respondents were asked how often, in a month, they saw tourists in their villages. The responses were varied, with the highest frequency being once per month by 28% of the respondents. Those who reported to having never seen tourists in their villages comprised 36% of the respondents.

Table 11: How often tourists are sighted by respondents by sub location

How often tourists are seen	Name of sub location					Total
	Kipini	Matangeni	Ozi	Mpeketoni	Kau	
No tourists	23%	39%	22%	43%	78%	36.07%
Once in a month	34%	14%	41%	41%	9%	28.86%
Twice in a month	16%	7%	22%	8%	2%	11.94%
Three times in a month	5%	2%	3%			2.49%
Once in a year	9%	7%	3%	3%	5%	5.72%
Two times in a year	10%	16%				6.97%
three times in a year	1%	4%	3%	1%	4%	2.49%
Rarely		9%	1%	3%		2.99%
Four times in a month		2%	1%		2%	1.00%
10 times per season			3%			0.50%
5 times in three months				1%		0.25%
six times in a month	1%					0.25%
six times per season	1%					0.25%
5 times in a month			1%			0.25%
Total	100	100	100	100	100	100.00

However, only 3% of the respondents reported that they had family members working in the tourism industry. A number of income generating products and services such as fish selling, sale of coconut products, traditional dance, boat riding, bird watching and identification, tour guiding, catering, security services, mat making, handcrafts and sale of crop produce were offered to the tourists and people on recreational expedition.

4.3. The Total Economic Value of the Mangrove Ecosystem Goods and Services

4.3.1. Direct use values

Firewood, fish, honey and building materials were considered to be making significant economic contribution to the welfare of the communities living around the mangroves in the Tana River delta. These were then used in estimating the direct use values (DUV) of the mangrove ecosystem. In assessing the Mangrove forest areas that contributed to certain production activities, the assumptions (based on the extent of the forest that community reaches in search of the forest products) summarized in Table 12 have been made: Note that that the mangrove forest area has the potential for joint-production-functions and, for this reason, the same amount of forest area can jointly produce two or more products. This is why the total percentage under different products does not necessarily add up to 100 percent.

Table 12: Key assumptions regarding the Flow of Goods at Present

		Percentage (%)	**Area (ha)**
	Total Mangrove forest Area		**2350**
1	Mangrove area contributing to fisheries production.	70	1645
2	Mangrove area contributing building materials	17	400
3	Mangrove area contributing to firewood.	17	400
4	Mangrove area contributing honey.	10	235

Fisheries: The Mangroves of the Tana delta despite being a nursery and breeding grounds for fish that comprise significant fish population and diversity of the Indian Ocean, is also rich in fisheries that were harvested by both artisanal and commercial fishermen. The socio-economic survey carried out in this study showed that a total of 791,338 kg of fish was harvested in 2013 and with modal price of selling 1 kg of fish at kshs. 100, the total annual fish values was

therefore kshs. 79,133,800 which was equivalents to US$ 920,160[2]. This translated to a marginal value of Kshs. 48,105 /Ha/year or US$ 559 /Ha/year.

Building materials: Mangroves in the Tana delta were used for the construction of houses by the community living in the surrounding environment. According to the community members, mangroves were preferable to other plants because of their durability and resistance to termites and spoilage from water logging. A total 5,131 poles of mangrove was harvested and sold for building houses in the Tana delta, with modal price of ksh.100. The total annual value of building poles was kshs. 513, 100 which was equivalent to US $ 5, 966 translating to a marginal value of Kshs. 1284.75 /ha/year or US $ 14.94 /ha/year.

Firewood: A total of 9,149 bundles of firewood were harvested in 2013. Using the prevailing price of firewood per bundle of ksh.100 gave the annual value of firewood to be Kshs.914, 900, or US$ 10638 translating to kshs. 2287.25 /ha/year or US$ 26.60 /ha/year.

Honey: Though honey fetched relatively good price of Kshs. 300, it's exploitation from the mangroves was exceedingly under developed, with only 178 litres extracted annually and was mainly used by the community living around the forest. The annual value of honey from the mangroves was ksh. 53, 400 or US$ 620.93 translating to kshs. 227/ha/year or US$ 1.55 /ha/year

[2] Using exchange rate of 1USD for Kshs.86 being taken from the annual average of the mean exchange rates for 2013

Table 13: Summary economic values of ecosystem goods of the mangroves

Ecosystem Goods	Area (ha)[3]	Ksh. /ha/year (US$. ha/year)	Total economic Value (US$)
Fisheries production	1645	48105 (559.36)	920,147.2
Building materials	400	1284.75 (14.95)	5,980
Firewood	400	2287.25 (26.60)	10,640
Honey	235	227 (2.6)	611
Total			**937, 378.2**

4.3.2. Indirect Use Values

The mangrove ecosystem services, mainly nursery and breeding ground for fish, shoreline protection, flood control and tourism and recreation constitute indirect use values (IUV) which was obtained by calculating the willingness to pay to continue enjoying the services. This was done by converting the amount of volunteer time that respondents were willing to give to help in mangrove restoration and protection into monetary times using rates of earnings of the respondents.

Multinomial logit model was used to estimate the probability that an individual will choose improvement in a certain mangrove ecosystem service. Table 14 presents the results of an attribute only choice model that includes an interaction variable with volunteer time and membership. All coefficients are statistically significant at the 1% level. As expected, the utility of the environmental protection alternatives is positively related to the nursery of fish and the number of tourists, while this utility is negatively related to shoreline erosion and the flood probability. An attribute only model that includes volunteer time without an interaction term (not

[3] The total amount of hectares is more than 2,350 when calculating all together. This is because some hectares provide multiple values.

shown here) shows that the coefficient of this variable is insignificant. The interaction variable of volunteer time with membership in Table 14 shows that volunteer time has opposite effects for members and non-members. The coefficient of volunteer time is positive and significant for those who are members of an environmental group meaning that they prefer environmental policy options that require more volunteer time. For non-members, the coefficient of volunteer time has the expected negative significant sign, meaning that they prefer to spend less volunteer time on environmental protection.

In addition to the model coefficients, Table 14 reports the marginal effects and elasticities which, respectively, represent the absolute and percentage change in the choice probability for one of the environmental protection options that results from a one unit or 1% increase in the explanatory variable. The marginal effects show that especially the nursery of fish and flood probability attributes have a large influence on respondents' choices. All elasticities are in absolute value smaller than unitary, which means that they are relatively inelastic. The elasticities of volunteer time have a similar size between members and non-members, but are opposite in sign.

Table 14: Estimation results of an attribute only model with volunteer time interacted with membership to environmental or social group

	Coefficient	Marginal effect	Elasticity
Nursery fish	0.14270***	0.03	0.29
Tourists	0.04953***	0.01	0.11
Shoreline erosion	-0.02475***	-0.006	-0.08
Flood probability	-0.68285***	-0.16	-0.19
Volunteer time	-0.02906***	-0.007	-0.20
Volunteer time × Membership	0.03821***	0.009	0.20
Constant of the opt out	-1.95730***		
AIC	1.646		
Psuedo-R^2	0.05		
Log-likelihood	-1968		
Observations	2412		

Notes: *** stands for significant at the 1% level.

Table 15 shows individual maximum willingness-to-pay (WTP) for non-members per attribute in terms of volunteering time per month or monthly opportunity costs. The results show that individuals are on average willing to spend approximately 5 hours monthly for gains in fish nursery per 1000 additional ton of fish, 2 hours per month for attracting 100 additional visitors, 1 hour per month to prevent a meter of shoreline protection and 2 hours per month to prevent each 0.1 increase in flood probability. It should be noted that the flood probability is bounded between 0 and 1 which is why the WTP is expressed per 0.1 probability unit. The figures about willingness to put in volunteer time are translated to opportunity costs amounts by multiplying hourly time with the local average hourly wage of 300 Kshs. This results in monetary WTP values of 1,473 Kshs per 1000 ton of fish, 511 Kshs per 100 tourists, 256 Kshs per 1 meter prevented shoreline erosion, and 705 Kshs per prevented increase in the flood probability of 0.1.

Table 15: Maximum willingness- to-pay for non-members per attribute in terms of volunteering time per month or monthly opportunity costs

	WTP in time	WTP in opportunity costs
Gain in nursery per 1000 ton of fish	4.91	1473 Kshs.
Gain in tourist per 100 visitors	1.70	511 Kshs.
Prevent shoreline erosion per meter	0.85	256 Kshs.
Prevent increase in flood probability per 0.1	2.35	705 Kshs

Furthermore, several models that examined how individual choices depend on geographical and socio-economic characteristics by creating interactions of these variable with the choice experiment attributes and the-opt out alternative were estimated. Final results of a model with only significant interaction variables are shown in Table 16 below. In particular, we tested whether preferences for the nursery of fish, shoreline erosion, the flood probability or the-opt out option have significant (at the 5% level) interactions with variables of distance to the shoreline, the mangrove or flood-prone areas. Only the interaction variable of distance to the mangrove with the-opt out is statistically significant and shows that people who live farther away from mangroves are more likely to choose for the-opt out. Moreover, we examined whether preferences for the attributes and the-opt out significantly relate with gender, age and the number of children in a household. Interactions of these variables with the attributes are insignificant (at the 5% level). These models did reveal that choosing for the-opt out positively relates with age and negatively with the number of children.

Table 16: Estimation results of an attribute only model with volunteer time interacted with membership to environmental or social group

	Coefficient	Marginal effect	Elasticity
Nursery fish	0.14342***	0.03	0.29
Tourists	0.04819***	0.01	0.11
Shoreline erosion	-0.02524***	-0.006	-0.09
Flood probability	-0.70530***	-0.16	-0.19
Volunteer time	-0.02905***	-0.007	-0.20
Volunteer time × Membership	0.03807***	0.009	0.20
Constant × distance to mangrove	0.63129***	0.05	1.01
Constant × age	0.03439***	0.003	1.30
Constant × number of children	-0.11549**	-0.009	-0.36
Constant of the opt out	-3.84421***		
AIC	1.617		
Psuedo-R^2	0.08		
Log-likelihood	-1911		
Observations	2412		

Notes: *** stands for significant at the 1% level.

Each household is willing to contribute between Kshs.256 to 1573 for each of the four ecosystem services of the mangroves as shown in Table 17 below.

Table 17: Households mean willingness to pay (in kshs. per month)

Mangrove Ecosystem Service	**Mean Monthly Willingness to Pay (Kshs.)**
Fish Nursery and Breeding Ground	1473 Kshs.
Tourism	511 Kshs.
Shoreline Protection	256 Kshs.
Flood control	705 Kshs

The households willingness to pay can also be expressed annually in which case, each of the monthly willingness to pay by the households are multiplied by 12. Therefore, every single year—assuming constant returns to scale of the mangrove wetland values—each household will be willing to contribute between Kshs.3072 and Kshs. 17676 depending on the ecosystem service.

Table 18: Households mean willingness to pay for mangrove ecosystem services (Kshs per year)

Mangrove Ecosystem Service	Annual mean Willingness to Pay (Kshs.)
Fish Nursery and Breeding Ground	17676
Tourism	6132
Shoreline Protection	3072
Flood control	8460

From a policy perspective, it is prudent to express these annual households willingness to pay for the ecosystem services for sampled households and finally for the population surveyed that benefit from the services. Tables 19 and 20 show the marginal willingness to pay for the sampled households and for the surveyed population respectively. A total of 405 households were sampled and this translated into a total annual willingness to pay ranging from Kshs. 1,244,160 and Kshs. 7,158,780 for the sampled households for the different mangrove ecosystem services (Table 18).

Table 19: Sampled households total willingness to pay for mangrove ecosystem services (Kshs/year)

Mangrove Ecosystem Service	Willingness to pay (Kshs/ year)
Fish Nursery and Breeding Ground	7,158,780
Tourism	2,483,460
Shoreline Protection	1,244,160
Flood Control	3,426,300

Considering the total population that directly benefit from the mangrove ecosystem services, the total household population estimated to be 3,746 (KNBS, 2009) was then multiplied by the mean household willingness to pay as shown in Table 19. The annual willingness to pay for the society range from Kshs. 11,507,712 to Kshs. 66,214,296 as shown in Table 20 below.

Table 20: Society total willingness to pay for different mangrove ecosystem services (Kshs per Year & US $)

Mangrove Ecosystem Service	Willingness to pay Kshs/Year	US$
Fish Nursery and Breeding Ground	66,214,296	769,933.67
Tourism	22,970,472	267,098.50
Shoreline Protection	11,507,712	133,810.60
Flood Control	31,691,160	368,501.86
Total indirect use value	**132,383,640**	**1,539,344.63**

The society willingness to pay values was converted into monetary values per hectare. This was done by dividing them by the total mangrove size in hectares (2350ha). With an assumption that each hectare contributes equally to the various mangrove ecosystem services, then these values known as the average value per hectare ranges from Kshs. 4896.90 /ha/year for shoreline protection and Kshs. 28,176.30/ ha/year for nursery and breeding ground for fish as shown in Table 21 below.

Table 21: Average Economic Values of Mangrove Ecosystem Services (Kshs./ha/year)

Mangrove Ecosystem Service	Willingness to pay (Kshs/ha/Yr.)
Fish Nursery and Breeding Ground	28176.30
Tourism	9774.70
Shoreline Protection	4896.90
Flood Control	13485.60
Total ecosystem services value	**56,333.47**

Table 22: A Summary of the total economic values of mangrove ecosystem goods and services in the Tana Delta

	Ecosystem Goods and Services	Area (ha)	US$/ha/year	Kshs/ha/Year	Economic value (US$)	Economic value (Ksh)
1	Fishing	1645	559.36	48105	920,147.20	79132725
2	Firewood	400	26.60	2287.25	10,640	914900
3	Building materials	400	14.95	1284.75	5,980	513900
4	Honey	235	2.6	227	611	53345
	Total direct use values				**937,378.20**	**80614870**
5	Nursery & breeding ground for fish	2350	327.63	28176.30	769,933.67	66,214,296
6	Shoreline protection	2350	56.94	4896.90	133,810.60	11,507,712
7	Tourism & recreation	2350	113.66	9774.70	267,098.50	22,970,472
8	Flood control	2350	156.81	13485.60	368,501.86	31,691,160
	Total indirect use values				**1,539,344.63**	**132,383,640**
	Total Economic values				**2,476,722.83**	**212998510**
	Average mangrove ecosystem value/ ha/year				1053.92	90637.70

4.4.IAD Framework and Integrated River Basin Management

4.4.1. The Biophysical attributes of the Tana Delta

Tana River Delta is located in Tana River Delta sub-county and Lamu West Sub-county in Tana River County and Lamu County respectively and it is found between 02°30'S, 40°20'E. The delta measures 130,000 ha (Mireri, 2010). A study conducted in 1986, however, showed that it had a size of 3000 km^2 or 300,000 ha **(**Beck et al, 1986).

The biophysical factors relevant to water management could be broadly categorized into climatic, hydrological, topographic, soil, vegetation and environmental factors (Bekele et al, 2012) and their detailed description is under the study area title under methodology.

4.4.2. Community Attributes

The major water resource appropriators in the Tana delta include: farmers (flood recessions, small scale irrigators, and large irrigation scheme farmers); pastoralists and agro pastoralists, hunters and gatherers, even though hunting was declared illegal as early as 1976; domestic water users, miners and mineral explorers, and industrial developers. In addition to direct water resource users, there are also a host of stakeholders whose interest and roles affect the water resources right inside the delta or outside the delta but which affects the waters in the delta, they include; water supply, water resource management, Agricultural development, Forestry sector, Energy production, Flood management and mitigation, Industrial development. There are also prospective land and water resource users in the delta. The major communities living in Tana delta are the Pokomo, Orma, Wardei, Bajuni, Malakote, Somali, Munyoyaya, Mijikenda, and the Waata, others include; Luos, Kambas, Taitas, Giriamas, and Kikuyus (KNBS, 2009; Ng'weno, 2012). Detailed description is found in the study area title under methodology section.

The Orma and Wardei pastoralists accuse the Pokomo farmers of restricting their access to water points and grazing fields. The Pokomo on the other hand blame the pastoralists for grazing on their farms and destroying their crops. The pastoralists have been also against the government-supported land adjudication process. Land alienation hampers community access to alternative grazing areas during the dry season. There also exists conflict between farmers and wildlife

4.4.3. Stakeholders: Public Institutions and their Roles

The institutions/ organisations that have been charged with responsibilities to manage the water resource, or sectors that have impact on water resources in the Tana delta include: Water Resources Management Authority (WRMA), Coast Water Services Board, National Irrigation Board, Tana and Athi Rivers Development Authority, Kenya Forest Services (KFS), National Environment Management Authority (NEMA), Coast Development Authority, Agriculture, Fisheries and Food Authority, KenGen, Flood Management Unit, Kenya Wildlife Service, National Land Commission, Tana River County Government. A detailed description of their roles is presented in annex 1

4.4.4. Enabling Environment: Policy and Legal Framework (The formal rules)

The rules influence the incentives and or disincentives that actors face and thus shape/determine the actors' behaviours (Hogson, 2006). The main concern in this institutional analysis was whether the rules are likely to solve the dilemmas related to the mangrove and the delta governance. This section therefore reviewed the water and water related strategies, policies, laws and regulations that govern the Tana River Basin (catchment).

Water Sector Policies and Strategies

The water sector has undergone a number of reforms that culminated into the formulation of the water policy in the year 1999; in addition, there are a number of strategies that have been

developed such as the National Water Resource Management Strategy, National Water Service Strategy, Tana Catchment Management Strategy and Flood Mitigation Strategy

Water Related Policies

From the sectors that have impacts on the water resource, the following polices have been formulated and adopted for implementation, agriculture sector development strategy, energy policy, flood mitigation strategy, environment policy and forest policy. The review off these policies focused on; direct impact of policies on water resource management, whether the policies take into account the implication of their implementation on water resources, whether there are provisions for multi-sectoral coordination on the implementation of the policies that including on water resource management.

The Water Sector Laws

The water laws reviewed include; the Water Act of 2002, Water Resource Management Rules of 2007, and the Irrigation Act. The review focused on: prescription of cross-sectoral coordination, recognition of water as an economic, social and environmental good, permitted and prohibited use of water, water rights and allocation and how the rights are implemented, existence of and types of sanctions, provisions for water resource conservation, provisions for conflict resolution and the implementation and enforcement of the laws.

Water Sector Related Laws

In this section; agriculture, energy, forest, environment, land and flood management laws and regulations were reviewed and the following criteria were assessed; permitted and prohibited actions that impact water resource, sanctions and fines or penalties that impact water resource, existence of provision for cross- sectoral coordination, whether water is recognised as an

important resource and any management tools (EIA, SIA, CBA) required in the laws that have implications on water resource.

4.4.5. Patterns of Interactions and Outcomes

Patterns of interactions describe the relationship between the various water resource appropriators and the stakeholders influencing water issues and decisions, and the linkages between the various policy and legal instruments. The outcomes are the results of the interactions between participants in an action arena (Smajgl, Leitch and Lynam 2009).

The results were organized in four categories: interactions and linkages between direct resource users such as farmers, pastoralists among others; linkages among the formal institutions with mandates on water resource and sectors affecting water in the Tana delta such as WRMA, KenGen, TARDA among others; linkages between the various policy instruments on water and water affecting sectors in respect to principles of integrated river basin management and common pool resource management; and also linkage between the water and water affecting laws in relations to the principles identified. The results are presented in table 29 below.

4.4.6. Evaluation for IRBM

Thirteen (13) principles/ elements have been identified to be adequate to facilitate integrated river basin management for the sustainable management of the mangroves in the Tana delta, these include; efficiency, fiscal equivalence, congruence, monitoring compliance, graduated sanctions, dispute resolution, participation, social equity, ecological sustainability, coordination, nested approach, basin wide planning.

Efficiency entails finding ways to maximize the value of water use and allocation decisions within and between sectors for sustainable social and economic development. It relates not only

to the efficiency with which water is used, but the efficiency with which it is "produced", i.e. the efficiency of the processes that go into providing water when, where and in the appropriate quantity and quality needed for a particular use (GWP, n.d) . Improving water efficiency helps to reduce water scarcity and maximize the benefits provided by existing water infrastructure. It also frees up water for other uses and reduces environmental degradation (GWP, n.d).

A review of the irrigation systems by the large scale irrigators showed that TARDA and NIB use canals which are highly inefficient for water loss reduction. Usually Governments' involvement in the development of irrigation infrastructure such as by TARDA and NIB is meant to increase economic productivity in the weakest sectors, thus improving the use of water in the context of greater equity, and creating incentives for technological change and agricultural improvements.

Tana River carries sediment estimated at 3.1 to 6.8 3 x10^9 kg /yr (Mireri, 2010; Syvitski et al. 2005; Kitheka et al. 2005), data on the trend whether there has been a decrease was not obtained, however, review of policy documents did not show existence of incentives or regulations that encourage or require farmers to adopt erosion-control practices and to reduce their use of slash-and-burn agriculture, and the consequence of this is a sustained siltation which reduces water storage in established infrastructures . The provisions of the Water Act 2002, which exempts state schemes from obtaining water permit is likely to be a perverse incentive against water resource since they may not pay for the use of the resource. Also, subsidies such as the one for fertilisers, while is good for the immediate well-being of farmers and the economy, are actually a perverse incentives for the water resources due to the non-point pollution associated with them, measures to offer counter incentives to avoid pollution should be instituted.

Fiscal equivalence refers to the concept in which those who benefit from a service should bear the major burden for financing that service (Ostrom, 1995). Since the provision of public

services such as water is always confronted with externalities, the government should be organized in such a way that every individual standing to benefit from a good or service bear the costs *and* decide on its provision (Klaphake, 2002). Water resource users pay for the use through abstraction permits from WRMA. The key question is whether the greater majority of the resource users pay for it and whether the pricing is at or close to cost recovery levels. In 2011, WRMA reported that three Governments owned agencies (KenGen, NIB and CWSB) owed them Kshs. 1 billion as charges for water use, and stated that most public institutions remain a challenge in terms of paying for water use, unlike the private companies which always make payments. The Water Rules of 2007 require large water abstractors to pay 50 cents for every cubic metre they draw from water resources. The Authority was in a position to raise Kshs. 350 million per year if all the water resource abstractors paid the charges (Standard, 2011).

In congruence, appropriation rules restricting time, place, technology and / or quantity of resource units are related to local, social and environmental conditions (Ostrom 1990, 2005). Rules set by WRMA tend to be uniform nationally, including WRUA guidelines; there has been a concern recently that WRUA formation and operations in the Arid and Semi-Arid Areas be reassessed to reflect the reality of the local conditions.

Ecological Sustainability

Ecologically sustainable water management is an iterative process in which both human water demands and ecosystem requirements are defined, refined, and modified to meet human and ecosystem sustainability now and in the future (Richter et al, 2003). Water-related ecological objectives need to be quantitatively defined so that they can be integrated with other water management objectives (Rogers & Bestbier 1997). There is also relation between ecological sustainability and social equity for instance, the ability of future generations to benefit from

water resources depend on sustainable use in the present and water-dependent ecosystems, such as wetlands, are an important resource to some communities (Peña, 2011). The water Act of 2002, Water Resource Management Rules of 2007, catchment management strategy and sub catchment management plans guidelines all stipulate the maintenance of river reserve[4]; however, neither the Tana Catchment Management Strategy nor the SCMPs have reserve levels. This contradicts the basis on which major water allocation is carried out for the planned and ongoing major water drawing projects in the Tana River.

Discharge of pollutants into a river is prohibited. However, there are still a host of non-point pollution that still take place e.g. chemicals and fertilisers from agricultural activities including irrigations as was observed by respondents in Ozi in relation to the TARDA Tana delta irrigation scheme

For monitoring compliance, Monitors, who actively audit common-pool resource conditions and appropriator behavior, are accountable to the appropriators and/or are the appropriators themselves, and for dispute resolution, appropriators and their officials have rapid access to low-cost, local arenas to resolve conflict among appropriators or between appropriators and officials (Ostrom, 2005). For purposes of accountability to the stakeholders, involvement of WRUAs as monitors to compliment WRMA staff, should be emphasised and enhanced through equipping the former with adequate skills

[4] According to the Water Act of 2002, in relation to a water resource, means that quantity and quality of water required— (a) to satisfy basic human needs for all people who are or may be supplied from the water resource; and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the water resource;

For Graduated sanctions, appropriators who violate operational rules are likely to receive graduated sanctions (depending on the seriousness and context of the offense) from other appropriators, from officials accountable to these appropriators, or from both (Ostrom, 2005). Whereas most of the sanctions call for fines in case of breach, setting of the fines at upper limits may seem as invitation for those in justice system (Judges and arbitrators) to make decisions based on the magnitude of the damage and capability of the accused. It also seems that the sanctions/fees might also appear not punitive enough for some potential offenders hence not a deterrent enough. Some informal ways of handling some violations may also be necessary to avoid transaction costs that are usually associated with the courts. Second offences need more punitive measures

Dispute Resolution

There are a number of avenues for conflict resolution, these include WRMA and WRUAs, Water Appeals board, and the Environment and Land Court. WRUAs, represents a cheaper option for arbitration costs and there is need to only strengthen them to be able to adequately address conflicts arising from their sub catchments but also, mobilise communities to form WRUAs since not all sub catchments have functional WRUAs, in the Tana delta, there are only two strong WRUAs out of the possible nine (9) WRUAs in the delta. Linkages between WRUAs across the drainage should be encouraged to ensure that focus on water resource use also takes cognizance of water needs by both up and down steam users.

Participation

Water is a resource that affects all; Government should work to ensure participation of all stakeholders. True participation is ensured only when all stakeholders are involved in the decision making at all levels. Further, water and water resources users should have the rights to

devise their own local institutions which are recognized by the national and county governments (Baker & Fyles, 2010; Ostrom, 1990). Water users have been granted the chance to form associations for the management of water sources, similarly, communities have legal rights to form associations for the management of water resources, one challenge for the WRUAs is how to engage the government agencies who also utilize the resource from their sub catchments since they never join the WRUAs hence not bound by the by-laws of the groups. Water Management Rules, however, requires that WRUA comments must be sought on any water use projects before approval. The challenge, though is that not all sub catchments have WRUAs and there are cases projects that transfer or transport water to distant geographical locations have little input on affected communities downstream for example majority of Kipini residents have little knowledge of the High Grand Falls Dam and the one million acre scheme in all of which will draw water from the Tana River.

Subsidiarity

The principle of subsidiarity is that a central authority should only perform those tasks which cannot be performed at a more local level (Winpenny, 2007). Subsidiarity takes the form of; de-concentration, delegation and devolution. Delegation is usually regarded is the most preferable for water resource management at the basin level and it can be prompt and definitive or gradual and progressive (Jaspes, 2014). A river basin management strategy with a high chance of success entails government delegating and sharing responsibilities for specific roles, tasks and functions to other organisations (Abernethy, 2001). Such delegated functions can include; Development of strategic river basin plan; Development of operational river basin plan; Contributing to river basin protection plan/measures;Water right or water permit allocation;Effluent discharge permit allocation; Allocation of drainage permits or drainage responsibilities;Co-ordination between

sub-basins; Collection of water charges; Fund administration and development; Appeal function; Awareness creation and capacity building and usually carried out by a basin/ catchment organisation (Jasper, 2002). Decentralizing decision making to the lowest level is also the only strategy to enhance participation (Baker & Fyles, 2010).

The principle of subsidiarity has been recognised in the Water Policy of 1999 and has been implemented in two different forms. The water services and sewerage sub sector implemented the delegated subsidiarity in which WASREB delegated water service provision to WSBs, whereas the water resource management sub sector is implementing the de-concentration subsidiarity through regional offices for all the catchments in the country each with sub regional offices too.

Social Equity

The basic human needs for water in Kenya is assumed to equal 25 litres of water per person per day (WRMA, 2007), though a study by Gleick (1996) on basic water requirements for human activities .recommends adoption of basic water requirements standard for human needs of 50 litres per person per day and guarantee its access independently of an individual's economic, social or political status. Other basic human uses of water at the delta include food and livelihood at the local/community levels such as flood recession farmers, small scale irrigation users, pasture and livestock watering, fishing, and tourism; and national food security through large scale irrigation. Customary uses of water resources at the delta include; hunting and gathering, fishing, farming and watering of livestock.

For cross sectoral coordination, there is a vision for catchment management which is of coordinated cross-sectoral partnership working at whole catchment and or sub catchment scale involving government departments, private sector and civil society (Smith et al, 2015). It is the

use of a multiple agency approach with overarching coordination function by a river basin organisation (Hooper, 2010). It requires that all of the public sector agencies with responsibilities for activities or policies that influence land, water and wetlands within river basins commit themselves to cooperative processes of consultation and joint setting of policy objectives, at national level as well as at river basin level (Ramsar Convention Secretariat, 2010). At the county level, there is a traditional practice of WESCOORD meetings in which all stakeholders in the water sector meet to discuss their activities, this is a platform that WRMA can use to present to the stakeholders the state and availability of the water resource to facilitate planning within the limits of available water and not the other way round. However, the enabling environment should entail the legal backing for WESCOORD and whether the institutions are legally bound to take part and abide by the process, and also whether WRMA has the capacity to cause other agencies to effect water use within what it can apportion them, WRMA on the hand will require adequate capacity and enough manpower to participate in all the WESCOORDs that exists in a basin/catchment area. Care should however, be taken to ensure that allocation is not based on county basis only since there are certain projects that are national or regional in nature. At the regional and national level, WRMA is mandated to liaise with other bodies for better management and regulation of water bodies, for example a number of agencies were involved in the development of the Tana Catchment Management Strategy. However, WRMA's coordination role as per this article appears weak compared to powers and roles that other agencies have been conferred to by their respective statute laws such as NEMA and TARDA which have their coordination of other agencies activities well-articulated, similarly, ASDS coordination unit also has a clear mandate that is stronger than WRMA save for the fact that it is a policy process rather than legal. Therefore if WRMA was to facilitate inter-sectoral

coordination to ensure that all the actors develop their plans based on available water as assessed by WRMA then there would be need to review Water Act of 2002.

Basin wide Planning

There is a management plan for the Tana Catchment called catchment management strategy; in addition there exist a number of WRUAs, some with sub catchment management plans. However, the critical question is whether all development plans by the various sectors that need water are factored in WRMA/WRUA plans and that those sectors' plans are based on water availability.

In nested approach/ enterprise, management of water resource must be done within the broader basin framework which is usually large and with many participants, hence nested enterprises that range in size from small to large enable participants to solve diverse problems involving different scale economies (Ostrom, 2005). By utilizing base institutions that are quite small, face-to-face communication can be utilized for solving many of the day-to-day problems in smaller groups (Ostrom, 2005). By nesting each level of organization into a larger level, externalities from one group to others can be addressed in larger organizational settings that have a legitimate role to play in relationship to the smaller entities (Ostrom, 2005), a basin organisation which has a basin management plan and linking all the Sub Catchment Management Plans through WRUAs is the key to achieving a nested enterprise. WRUAs need to collaborate in order to achieve a basin wide approach to water resource management, the River basin/ catchment need to coordinate all the WRUAs, the basin management strategy should be instrument for coordination and cooperation

CHAPTER 5: DISCUSSION AND CONCLUSIONS

The purpose of the study was to estimate the economic values of the mangrove ecosystem goods and services and investigate the suitability of the existing institutional arrangements to harness the values within a broader integrated river basin management framework. The findings show that in deed mangroves have economic value and that the existing institutional arrangements mimics the necessary elements of integrated river basin management to some degree in terms of legal architecture, however, on implementation, a good number of requirements have not been addressed despite the twelve (12) years of reforms.

The most important mangrove ecosystem goods and services in the Tana delta include: biomass fuel (firewood); poles for fencing, building houses, boat traps and boat construction; dyes; medicinal herbs; fodder; honey; fish; and provision of nursery and breeding ground for fish; shoreline protection; flood control; and a source of tourism and recreational attraction.

The use of mangrove ecosystem products is not as high as the recognition of the services provided by the mangroves, and this is attributed to the fact that there is a ban in force againsts harvesting of the mangrove biomass products in the Tana delta. Firewood was valued at US$ 26.60/ha/year, a study in Gazi Bay valued firewood at US$ 16.8/ha/year (UNEP, 2011), whereas another study conducetd by Kairo et al (2009) also in Gazi Bay but in replanted planted mangroves valued firewood at US$ 18.5/ha/year. Building poles was valued at US$ 14.95/ha/year, a figure that is significantly higher than the Gazi Bay valuation of US$ 4/ha/year (UNEP, 2011). Valuation of honey was US$ 2.6/ha/year which was fairly less than Gazi Bay valuation of US$ 14.70/ha/year, this is likely attributable to an established (though still new) bee

keeping in Gazi Bay (UNEP, 2011). The economic value of fisheries was estimated to worth US$ 559.36/ha/year, this is generally higher than the values of fisheries in Gaze Bay that was valued at US$ 44/ha/year (UNEP, 2011), the reason for this disparity could be due to the fact that the delta mangroves adjoins the Ungwana Bay that is credited to be the richest and most productive fishery ground along the Kenyan Coast (Mwatha, 2002).

Flooding is more prevalent and dangerous in Ozi and Mpeketoni sub locations, probably because floods reach the settlements before encountering the mangrove forests which have been credited for checking the strength of floods. Residents of Kipini despite being the closest to the Tana River, experience less flooding compared to those of Ozi and Mpeketini, ironically they (Kipini residents) do not quite rank flood control services of the mangroves highest in comparison to residents of Ozi and Mpeketoni, it is most likely that there is a strong linkage of the role mangroves play, given that Kipini is the last settlement to the ocean and the mangrove forest which is behind the settlement could be acting as a break before floods wreck havoc. The economic values of mangroves for flood control was valued at US$ 156.81, other studies conducted in Kenya did not value flooding probably due to the fact that the site (Gazi Bay) is not drained by a river course.

The mangrove wetland acts as a breeding ground and nursery for the following groups of fish: catfish; prawns such as Coctail, *Jumbo*, Tiger, Red sniper, Banana, *Pilipili*; Tilapia; and Mudfish. Majority of the respondents (three quarters of the population) in the three locations depend on fish that breed at the mangroves, and 44% of the population are involved in harvesting of fish that breed at the mangroves. The value of nursery and breeding ground for fish was valued at US$327.63/ha/year.

Coastline erosion is one of the major environmental challenges in the delta, with the average extent of erosion claiming around 95 metres, particularly on the sections of the shoreline that is not bordered by the mangroves. In deed an hotel has lost most of its buildings to constant erosion of the shoreline by the ocean waves, suggesting urgent need to protect the shoreline. Mangroves have the potential to help check on the erosion has majority of the respondents agree. Little intervention has however, taken place to address the erosion. The total economic value of mangroves in Tana delta in shoreline protection is US$ 56.94 which is lower than the study conducted by UNEP in 2011 in Gazi Bay for shoreline protection, which was valued at US$ 91.70, this probably could have been attributed to the shoreline side flanked by the mangroves in the Tana delta also being accompanied by a high sand dune that also offers protection.

Tourism and recreation seems much more developed in Ozi sub location more than in any other sub location, it is only in Ozi where it was reported that there are family members who work in the tourism industry and a number of products and services are on offer for tourists. Overall, the economic value of tourism and recreation is US$ 113.66/ ha/year which is significantly higher than the study on Gazi Bay by UNEP in 2011 that was valued at US$ 6.50/ ha/year, however it is within the global overview of between US$ 43 – 151,100/ ha/year (Spalding et al, 2010).

The total economic value of the mangroves is US$ 1053.92 which though close to the study conducted in Gazi Bay which was valued at US$ 1092.30, is still below the global overview which is between US$ 2000- 9000/ha/year (Spalding et al, 2010). This is majorly due to two reasons; carbon sequestration which is widely regarded as a major services that mangroves provide was never included in this study because of the laborius nature and resouce intensitiy associated with such a study, estuarine mangroves are known to sequster carbon by as much as 8 tonnes /ha/year (Murray et al, 2011) and, using a figure of US$ 7 /tonne/ha (UNEP, 2011) that

was used to estimate the carbon value of mangroves in Gazi Bay, an indicative figure of US$ 56 /ha/year excluding the value of existing carbon stocks ispossible; the other reason is the ban on harvesting of the biomass material from the forest which makes firewood and poles extraction and trade illigal.

Approval of the mangrove ecosystem services appears to decline as distance from the mangroves also increases, for instance, residents of Matangeni (the farthest subocation from the mangroves among the sublocations that were surveyed) reported the lowest approval for all of the mangrove ecosystem services identified. This probably points to a particular attention that decision makers need to do when stakeholder engagments are necessary, so that more representatiion of real stakeholders be engaged in such processses.

Contrary to the popular notion that flooding menace in the delta is caused by excess rainfall upstream, respndents, believe, that before the dams on the Tana river were constructed, they used to cope with natural flood events, however, it is the post dam construction floods usually occuring when the dam waters are released due overflow that cause destruction at the delta. They are therefore skeptical about the prospect of an additional dam being any better. From an ecological perspective, an additional dam whose among the many purpose is to eradicate flooding at the delta that is accused of destruction of property would translate into an ecological disaster to among others the mangroves. Reports of salinity levels at the delta conducted at different time periods gives an indication of a general incresase in salinity at the delta, with ranges of up to 35ppt being largely above the optimal salinity tolerable levels of most mangroves. Respondents believe that flood control in the delta through upstream projects such as High Grand Falls would lead to the decline of Mangroves. This belief is consistent with observations elsewhere specifically in Cahora Basa dam in River Zambezi where many of the

mangroves in the delta have dried out and died ,large mammals, have almost disappeared from the delta and floodplain 'recession agriculture' has declined significantly (Davies and Day 1998; Chenje and Johnson 1996). Water Act of 2002 and the Water Management Rules of 2007 provide for resrve flow which is supposed to guarantee environmental flows for the various ecosystems downstream, however, the reserve flow levels for the Tana River has not been established. The water rules also require early warning for downstrem communities during release of dam waters such as by the KenGen, it seems that such warnings either don't reach every household or they are ignored by some people since losses due to flooding have been reported in Ozi and Mpeketoni.

Majority of the respondents have awareness of the Lamu port, out of the three major development projects that will depend on the waters of Tana River. However, more than half of the respondents have no knowledge of the proposed one million acre scheme in Galana/Kulalu ranch and the High Grand Falls dam. This may suggest that despite the elaborate provisions for public participation in the Water Act of 2002 and Water Resource Management 2007, there could have been inadequate public engagement in Kipini, probably because these projects are spearheaded by agencies whose legal basis are not founded on strong public participation, and WRMA does not have a strong coordination role other than liaison with other bodies for the better regulation and management of water resources.

In the study, respondents who have membership to environmental groups, chose policy options that had more volunteer time for mangrove conservation than non-members, perhaps an indication that engaging communities on environmental education would improve their commitment to conservation of nature and natural resources.

CHAPTER 6: SUMMARY AND RECOMMENDATIONS

6.1. Summary

- Mangroves contribute significantly to the well-being of the people by providing a number of products such as fish, firewood, building materials, honey, and ecosystem services such as flood control, nursery and breeding ground for fish, shoreline protection, and tourism and recreation, and such should be safeguarded, enhanced and or considered/ factored during planning for the development of the delta and in deed the Tana basin.
- The economic values of the mangrove ecosystem goods and services are based on the local economy; therefore a comparative use of the values with any other economic activities should take cognisance of that.
- The method of public consultation and participation to sensitize the communities on the planned development projects on the Tana River might have not been effective.
- Given that Integrated River Basin Management is a tripartite approach to management and use of water resource in a basin ensuring that social, economic and environmental needs are adequately supplied by the water resource, it is vital for the framework to be employed in Tana catchment, currently, the policy and legal instruments have to good measure captured the letter of IRBM with a few areas needing improvement, however, the greatest challenge is the implementation of the IRBM where there are deficiencies on realities despite the legal backing.

6.2. Recommendations

In order to harness the economic benefits of the mangroves best, it is imperative that adequate ecological balance is maintained so that resource inputs neccesary for their good health is not disturbed. One such important ecologogical requirement is the salinity range and that is also affetced by the frequency and duration of the flooding of the delta largely by the upstream water through the Tana river flooding that usually breaks its bank during ainy season.

- Mangroves need regular flooding of the delta to neutralise the potential salinity increment beyond the tolerable levels of the various species that inhabit the area, a better design of upstream dams and irrigation projects to allow the ecosystem receive its fair share of the important resource input is desirable while also safeguarding people from the vagaries of the negative impact of floods.
- Mangroves should be planted along the shorelines particularly on the eastern/northern side of Kipini settlements to help check coastline erosion. In addition, the forest needs a restoration plan to reclaim its original state through reforestation.
- Public education on the significance of the mangroves and its contribution to the economic well-being of the residents of Kipini division need to be promoted including among policy and decision makers both at county and national levels to help in harnessing these values during appropriation of the Tana basin decision moments.
- A management plan for the mangroves in the Tana delta should be developed which should be informed by a study on the maximum sustainable yield establishment to help decision making on whether the ban on harvesting to stay or be lifted and instead controlled use be established, the plan should also be informed by a study on the mangroves' environmental flow requirements (salinity levels and the role of flooding).

- The figures for total economic values are conservative estimates due ban on harvesting of the mangroves and exclusion of the carbon stock values which have the potential contribute significantly. It is therefore further recommended that an assessment of the economic values of the carbon stocks in the Tana delta Mangroves be considered.
- The Water Act 2002 should be reviewed to among others provide for; cross sectoral-sectoral coordination among water related sectors and government institutions to be led by WRMA both at the catchment and national level, delegated subsidiarity in WRMA as opposed to the current de-concentration, repeal sections of the Act that exempts state schemes from holding water permits to promote water use efficiency.
- Government should review the Water Act 2002 and the Tana and Athi Rivers Development Authority Act Cap 774 to remove overlaps, inconsistences and conflicts in their roles and functions.
- The Water Resource Management Authority should urgently develop both ecological flow requirements for the catchment, and the basic human water needs to quantify the Tana River Reserve flow to help in integrated water management water allocation for social and economic prosperity.
- Catchment and Sub catchment management plans should reflect the local social and environmental conditions such as the unique farmers –pastoralists interactions. The plans should assign responsibility of tree planting to CFAs in areas where they exist to avoid conflicts within local institutions.
- Efficiency in irrigation systems should be enhanced, particularly in the government led irrigation schemes where canals are used.

- .WRMA should promote water use efficiency through among others ;engaging in public information campaigns which has the prospect of inculcating a shared vision for efficient use of water by consumers; developing water efficiency labeling or positive press for public and private sector institutions that use water resource efficiently, and promote formation of more WRUAs in the delta.

7. REFERENCES

Abernethy, C. L. (Ed.). (2001). *Intersectoral Management on River Basins: Proceedings of an International Workshop on Integrated Water Management in Water-Stressed River Basins in Developing Countries: Strategies for Poverty Alleviation and Agricultural Growth, Loskop Dam, South Africa, 16-21 October 2000* (Vol. 416). IWMI.

Accent. 2010. Review of Stated Preference and Willingness to Pay Methods. *Competition Commission.*

Adhikari, B., Baig, S. P., & Iftikhar, U. A. (2010). The use and management of mangrove ecosystems in Pakistan. *The Journal of Environment & Development*, *19*(4), 446-467.

Alan Pickaver & Dianeetha Sadacharan (eds.): The Benefits of Inter-linking Coastal and River Management, Twenty case studies world-wide indicate opportunities and constraints. Coastline Reports 10 (2007). EUCC-The Coastal Union. Available at http://www.eucc-d.de/icarm/CoastlineReports10_web.pdf

Andres, A. (2013). Tana River Disputes in a Drying Climate

Baker, R. S., & Fyles, I. H. (2010). *Water and Food Security in Central Asia*. C. Madramootoo, & V. Dukhovny (Eds.). Springer.

Bandaranayake, W. M. (1998). Traditional and medicinal uses of mangroves. *Mangroves and salt marshes*, *2*(3), 133-148.

Bann, C. (1998). The economic valuation of mangroves: a manual for researchers (No. sp199801t1). Economy and Environment Program for Southeast Asia (EEPSEA

Barbier E. B. (2011). Wetlands as natural assets, Hydrological Sciences Journal, 56 (8): 1360-1373.

Barbier, E. B., Acreman, M. C. and Knowler, D. 1997. *Economic valuation of wetlands: A guide for policy makers and planners.* Ramsar Convention Bureau, Gland, Switzerland.

Barbier, E. B., Acreman, M. C. and Knowler, D. 1997. *Economic valuation of wetlands: A guide for policy makers and planners.* Ramsar Convention Bureau, Gland, Switzerland.

Barbier, E.B., S. Baumgärtner, K. Chopra, C. Costello, A. Duraiappah, R. Hassan, A. Kinzig, M. Lehman, U. Pascual, S. Polasky, C. Perrings 2009. The Valuation of Ecosystem Services. Chapter 18. In: Naeem S., D. Bunker, A. Hector, M. Loreau and C. Perrings (eds.), Biodiversity, Ecosystem Functioning, and Human Wellbeing: An Ecological and Economic Perspective. Oxford University Press, Oxford, UK, pp. 248–262.

Bateman, I.J., Carson, R.T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D.W., Sugden, R., and Swanson, J., (2002), Economic Valuation with Stated Preference Techniques: A Manual. Edward Elgar, Ltd. Cheltenham, 458 pp.

Beck, R., Taiti, S.W. & Thalen, D.C.P. Land Use Along the Tana River, Kenya A Study with Small Format Aerial Photography and Microlight Aircraft. A.A. Balkema. Symposium on Remote Sensing for Resources Development and Environmental Management, Enschede August 1986. I. 1986. Boston, MA, USA.

Birol, E., Karousakis, K., & Koundouri, P. (2006). Using a choice experiment to account for preference heterogeneity in wetland attributes: the case of Cheimaditida wetland in Greece. *Ecological economics*, *60*(1), 145-156.

Blomquist, W., & deLeon, P. (2011). The Design and Promise of the Institutional Analysis and Development Framework. *Policy Studies Journal*, *39*(1), 1-6.

Brander, L. Gómez-Baggethun, G., Martín-López, B. and Verma, M. (2010). The economics of valuing ecosystem services and biodiversity, In Kumar P. (ed.) TEEB: The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations, Earth Scan, London and Washington. Chapter 5.

Bucx, T., W. van Driel, H. de Boer, S. Graas, V.T. Langenberg, M. Marchand and C. Van de Guchte. 2014: Comparative assessment of the vulnerability and resilience of deltas – extended version with 14 deltas - synthesis report. Delta Alliance report number 7. Delta Alliance International, Delft-Wageningen, The Netherlands

Butler, C., Chambers, R., Chopra, K., Dasgupta, P., Duraiappah, A. K., Kumar, P., ... & Niu, W. Y. (2003). Ecosystems and human well-being. *Ecosystems and human well-being a framework for assessment*, 71-84.

Callicott, J. B. (1997). Conservation values and ethics. *GK Meffe, CR Carroll (a cura di), Principles of conservation biology. Second edition. Sinauer Associates, Inc. Sunderland, Massachussets*.

Camacho, L. D., Gevaña, D. T., Carandang, A. P., Camacho, S. C., Combalicer, E. A., Rebugio, L. L., & Youn, Y. C. (2011). Tree biomass and carbon stock of a community-managed mangrove forest in Bohol, Philippines. *Forest Science and Technology*, *7*(4), 161-167.

Cameron, T. A., and J.R. DeShazo. 2013. "Demand for Health Risk Reductions." *Journal of Environmental Economics and Management* 56: 87-109.

Carson, R.T., and T. Groves. 2007. "Incentive and Informational Properties of Preference Questions." *Environmental & Resource Economics* 37: 181-210.

Christie, M., & Rayment, M. (2012). An economic assessment of the ecosystem service benefits derived from the SSSI biodiversity conservation policy in England and Wales. *Ecosystem Services*, *1*(1), 70-84.

Cole, D. H. (2013). The Varieties of Comparative Institutional Analysis. *2013 Wisconsin Law Review 383 (2013).*

Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. Available at http://www.ramsar.org/cda/en/ramsar-documents-texts/main/ramsar/1-31-38_4000_0__ accessed on 25th December 2013

Costanza, R., 2000. Social goals and the valuation of ecosystem services. Ecosystems 3, 4–10.

Dalmas Oyugi & M.L. Thieme. (2008). Tana, Athi & Coastal Drainages Major Habitat Type: tropical and subtropical coastal rivers. *Published by WWF/TNC*. Available at http://www.feow.org/ecoregion_details.php?eco=567

De Groot, R., Fisher, B., & Christie, M. (2010). The economics of valuing ecosystem services and biodiversity. *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Earthscan, Londres*.

De Groot, R., Brander, L., Van Der Ploeg, S., Costanza, R., Bernard, F., Braat, L., ... & Van Beukering, P. (2012). Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem services*, *1*(1), 50-61.

de Lacerda, L. D. (2002). *Mangrove ecosystems: function and management*. Springer Science & Business Media.

Do, T. N., & Bennett, J. (2009). Estimating wetland biodiversity values: a choice modelling application in Vietnam's Mekong River Delta. *Environment and Development Economics*, *14*(02), 163-186.

Donato. C.D., Kauffman. J.B, Murdiyarso. D., Kurnianto.S. Stidham.M., Kanninen.M. 2011. Mangroves among the most carbon-rich forests in the tropics. *Nature Geo Science.*

Dubois, O., & Lowore, J. (2000). *The'journey'towards collaborative forest management in Africa: lessons learned and some'navigational aids': an overview* (No. 15). IIED.

East African Wildlife Society [EAWS] (n.d.) Scarcity of Land and Resources is cause of Tana Delta Violence. Available at http://www.kenyawetlandsforum.org/Reports/Tana%20Delta%20fact%20sheet.pdf accessed on 5th April 2015

FAO. 2010. Global Forest Resources Assessment 2010. FAO Forestry Paper 163. Rome

Farber, S. C., Costanza, R., & Wilson, M. A. (2002). Economic and ecological concepts for valuing ecosystem services. *Ecological economics*, *41*(3), 375-392.

Farber, S. C., Costanza, R., & Wilson, M. A. (2002). Economic and ecological concepts for valuing ecosystem services. *Ecological economics*, *41*(3), 375-392.

Feller, C.L, M. Sitnik, ed (1996). Mangrove Ecology: A Manual for a Field Course. Washington. DC. Smithsonian Institution

Field CD (1995). Journey amongst mangroves. International Society for Mangrove Ecosystems, Okinawa, Japan

Garber-Yonts, B., Kerkvliet, J., & Johnson, R. (2004). Public values for biodiversity conservation policies in the Oregon Coast Range. *Forest Science*, *50*(5), 589-602.

Garcia, S. M., Zerbi, A., Aliaume, C., Do Chi, T., & Lasserre, G. (2003). Fisheries Management. 2. The ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fisheries. Rome: FAO*.

Garrod, G., Willis, K.G. 1999. Economic Valuation of the environment. Edward Elgar, Cheltenham.

Gleick, P. H. (1996). Basic water requirements for human activities: Meeting basic needs. *Water international*, *21*(2), 83-92.

Global Water Partnership [GWP] (2013). River basin organisations. Retrieved from http://www.gwp.org/en/ToolBox/TOOLS/Institutional-Roles/Creating-an-Organisational-Framework/River-basin-organisations/ accessed on 4th November 2015

Goulder, L.H., Donald, K., 1997. Valuing ecosystem services: philosophical bases and empirical methods. In: Daily, G.C. (Ed.), Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, DC, pp. 23–48.

Government of Kenya [GoK] (1966) Irrigation Act. *Government Printer, Nairobi*

Government of Kenya [GoK] (1981) Tana and Athi Rivers Development Authority Act. [Act No. 8 of 1981, s. 3.]

Government of Kenya [GoK] (1999) Water Policy, 1999. *Government Printer, Nairobi*

Government of Kenya [GoK] (1999). Environmental Management and Co-ordination Act, 1999. *Government Printer, Nairobi*

Government of Kenya [GoK] (2002). Water Act, 2002. *Government Printer, Nairobi*

Government of Kenya [GoK] (2005) Forest Act, 2005. *Government Printer, Nairobi*

Government of Kenya [GoK] (2007a).Sessional Paper No.1 of 2007 on Forest Policy. *Government Printer, Nairobi*

Government of Kenya [GoK] (2007b) Water Resource Management Regulations, 2007

Government of Kenya [GoK] (2008) Tana River Basin Catchment Management Strategy, 2008-2013. *Government Printer, Nairobi*

Government of Kenya [GoK] (2010) Agricultural Sector Development Strategy for 2010-2020 Retrieved from http://www.finland.or.ke/public/default.aspx?nodeid=46394&contentlan=2&culture=en-US. Accessed on 13th January 2015

Government of Kenya [GoK] (2012a) County Governments Act, 2012, *Government Printer, Nairobi*

Government of Kenya [GoK] (2012b) National Land Commission Act, 2012. *Government Printer, Nairobi*

Government of Kenya [GoK] (2013a) Agriculture, Fisheries and Food Authority Act, 2013. *Government Printer, Nairobi*

Government of Kenya [GoK] (2013b) Wildlife Conservation and Management Act, 2013. *Government Printer, Nairobi*

Government of Kenya [GoK] (2013c) Crops Act, 2013. *Government Printer, Nairobi*

Government of Kenya [GoK]. 2009. National Environment Action Plan Framework (2009-2013). Available at

Hagedorn, K. (2008). Particular requirements for institutional analysis in nature-related sectors. European Review of Agricultural Economics 35(3), 357-384.

Hagedorn, K.; Arzt, K. and Peters, U. (2002). Institutional Arrangements for Environmental Co-operatives: a Conceptual Framework. In: Hagedorn, K. (ed.): Environmental Cooperation

and Institutional Change: Theories and Policies for European Agriculture. Cheltenham: Edward Elgar, pp.3-25.

Hagedorn. K. 2014. Institutions of Sustainability. Available at http://www.institutions-of-sustainability.de/#top accessed on 6th March 2014

Herriges, J., C. Kling, C. Liu, and J. Tobias. 2010. "What are the Consequences of Consequentiality?" *Journal of Environmental Economics and Management* 59: 67-81

Hooper, B. (2010). River basin organisation performance indicators: application to the Delaware River basin commission: supplementary file. *Water Policy*, *12*, 1-24.

Hooper, B. P. (2005). *Integrated river basin governance: learning from international experiences*. IWA publishing.

Hunter, M. L. (1999). *Maintaining biodiversity in forest ecosystems*. Cambridge university press.

Hussain, Z. and Acharya, G. (Eds.) (1994). Mangroves of the Sundarbans, Volume **2:** Bangladesh". IUCN, Gland, Switzerland, 257 pp.

Imperial, M. T., & Yandle, T. (2005). Taking institutions seriously: using the IAD framework to analyze fisheries policy. *Society and Natural Resources*, *18*(6), 493-509.

Interis, M., & Petrolia, D. (2015). Coastal Ecosystem Services of the Gulf of Mexico: Does their Value Depend on the Providing Habitat?. In *2015 Annual Meeting, January 31-February 3, 2015, Atlanta, Georgia* (No. 196610). Southern Agricultural Economics Association.

Jansen, P.C.M., 2005. Xylocarpus granatum J.König In: Jansen, P.C.M. & Cardon, D. (Editors). PROTA 3: Dyes and tannins/Colorants et tanins. [CD-Rom]. PROTA, Wageningen, Netherlands

Jaspers, F. G. (2003). Institutional arrangements for integrated river basin management. *Water policy*, *5*(1), 77-90.

Jaspers, F. G. (2003). Institutional arrangements for integrated river basin management. *Water policy*, *5*(1), 77-90.

Jaspers. F. (2014). Towards Integrated Water Resources Management- International experience in development of river basin organisations. *United Nations Environment Programme*

Joint Nature Conservation Committee [JNCC] (2013). Ecosystem Services Valuation. Available at http://jncc.defra.gov.uk/default.aspx?page=6383 accessed on 20th August 2015

Kairo, J., C. Wanjiru, and J. Ochiewo. 2009. "Net Pay: Economic Analysis of a Replanted MangrovePlantation in Kenya." *Journal of Sustainable Forestry* 28 (3–5): 395–414.

Kairo, J.G. 1997. Mangrove Forests of Kenya, Status and Management. SAREC-Sida Regional Workshop on Mangrove Ecology, Physiology and Management. Zanzibar, Dec. 3-14.

Kathiresan K, Bingham BL (2001) Biology of mangroves and mangrove ecosystems. Adv Mar Biol 40:81–251

Kathiresan, K. "Threats to Mangrove: Degradation and Destruction of Mangrove." *Google website* (2007).

Kathiresan. K. 2008. Ecology and Environment of Mangrove Ecosystems. Available at http://ocw.unu.edu/international-network-on-water-environment-and-health/unu-inweh-course-1-mangroves/ accessed on 28th January 2014

Kenya Wetlands Forum. 2010. Types of wetlands. Available at http://www.kenyawetlandsforum.org/index.php?option=com_content&view=article&id=22&Itemid=12 accessed on 22nd January 2014

Khan, S., & Malano, H. (2009). Integrated modelling approaches to support water resource decision making: Crossing the chasm. In *18th World IMACS Congress and MODSIM09*

International Congress on Modelling and Simulation. Cairns, Modelling and Simulation Society of Australia and New Zealand and International Association for Mathematics and Computers in Simulation (pp. 3838-3843).

Klaphake, A. (2002). River Basin Management and the Economic Theory of Federalism. *Reforming Institutions for sustainable Water Management*, 71-80.

Knowler, D., Philcox, N., Nathan, S., Delamare, W., Haider, W., Gupta, K . (2009). *Assessing prospects for shrimp culture in the Indian Sundarbans: A combined simulation model link and choice experiment approach.* Marine Policy 33 (2009) 613–623

Komiyama A, Poungparn S, Kato S. 2005. Common allometric equations for estimating the tree weight of mangroves. J. Tropic. Ecol. 21:471–477.

Kosenius, A. K., & Ollikainen, M. (2011). Economic valuation of ecosystem services provided by coastal habitats in Finland, Sweden, and Lithuania. *Discussion Paper-Department of Economics and Management, University of Helsinki*, (57).

Koundouri, P., Scarpa, R., & Stithou, M. (2014). A choice experiment for the estimation of the economic value of the river ecosystem: Management policies for sustaining NATURA (2000) species and the coastal environment. In *Water Resources Management Sustaining Socio-Economic Welfare* (pp. 101-112). Springer Netherlands.

Krutilla, J.V. 1967. Conservation reconsidered. American Economic Review 57: 777–786.

Krutilla, J.V., Fisher, A.C. 1975. The Economics of the Natural Environment. Studies in the Valuation of Commodity and Amenity resources. John Hopkins Press for Resources for the Future, Baltimore.

Kuenzer, C., & Tuan, V. Q. (2013). Assessing the ecosystem services value of Can Gio Mangrove Biosphere Reserve: Combining earth-observation-and household-survey-based analyses. *Applied Geography*, *45*, 167-184.

Lasco RD, Pulhin FB. 2003. Philippine forest ecosystems and climate change: carbon stocks, rate of sequestration and the Kyoto Protocol. Ann. Tropic. Res. 25(2):37–51.

Leopold, Aldo, 1949. A Sand County Almanac. Oxford University Press, New York.

M.J.M. (2004). Economic valuation of Kenya's mangrove forest: a case study of Mida creek; Kilifi, Kenya.

Maingi, J. K., & Marsh, S. E. (2002). Quantifying hydrologic impacts following dam construction along the Tana River, Kenya. *Journal of Arid Environments*, *50*(1), 53-79

Makenzi et al., 2013*;* Trend Analysis of Climate Change and its Impacts on Crop Productivity in the Lower Tana River Basin, Kenya (*Octa Journal of Environmental Research) [*P. Makenzi*a, P. Ketiema, P. Omondib, E. Marangaa and C. Wekesac]

Martin, P. (2007). *Conflict and its Socio-economic Impact in Garsen Division, Tana-River District.* Eldoret: Moi University, Department of Anthropology.

Martinsson, P., Carlsson, F., & Alpizar, F. (2001). Using Choice Experiments for Non-Market Valuation. *rapport nr.: Working Papers in Economics, nr*, (52)

McNally, R., & Tognetti, S. S. (2002). *Tackling poverty and promoting sustainable development: Key lessons for integrated river basin management*. WWF-UK.

Ministry of Agriculture, Annual Report for Tana Delta District, 2012

Ministry of Energy [MOE] (2004) Sessional Paper No.4 on Energy. Retrieved from http://www.erc.go.ke/images/Regulations/SESSIONAL%20PAPER%204%20ON%20ENERGY%202004.pdf

Ministry of Environment and Mineral Resources, Kenya [MEMR]. 2012. Kenya Wetlands Atlas.

Ministry of Environment, Water and Natural Resources [MEWNR] (2013) National Environment Policy. Retrieved from

Ministry of Water and Irrigation [MWI] (2007) the National Water Resource Management Strategy, 2007-2009. *First Edition. Retrieved from* *http://wstf.go.ke/watersource/Downloads/006.%20Water%20Resources%20Management%20Strategy.pdf*

Ministry of Water and Irrigation [MWI] (2007) the National Water Service Strategy, 2007-2015. *Retrieved from* *http://www.wasreb.go.ke/policy-instruments*

Ministry of Water and Irrigation [MWI] (2009) Flood Mitigation Strategy. Retrieved from http://wescoord.or.ke/documents/Keydocs/FloodMitigationStrategy_MoWI_200906.pdf

Mireri, C. (2010). Tana River Delta (TRD) Conservation and Development Master Plan.

Mireri, C., Onjala, J., & Oguge, N. (2008). The Economic Valuation of the Proposed Tana Integrated Sugar Project (TISP), Kenya.

Mokhtar, M. B., Toriman, M. E. H., Hossain, M., Abraham, A., & Tan, K. W. (2011). Institutional challenges for integrated river basin management in Langat River Basin, Malaysia. *Water and Environment Journal*, *25*(4), 495-503.

Moore, R., Williams, T., & Rodriguez, E. (2011). Valuing Ecosystem Services from Private Forests.

Murray, B. C., Pendleton, L., Jenkins, W. A., & Sifleet, S. (2011). Green payments for blue carbon: Economic incentives for protecting threatened coastal habitats. *Nicholas Institute for Environmental Policy Solutions, Report NI*, *11*(04).

Mvula, P. M., & Haller, T. (2009). Common pool resource management in Lake Chilwa, Malawi: a wetland under pressure. *Development Southern Africa*, *26*(4), 539-553.

Mwatha, G. M. (2002). *Current status of trawl fishery of Malindi-Ungwana Bay* (p. 97). KMFRI final technical report.

Mwatha, G. M. (2002). *Current status of trawl fishery of Malindi-Ungwana Bay* (p. 97). KMFRI final technical report.

National Environment Management Authority [NEMA] (2009) Tana River District Environment Action Plan 2009-2013.

National Environment Management Authority, (EMA), Kenya. 2011. Kenya- State of the Environment and Outlook Report 2010

National Irrigation Board [NIB] (n.d) Mandate and Functions of NIB. retrieved from http://www.nib.or.ke/about-nib/mandate.html

Nature Kenya (n.d) Formation of Tana River Delta Community Forest Association Underway. Retrieved from *http://www.naturekenya.org/content/formation-tana-river-delta-community-forest-association-underway*

Oel, V. P., Krol, M. S., & Hoekstra, A. Y. (2007). A river basin as a common-pool resource: a case study for the Jaguaribe basin in Brazil.

Oezdemiroglu, E., Pearce, D., & Department for Transport, Local Government and the Regions (DTLR), London (United Kingdom), (2002). *Economic valuation with stated preference techniques-Summary guide*.

Okazawa, H., Toyoda, H., Suzuki, S., SHIMADA, S., & NISHIMAKI, R. (2009). Long-term-discharge Analysis Using the EPA Method for the Tana River in Kenya. *沙漠研究: 日本沙漠学会誌*, *19*(1), 57-60.

Olson D.M., Dinerstein E., Wikramanayake E.D., Burgess N.D., Powell G.V.N., Underwood E.C., D'amico J.A., Itoua I., Strand H.E., Morrison J.C., Loucks C.J., Allnutt T.F., Ricketts T.H., Kura Y., Lamoreux J.F., Wettengel W.W., Hedao P. And Kassem K.R. 2001. Terrestrial Ecoregions of the World: A New Map of Life on Earth. *BioScience* 51, 933-938.

Ong, J.E. & Gong, W.K. (2013) *Structure, Function and Management of Mangrove Ecosystems*. ISME Mangrove Educational Book Series No. 2. International Society for Mangrove Ecosystems (ISME), Okinawa, Japan, and International Tropical Timber Organization (ITTO), Yokohama, Japan.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge university press.

Ostrom, E. (1995, October). The institutional analysis and development framework: An application to the study of common-pool resources in sub-Saharan Africa. In *Paper, Bloomington Indiana: Workshop in Political Theory and Policy Analysis, Indiana University* (Vol. 10).

Ostrom, E. (2002). Common-pool resources and institutions: Toward a revised theory. *Handbook of agricultural economics, 2*, 1315-1339.

Ostrom, E. (2005). Self-governance and forest resources. *Terracotta reader: A market approach to the environment*, 131-154.

Ostrom, E. (2011). Background on the institutional analysis and development framework. *Policy Studies Journal*, *39*(1), 7-27.

Pagiola, S, K.Von Ritter, J. Bishop. 2004. Assessing the economic value of ecosystem conservation.

Parliament, T. V. (2011). POSTnote 378 - Ecosystem Service Valuation available at http://194.109.159.7/ukparliament/20110322165506/http://parliament.uk/documents/post/postpn_378-Ecosystem-Service-Valuation.pdf accessed 20th Match 2015

Pascual, U., Muradian, R., Brander, L., Gómez-Baggethun, E., Martín-López, B., & Verma, M. (2010). The Economics of Ecosystems and Biodiversity: The Ecological and Economic Foundations. *TEEB Documents*.

Pearce .D.W. and Moran. D. 1994 *The Economic Value of Cultural and Biological Diversity*, Earthscan, London.

Pearce, D., & Özdemiroğlu, E. (2002). *Economic valuation with stated preference techniques: summary guide*. Department for Transport, Local Government and the Regions.

Pearce, D.W. and Warford, J.J. 1993. *World without End*. Oxford University Press, Oxford

Pearce. D.W. and Warford. J. 1993 *World without End: Economics, Environment and Sustainable Development*, Oxford University Press, New York and Oxford.

Peña, H. (2011). *Social equity and integrated water resources management*. Global Water Partnership, Technical Committee (TEC).

Pessarakli, M. (Ed.). (1999). *Handbook of plant and crop stress*. CRC Press.

Pickmeier, U. (2011) Land Acquisitions in Tana Delta, Kenya (Bio-)fueling Local Conflicts? A Youth Perspective. Nijimegen: Radboud Universiy, Master thesis.

Plummer, M. L. (2009). Assessing benefit transfer for the valuation of ecosystem services. *Frontiers in Ecology and the Environment*, *7*(1), 38-45.

Polski, M. M., & Ostrom, E. (1999). An institutional framework for policy analysis and design. In *Workshop in Political Theory and Policy Analysis Working Paper W98-27. Indiana University, Bloomington, IN*.

Prager, K. (2010). Applying the institutions of sustainability framework to the case of agricultural soil conservation. *Environmental Policy and Governance*, *20*(4), 223-238.

Ramsar Convention Secretariat, 2010. *River basin management: Integrating wetland conservation and wise use into river basin management.* Ramsar handbooks for the wise use of wetlands, 4th edition, vol. 9. Ramsar Convention Secretariat, Gland, Switzerland.

Ratner, B. D. (2011). *Common-pool resources, livelihoods, and resilience: Critical challenges for governance in Cambodia* (No. 1149). International Food Policy Research Institute (IFPRI).

Ravilious, Corinna, M. Taylor, and Edmund P. Green. "Mangroves of East Africa." (2003). UNEP-WCMC

Richter, B. D., Mathews, R., Harrison, D. L., & Wigington, R. (2003). Ecologically sustainable water management: managing river flows for ecological integrity. *Ecological applications*, *13*(1), 206-224.

Robertson, A. I., & Alongi, D. M. 1992. Tropical mangrove ecosystems (Vol. 41, pp. 1-330). American Geophysical Union. Page 126.

Robertson, A.I. and Alongi, D.M. 1992. *Tropical Mangrove Ecosystems*. American Geophysical Union, Washington, DC

Rogers, K. and R. Bestbier. 1997. Development of a Protocol for the Definition of the Desired State of Riverine Systems in South Africa. Pretoria (S.Africa): South African Wetlands Conservation Programme, Dept. of Environmental Affairs and Tourism.

Rosenberger RS and Phipps TT. 2007. Correspondence and convergence in benefit transfer accuracy: a meta-analytic review of the literature. In: Navrud S and Ready R (Eds).

Environmental values transfer: issues and methods. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Rosenberger, R. S., & Loomis, J. B. (2001). Benefit transfer of outdoor recreation use values: a technical document supporting the Forest Service Strategic Plan (2000 revision). *General Technical Report-Rocky Mountain Research Station, USDA Forest Service*, (RMRS-GTR-72).

Rügnitz, M. T.; Chacón, M. L.; Porro R. 2009. *Guía para la Determinación de Carbono en Pequeñas Propiedades Rurales*. 1. ed. Lima, Perú: Centro Mundial Agroflorestal (ICRAF) /Consórcio Iniciativa Amazônica (IA). 79 p.

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.

Samoilys, M., Osuka, K., & Maina, G. W. (2011). Review and assessment of biodiversity values and conservation priorities along the Tana Delta-Pate Island coast of northern Kenya.

Sathirathai, S., & Barbier, E. B. (2001). Valuing mangrove conservation in southern Thailand. *Contemporary Economic Policy*, *19*(2), 109-122

Saunders, F. (2011). The Politics of People-not just mangroves and monkeys: A study of the theory and practice of community-based management of natural resources in Zanzibar.

Schlager, E. (2004). Common-pool resource theory. *Environmental Governance Reconsidered. MIT Press, Cambridge*, 145-176.

Schmitt C.B., Belokurov A., Besançon C., Boisrobert L., Burgess N.D., Campbell A., Coad L., Fish L., Gliddon D., Humphries K., Kapos V., Loucks C., Lysenko I., Miles L., Mills C.,

Minnemeyer S., Pistorius T., Ravilious C., Steininger M. and Winkel G. 2009. Global Ecological Forest Classification and Forest Protected Area Gap Analysis. Analyses and recommendations in view of the 10% target for forest protection under the Convention on Biological Diversity (CBD). 2nd revised edition. Freiburg University Press, Freiburg, Germany.

Secours Islamique France [SIF]. (2013.) Tana River, Tana Delta, Ijara, Lamu Assessment report May 2013

Secretariat of the Convention on Biological Diversity [CBD] .2010. Global Biodiversity Outlook 3. Montreal. 94 pages

Selvam, V. E. (2007). Trees and shrubs of the Maldives. *RAP Publication*, (12).

Semesi, A.K. 1986. Zonation and vegetation structure of mangrove communities in Tanzania. In: Status and Utilisation of Mangroves. Mainoya, J.R. and Siegel, P.R. (Eds.). Proceedings of a Workshop on "Save the Mangrove Ecosystems in Tanzania", 21-22 February 1986. Faculty of Science, University of Dar es Salaam, pp. 15-36.

Semesi. A. K.1998. Mangrove Management and Utilization in Eastern Africa. Ambio.Vol. 27, No. 8, Building Capacity for Coastal Management (Dec., 1998) , pp. 620-626 Published by: Springer on behalf of Royal Swedish Academy of Sciences. Stable URL: http://www.jstor.org/stable/4314807 accessed on 23rd January 2014

Singh, A., Diop, S., & M'mayi, P. L. (2006). Africa's lakes: atlas of our changing environment.

Smith, L., Porter, K., Hiscock, K., Porter, M. J., & Benson, D. (Eds.). (2015). *Catchment and river basin management: integrating science and governance*. Routledge.

Standard, 2011. State Firms Warned over sh1b Water Bill

Talaat, R., Turner, R. K., Grant, A., & Fisher, B. Visitor Preferences for Coral Reef Conservation in Ras Mohammed National Park.

Tana and Athi Rivers Development Authority [TARDA] (n.d) Projects. Retrieved from http://www.tarda.co.ke/projects/

Tana River Delta. 2004. Tana River Delta, Kenya. Available at

TEEB (2010), The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan, London and Washington

TEEB (2010). The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan, London and Washington. Chapter 5.

The Economics of Ecosystem and Biodiversity [TEEB]. n.d. Glossary of Terms. http://www.teebweb.org/resources/glossary-of-terms/ (accessed 27th January 2014)

The Economics of Ecosystem and Biodiversity [TEEB]. n.d. TEEB Training for National Level Implementation. http://www.teebweb.org/resources/training-resource-material/module-one/ (accessed 27th January 2014).

Tibor Vegh, Megan Jungwiwattanaporn, Linwood Pendleton, and Brian Murray. 2014. *Mangrove Ecosystem Services Valuation: State of the Literature.* NI WP 14-06. Durham, NC: Duke University.

Trombulak, S. C., Omland, K. S., Robinson, J. A., Lusk, J. J., Fleischner, T. L., Brown, G., & Domroese, M. (2004). Principles of Conservation Biology: Recommended Guidelines for Conservation Literacy from the Education Committee of the Society forConservation Biology*. *Conservation biology*, *18*(5), 1180-1190.

UNEP (1998) Eastern African Atlas of Coastal Resources. Available at http://gridnairobi.unep.org/chm/EAFDocuments/Kenya/Eastern_Africa_Atlas_of_Coastal_Resources_Kenya.pdf accessed on 30th March 2015

UNEP (2010). *Guidance manual for the valuation of regulating services*.

UNEP (United Nations Environment Programme). 2011. *Economic Analysis of Mangrove Forests: A Case Study in Gazi Bay, Kenya*. New York: UNEP.

UNEP, 2011. *Economic Analysis of Mangrove Forests: A case study in Gazi Bay, Kenya*, UNEP, iii+42 pp.

van Beukering, P., Brander, L., Tompkins, E., & Mackenzie, E. (2007). *Valuing the environment in small islands: An environmental economics toolkit*. Joint Nature Conservation Committee.

Van Lavieren, H., Spalding, M., Alongi, D., Kainuma, M., Clüsener-Godt, M., and Adeel, Z. 2012. Securing the Future of Mangroves. A Policy Brief. UNU-INWEH, UNESCO-MAB with ISME, ITTO, FAO, UNEP-WCMC and TNC. 53 pp.

Wanyumu.D.G (2011) Lower Tana WRUAs. *Water Resource Management Authority*

Watson, N. (2004). Integrated river basin management: A case for collaboration. *International Journal of River Basin Management*, *2*(4), 243-257

Wegerich, K. (2002). Natural drought or human made water scarcity in Uzbekistan. *Central Asia and the Caucasus*, *2*(14), 154-162.

White, D., Minang, P., & Agus, F. (2011). Estimating the opportunity costs of REDD+– A training manual. *World Bank, Washington DC, USA*.

Winpenny. J. (2007). Financing Water Infrastructure and Services: An introductory guide for practitioners in developing countries. *Working Draft. EU Finance Working Group*

8. LIST OF ANNEXES

Annex 1: Stakeholders (Public Institutions and their Roles)

Institution	Functions, Powers and projects
Water Resource Management Authority (WRMA)	• To develop principles, guidelines and procedures for the allocation of water resources; • To monitor, and from time to time reassess, the national water resources management strategy; • To receive and determine applications for permits for water use • To monitor and enforce conditions attached to permits for water use • To regulate and protect water resources quality from adverse impacts • To manage and protect water catchments • In accordance with guidelines in the national water resources management strategy, to determine charges to be imposed for the use of water from any water resource • To gather and maintain information on water resources and from time to time publish forecasts, projections and information on water resources • To liaise with other bodies for the better regulation and management of water resources • With the consent of the Attorney-General given under the Criminal Procedure Code, undertake the prosecution of any offences arising under the Water Act of 2002 or in connection with the performance of its functions *Source: (GoK, 2002)*
Water Services Regulatory Board (WASREB)	• To determine standards for the provision of water services to consumers • To establish procedures for handling complaints made by consumers against licensees; • To monitor compliance with established standards for the design, construction, operation and maintenance of facilities for water services;

	• To monitor and regulate licensees and to enforce licence conditions • To develop guidelines for the fixing of tariffs for the provision of water services; • To develop guidelines for and provide advice on the cost effective and efficient management and operation of water services; • To promote water conservation and demand management measures • In accordance with the national water services strategy, to determine fees, levies premiums and other charges to be imposed for water services • To liaise with other bodies for the better regulation and management of water • The board may, with the consent of the Attorney- General given under the Criminal Procedure Code, undertake the prosecution of any offences arising under the Water Act or in connection with the performance of its functions *Source: (GoK, 2002)*
Coast Water Services Board (CWSB)	• Is responsible for the efficient and economical provision of water services authorised by the licence. • Water services authorised by a licence shall be provided by an agent of the board in accordance with section 55 of the water Act of 2002, except in circumstances where the regulatory Board is satisfied that the procurement of an agent is not possible or that the provision of services by an agent is not practicable *Source: (GoK, 2002)*
National Irrigation Board	• Established under the National Irrigation Board Act Chapter 347 Laws of Kenya • To promote and improve national irrigation schemes in the country • Conducting research and investigation into the establishment of national schemes; • Designing, constructing, supervising and administering irrigation schemes • Coordinating and planning settlement on national irrigation schemes;

	• Determining the number of settlers to be accommodated in national irrigation schemes; • Formulating and executing policy regarding national irrigation schemes in conjunction with the Water Resource Authority; *However, in 2002 the board restructured itself following changes in government policy to focus its activities in;* • Coordination of construction and rehabilitation of major irrigation and drainage infrastructure; • Operation and maintenance of major irrigation and drainage infrastructure; • Administering land in the public schemes and providing technical advice to farmers *Source: (GoK, 1966; NIB,n.d).*
Tana and Athi Rivers Development Authority (TARDA)	• Created by an act of parliament (CAP 443) in 1974 • Advises the Government generally and the Ministries responsible for agriculture, economic planning, natural resources, power, wildlife, water development, finance and the office of the president, in particular on all matters affecting the development of the Tana River Basin including the apportionment of water resources • To draw up and keep up-to-date, a long-range development plan for the Area

	• To initiate such studies, and to carry out such surveys, of the Area as it may consider necessary, and to assess alternative demands within the Area on the resources thereof, including electric power generation, irrigation, wildlife, land and other resources, and to recommend economic priorities • To co-ordinate the various studies of, and schemes within, the Area so that human, water, animal, land and other resources are utilized to the best advantage, and to monitor the design and execution of planned projects within the Area • To effect a programme of monitoring of the performance of projects within the Area so as to improve that performance and establish responsibility there for, and to improve future planning • To ensure close co-operation between all agencies concerned with the abstraction and use of water within the Area in the setting up of effective monitoring of that abstraction and use • To collect, assemble and correlate all such data related to the use of water and other resources within the Area as may be necessary for the efficient forward planning of the Area • To maintain a liaison between the Government, the private sector and foreign agencies in the matter of the development of the Area with a view to limiting the duplication of effort and to assuring the best use of technical resources • To cause the construction of any works necessary for the protection and utilization of the water and soils of the area *Source: GoK (1981)*
	Activities and Projects TARDA is operating a rice irrigation scheme project in the Tana Delta which it states to have the potential for 1700 ha of rice production under irrigation. Currently 1500 acres of maize is being grown under the economic stimulus programme. The authority employs furrow irrigation method which is not an efficient way to utilize the resource

	Source: (TARDA, n.d)
Agriculture, Fisheries Food Authority	• Promote best practices in, and regulate, the production, processing, marketing, grading, storage, collection, transportation and warehousing of agricultural and aquatic products excluding livestock products • Advise the national government and the county governments on agricultural and aquatic levies for purposes of planning, enhancing harmony and equity in the sector; • Advices the Cabinet Secretary, who in consultation with the National Land Commission, provide land development guidelines, applicable in respect of any category of agricultural land to the owners or the occupiers thereof which shall be implemented by the respective county governments taking into account the circumstances of the respective areas under their jurisdiction. • Advices the Cabinet Secretary, who in consultation with the National Land Commission, for the purposes of the conservation of the soil, or the prevention of the adverse effects of soil erosion on, any land, may, prescribe national guidelines for any or all of the matters— (a) prohibiting, regulating or controlling the undertaking of any agricultural activity including the firing, clearing or destruction of vegetation when such prohibiting, regulating or controlling is deemed by the Cabinet Secretary to be necessary for the protection of land against degradation, the protection of water catchment areas or otherwise, for the preservation of the soil and its fertility; (b) requiring, regulating or controlling— (i) the afforestation or re-afforestation of land; (ii) the drainage of land, including the construction, maintenance or repair of drains, gullies, contour banks, terraces and diversion ditches; (iii) salination, acidification and saltification of soil *Sources: (GoK, 2013a).*
Kenya Forest	• The roles and functions of the Kenya Forest Services have been drawn from the Kenya Forest Act of 2005

Service	• Manage all State forests • Manage all provisional forests in consultation with the forest owners • Protect forests in Kenya in accordance with the provisions of this Forest Ac of 2005 • Draw or assist in drawing up management plans for all indigenous and plantation State, local authority, provisional and private forests in collaboration with the owners or lessees, as the case may be • Enforce the conditions and regulations pertaining to logging, charcoal making and other forest utilisation activities • Collect all revenue and charges due to the Government in regard to forest resources, produce and services • Develop programmes and facilities in collaboration with other interested parties for tourism, and for the recreational and ceremonial use of forests • Collaborate with other organisations and communities in the management and conservation of forests and for the utilisation of the biodiversity therein • Promote the empowerment of associations and communities in the control and management of forests • Manage forests on water catchment areas primarily for purposes of water and soil conservation, carbon sequestration and other environmental services • Enforce the provisions of the Act and any forestry and land use rules and regulations made pursuant to any other written law. *Source: (GoK, 2005)*
National Environment Management Authority (NEMA)	• Established under the Environment and Management Coordination Act (EMCA) of 1999 • To co-ordinate the various environmental management activities being undertaken by the lead agencies and promote the integration of environmental considerations into development policies, plans, programmes and projects with a view to ensuring the proper management

	and rational utilization of environmental resources on a sustainable yield basis for the improvement of the quality of human life • Take stock of the natural resources in Kenya and their utilisation and conservation • Establish and review in consultation with the relevant lead agencies, land use guidelines • Examine land use patterns to determine their impact on the quality and quantity of natural resources • Carry out surveys which will assist in the proper management and conservation of the environment • Identify projects and programmes or types of projects and programme, plans and policies for which environmental audit or environmental monitoring must be conducted under this Act • Monitor and assess activities, including activities being carried out by relevant lead agencies, in order to ensure that the environment is not degraded by such activities, environmental management objectives are adhered to and adequate early warning on impending environmental emergencies is given • Undertake, in co-operation with relevant lead agencies, programmes intended to enhance environmental education and public awareness about the need for sound environmental management as well as for enlisting public support and encouraging the effort made by other entities in that regard • Render advice and technical support, where possible, to entities engaged in natural resources management and environmental protection so as to enable them to carry out their responsibilities satisfactorily • In consultation with the relevant lead agencies, issue guidelines for the management of the environment of lakes and rivers
	Powers of NEMA- *NEMA may, after giving reasonable notice of its intention so to do, direct any lead agency to perform, any of the duties imposed upon*

	the lead agency, in the field of environment and if the lead agency fails to comply with such directions, the Authority may itself perform or cause to be performed the duties in question, and the expense incurred by it in so doing shall be a civil debt recoverable by the Authority from the lead agency *Source: (GoK, 1999)*
Kenya Wildlife Service (KWS)	• To conserve and manage national parks, wildlife conservation areas, and sanctuaries under its jurisdiction; To provide security for wildlife and visitors in national parks, wildlife conservation areas and sanctuaries; • To set up a county wildlife conservation committee in respect of each county • To promote or undertake commercial and other activities for the purpose of achieving sustainable wildlife conservation • To collect revenue and charges due to the national government from wildlife and, as appropriate, develop mechanisms for benefit sharing with communities living in wildlife areas • To develop mechanisms for benefit sharing with communities living in wildlife areas; • To coordinate the preparation and implementation of ecosystem plans • To assist and advise in the preparation of management plans for community and private wildlife conservancies and sanctuaries; • To undertake and conduct enforcement activities such as anti- poaching operations, wildlife protection, intelligence gathering, investigations and other enforcement activities for the effective carrying out of the provisions of the Act; (o) identify user rights and advise the Cabinet Secretary thereon. *Source: (GoK, 2013b)*
National Land Commission	• To manage public land on behalf of the national and county governments • To recommend a national land policy to the national government • To advise the national government on a comprehensive programme for the registration of title in land throughout Kenya

	• To conduct research related to land and the use of natural resources, and make recommendations to appropriate authorities • To encourage the application of traditional dispute resolution mechanisms in land conflicts • To monitor and have oversight responsibilities over land use planning throughout the country • On behalf of, and with the consent of the national and county governments, alienate public land • Monitor the registration of all rights and interests in land • Ensure that public land and land under the management of designated state agencies are sustainably managed for their intended purpose and for future generations • Manage and administer all unregistered trust land and unregistered community land on behalf of the county government • Develop and encourage alternative dispute resolution mechanisms in land dispute handling and management *Source: (GoK, 2012b)*
County Government	• Agriculture, including— crop and animal husbandry; livestock sale yards; county abattoirs; plant and animal disease control; and fisheries. • County health services, including, in particular— county health facilities and pharmacies; veterinary services, refuse removal, refuse dumps and solid waste disposal. • Control of air pollution, noise pollution, other public nuisances and outdoor advertising • Cultural activities, public entertainment and public amenities, including— racing cinemas; video shows and hiring; libraries; museums; sports and cultural activities and facilities; and county parks, beaches and recreation facilities • County transport, including—county roads; street lighting; public road transport; and ferries and harbours

	• Animal control and welfare, including— facilities for the accommodation, care and burial of animals. • Trade development and regulation, including— markets; trade licences; fair trading practices; local tourism; and cooperative societies • County planning and development, including— statistics; land survey and mapping; boundaries and fencing; housing; and electricity and gas reticulation and energy regulation. • Implementation of specific national government policies on natural resources and environmental conservation, including— soil and water conservation; and forestry • County public works and services, including— storm water management systems in built-up areas; and water and sanitation services • Firefighting services and disaster management • Ensuring and coordinating the participation of communities' and locations in governance at the local level and assisting communities and locations to develop the administrative capacity for the effective exercise of the functions and powers and participation in governance at the local level. • facilitate the development of a well-balanced system of settlements and ensure productive use of scarce land, water and other resources for economic, social, ecological and other functions across a county • Maintain a viable system of green and open spaces for a functioning eco-system • Protect the historical and cultural heritage, artefacts and sites within the county • Work towards the achievement and maintenance of a tree cover of at least ten per cent of the land • To develop — county integrated development plan; county sectoral plans; county spatial plan *Source: (GoK, 2012a)*

Water Resource Users Association	• Water Resource User Association (WRUA), is an association of water users, riparian land owners, or other stakeholders who have formally and voluntarily associated for the purposes of cooperatively sharing, managing and conserving a common water resource • The membership of WRUAs is recommended to be open to any individual, water project, company, or organisation who impacts or benefits from a particular water resource • Promotion of controlled and legal water use activities, • Safeguard the reserve flows for downstream ecological demands and basic human requirements • Reduce and solve water use conflicts • Promote catchment conservation measures to improve water quantity and quality. *Source: (GoK, 2007)*
	• *The Tana delta has been delineated by WRMA to have a potential of close to seven WRUAs, in which the most active ones at include Lake Kenyatta, Witu and Shakababo WRUAs (Wanyumu, 2011.)*

Community Forest Association	• These are voluntary associations by members of a forest community duly registered under the societies Act laws of Kenya as provided for in the Forest Act of 2005, and a) may apply to the Director of Forest Service for permission to participate in the conservation and management of a state forest or a local authority forest (now under County Governments) • To protect, conserve and manage such forest or part thereof pursuant to an approved management agreement entered into under this Act and the provisions of the management plan for the forest; • To formulate and implement forest programmes consistent with the traditional forest user rights of the community concerned in accordance with sustainable use criteria • To protect sacred groves and protected trees • To assist the KFS in enforcing the provisions of the Forest Act and any rules and regulations made, in particular in relation to illegal harvesting of forest produce; • With the approval of the Board enter into partnerships with other persons for the purposes of ensuring the efficient and sustainable conservation and management of forests • The Community Forest Associations may also be conferred any of the following forest user rights – collection of medicinal herbs; harvesting of honey; harvesting of timber or fuel wood; grass harvesting and grazing; collection of forest produce for community based industries; ecotourism and recreational activities; scientific and education activities; plantation establishment through non-resident cultivation; contracts to assist in carrying out specified silvicultural operations; development of community wood and non-wood forest based industries *Source: (GoK, 2005)*

	There is a process in place to form a community forest association in the Tana delta called the Tana Delta Community Forest Association, which could potentially oversee the sustainable management and conservation of the over seventy thousand (over 70,000ha) hectares of gazetted forest in delta which include; Kokani forest (61,495.5 ha), Mwina forest (3,347.2 ha), Hewani forest (2,698.2 ha) and mangrove ecosystems in Ozi, Kipini and Chara locations (2,665 ha) (Nature Kenya, 2014).
Community Wildlife Association	• According to Wildlife Conservation and Management Act of 2013, communities, landowners, groups of landowners and existing representative organizations may establish a community wildlife association and register under the appropriate law or in the case of an individual owner may be registered as a recognized wildlife manager by the County Wildlife Conservation and Compensation Committee • To facilitate conflict resolution and cooperative management of wildlife within a specified geographic region or sub-region. • Ensure that the association membership or the wildlife manager protects, conserves and manages wildlife conservancies and sanctuaries under their jurisdictions pursuant to their respective approved management plans • Assist the service in combating illegal activities, including poaching and bush meat trade • Keep the regional wildlife conservation area committee informed of any development changes and occurrences within their area that may adversely affect wildlife *Source: (GoK, 2013b)*

Annex 2: Water Sector Policies and Strategies

Policies/ strategies	Required/permitted actions
The Water Policy of 1999	• The ministry in charge of water to clearly define the roles of all actors in the water sector with emphasis on the role of the government to be that of regulatory and monitoring • Decision making process in regard to water resource management is to be decentralised by adopting three water resource management levels comprising national, basin, and sub catchment coupled by setting up institutions at the three levels • Use of water for agriculture and calls for construction of dams to conserve water where it occurs naturally and harnessing of surface run off to support irrigation using non wasteful irrigation practices • Use of water for livestock development through provision and conservation of all water available and occurring within livestock rearing areas through construction of water pans and ground water harvesting • Use of water for wildlife through development and conservation of water resources within national parks and reserves • Use of water for fisheries through ensuring that design of impounding structures take into account the existing aquatic life • Identification and development of appropriate water supply system to meet the current and future industrial demand for water • To ensure that wastewater from industrial establishments will be treated before being discharged into natural water river courses • Use of water for energy through facilitating the process aimed at energy production while at the same time ensuring that appropriate conservation measures are in place to realise sufficient quantity of water • A national standing committee will be established that will also spearhead the formulation of a consolidated policy on land, water and forest • Government to encourage enhanced participation in water development

	activities by stakeholders and to set a collaborative mechanism with stakeholders for mobilisation of resources for water development. • Development of retardation basins for flood management *Source: (GoK, 1999)*
	• Policy acknowledges the potential of conflict among water resource users including from various sectors to agencies tasked with water resource management and development however, it does not provide the tools for conflict resolution • Policy does not provide for assessment of the relative environmental, economic and social values of water
National Water Resource Management Strategy	**Reserve Water** It has priority over all water uses and the requirements of the Reserve must be met before water can be allocated for other uses. For cases where water is already allocated for use the requirement of the ecological reserve may be met progressively over time *(MWI, 2007a).*
National Water Service Strategy	• To reduce unaccounted for water due to both economic and technical losses to 30% by 2015 • To achieve operation and maintenance cost recovery of all WSS systems gradually by 2010 with the exception of targeted subsidies to the poor • Investments shall promote demand management and stakeholder involvement • The Ministry shall ensure that coordination and cooperation on national level between the different Ministries and state agencies as well as partner institutions and agencies are effective and efficient *Source: (MWI, 2007b)*
Tana River Basin Catchment Management	• The social needs of water in as much as the economic importance is equally important • The regional WRMA will support involvement of WRUAs to solve water conflicts

Strategy, 2008-2013	• Water allocation will be guided by the Water Allocation Plan (WAP) to capture the priorities, procedures, and management controls that relate to the sharing of the resource between the different users • Flood management will be through development of procedures for multi-purpose dams in collaboration with TARDA • The main activities for protecting against flood include: compilation of an inventory of high risk flood sites; Study of hydrologic regime and elaboration of hydrologic forecasting models; Construction of flood protection structures (i.e. dams, dykes) in upstream locations and at vulnerable sites (multipurpose storage development); Organizing the land use and human activities in vulnerable zones; Designing and implementing flood warning systems; Developing and implementing an emergency plan in case of inundations • The main activities for alleviating drought effects include: constructing inter-seasonal regulating structures and water transfer canals; implementing an emergency plan in order to face drought periods • Management tools: cooperation with NEMA and all other relevant institutions to ensure that Environmental Impact Assessment (EIA) is appropriately done; significant impacts of all development options and other interventions will be assessed; Social and environmental considerations will be accorded the same attention as those of technical, financial and economic nature • The strategy provides estimates of the cost of its implementation and identifies the means for financing. • The roles of other agencies such as KenGen, NIB, TARDA, WSB, NEMA among others duly recognised and their participation in the various water resource management approaches *Source: (GoK, 2008)*

Flood Mitigation Strategy	• A flood mitigation strategy was developed by the Ministry of Water and Irrigation in 2009 • Reducing Vulnerability through improved livelihoods- subsidized agricultural inputs, affordable and appropriate rural credit facilities, marketing infrastructure, crop diversification • Integrated Approach to Water Resources Development and Flood Management • Entrenchment of flood mitigation in CMS through improved land use planning • Soil and water conservation measures should be enhanced in collaboration with the Ministry of Agriculture • Flood embankment (Structural Measures) • Flood Preparedness/ Flood forecasting through updating flood monitoring network, and setting up appropriate communication system to provide advance flood warning to the village level communities • Establishment of a flood management fund by the ministry of water and irrigation • Creation of a flood management unit at WRMA with a mandate to carry the following functions: establishing a Flood Information System through compilation of flood damage data; planning, design and project formulation; construction supervision and maintenance of flood management works and coordination with other related Ministries and organizations *Source: (MWI, 2009)*
	Interventions for Tana River Basin include • Design dykes for the valley bottoms with high to medium vulnerability community and infrastructure • Implementation of the Tana Delta Irrigation Scheme and the sub catchment drainage system by the Ministry of Water and Irrigation and that of Lands and Agriculture (MWI, 2009)

Annex 3: Water Related Policies and Strategies

Policies	Required /Permitted Action
Agriculture policy (Agricultural Sector Development Strategy for 2010-2020)	**Water and Irrigation Sub Sector** *Finalization and implementation of the national irrigation policy and legal framework to:* • Fully develop and exploit the irrigation and drainage potential in the country • Coordinate, manage and regulate the core activities within the irrigation and drainage subsector • Establish and promote a multi-sectoral approach to sustainable irrigation and drainage development and management *Intensification and expansion of irrigation-* • Acceleration of the development of irrigation and drainage through financing the construction of major irrigation, drainage and flood control infrastructure to attain Vision 2030 target of developing 32,000 ha per annum and 704,000 ha of new irrigation areas by 2030 • Improvement of the performance and productivity of existing irrigation schemes, • Strengthening of the irrigation water users' associations to ensure that they have capacity and resources to operate optimally and maintain the irrigation systems in schemes. *Improvement of rainwater harvesting and storage for agriculture-* • Enforcement of the law that requires each irrigation scheme to develop facilities that store water for 90 days for agricultural production; • Investment in the development of storage facilities for smallholder and national irrigation schemes *Rehabilitation and protecting water catchments*

	Implementation of the irrigation flagship project • construction of the Tana Delta Project, aimed at irrigated sugar production covering 16,000 ha **Increasing Area under Cultivation in the ASAL (ASAL Development)** • About 9.2 million ha of irrigation potential in the ASALs will be exploited, particularly the Tana and Athi basins **Developing River Basins and large Water Bodies** *Conserving River Banks, water bodies and Catchments* • The regional development subsector will carry out feasibility studies to protect and conserve the environment, and will formulate and implement programmes and projects that promote protection and conservation of river banks, water bodies and catchments areas in collaboration with communities and stakeholders. *Integrated River Basin Development* • The regional development subsector will formulate and implement integrated programmes and projects that will increase hydropower generation, area under irrigation, storage water capacity and area under catchments conservation.
	• The Agricultural Sector Coordination Unit (ASCU) was established in 2005 to address the fragmentation of responsibilities between agriculture and rural development-related ministries and non-state actors. The ASCU secretariat has personnel seconded from key constituent ministries. • The ASCU mandate is to facilitate and add value to the reform process and to coordinate the efforts of sector ministries and other stakeholders towards implementing the ASDS vision. • ASCU will link the sector players and provide an enabling environment for sector-wide consultations. ASCU will not be involved in the actual implementation of the strategy. However, it shall coordinate budgeting within the sector, and participate in the review of subsector strategic and annual work plans to ensure they conform to ASDS, Vision 2030, the MDGs and other Government development agenda.

	Source: (GoK, 2010)
Energy policy	• The energy policy of 2004 acknowledges that the Environment Management and Coordination Act of 1999 requires that all energy development projects be subjected to environmental Impact assessments and licenses be granted prior to their implementation. • Periodic environmental audits are required to be made and licenses cancelled for defaulters thus terminating the project and the policy empowers to ERC to ensure investors comply by giving it the legal authority to be a one-stop office for permitting and licensing of generation, transmission and distribution. • The policy also acknowledges that construction and operation of electric power projects have direct impacts on the quality of the environment either by the emission of pollutants or by changing the ecological systems, but does not prescribe the effects. It also does not provide for cooperation and coordination with other relevant agencies *Source: (MOE, 2004)*
Environment policy	• Use of innovative environmental management tools such as incentives, disincentives, total economic valuation, indicators of sustainable development, Strategic Environmental Assessments (SEAs), Environmental Impact Assessments (EIAs), Environmental Audits (EA) and Payment for Environmental Services (PES); • Promotion and enhancement of cooperation, collaboration, synergy, partnerships and participation in the protection, conservation, sustainable management of the environment and natural resources. • Promotion of sustainable use of freshwater and wetland resources and the conservation of river and lake ecosystems through development and implementation of river basin management plans, Development and implementation of a national wetland policy and regulations; • Development and implementation of catchment-based wetland management plans for all Ramsar sites through a participatory process,

	• Rehabilitation and restoration of degraded wetlands, riverbanks and lakeshores and, as appropriate, promote and support establishment of constructed wetlands, • Harmonisation and coordination of the roles of various regulatory agencies charged with the management of freshwater and wetland ecosystems; • Promotion of sustainable use of marine resources and the conservation of vulnerable coastal ecosystems, • Development and implementation of a harmonised Integrated Coastal Zone Management (ICZM) Policy, • Harmonisation and coordination of the roles of various regulatory agencies charged with the management of coastal and marine resources, • Involvement and empowerment of communities in the management of coastal and marine ecosystems; • Application of Integrated Water Resources Management (IWRM) in ASALs with a view to harvesting flood and river water, • Involvement and empowerment of communities in the management of ASAL ecosystems; Protection, conservation and improvement of the habitats, corridors and dispersal areas of wildlife and protection of endangered wildlife species, and involvement of community participation in conservation activities; • Protection of fish breeding grounds and implement closed season's regulations where necessary; Development and implementation of an environment-friendly livestock production policy that takes cognizance of livestock mobility and communal management of natural resources. • For coordination and multi sectoral cooperation the government will institutionalize cooperative governance and integrated approach to the management of the environment and natural resources by explicitly identifying and integrating environmental considerations in relevant sectoral and cross-sectoral policies, laws, planning and development

	process. • Government will develop and implement delegation instruments to provide a framework for cooperative and collaborative management between NEMA and the lead agencies *Source: (MEWNR, 2013)*
Forest Policy	• A coordinated and participatory approach to forest conservation and management • Subsidiarity-The management of forest resources will be through the decentralization and devolution of authority and responsibilities to the lowest level possible • Precautionary Principle-where there are credible threats of serious or irreversible damage to forest resources, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation • Polluter and User Pays Principle: The polluter and user of forest resources shall be responsible for paying for the full environmental and social costs of the damage done to the natural environment as a result of their activities • Establishment of mechanisms for building partnerships as well as cross and inter-sectoral coordination between government agencies, communities, and the private sector, and non-state organizations • Establishment and maintenance of a Forest Resource Account for inclusion in the System of National Accounts • Domesticate environmental and other sectoral policies in order to achieve the national development objectives • Develop and implement a national strategy for the rehabilitation, restoration and protection of degraded forest ecosystems, not least indigenous forests, and forests located in water catchment areas • Encourage the preparation of participatory forest management plans with community forestry associations on public land, and determine the user

	rights specific to the availability of forest resources • Encourage private sector participation in the establishment and management of forest plantations on public and community through the granting of concessions on a competitive basis • Encourage species diversification through consideration of indigenous and well screened exotic tree species to meet requirements of the market • Recognize explicitly cross-cutting issues in developing and implementing national forest strategies, programmes and plans *Source: (GoK, 2007)*

Annex 4: Water Sector Laws

Laws/Regulations	Permitted/required action	Prohibited action	Sanctions authorized for rule breaking
Water Act 2002	Formation of a catchment/ basin advisory committee; Regulation of multiple uses of water; and conservation and protection of the resource;		
	Right to use water which entail abstraction or use of water from a water resource for domestic use which does not involve employment of works- within the meaning of the Act; Right to use water where any development of ground water, where none of the works necessary for the development are situated— (i) within one hundred metres of any body of surface water (other than in closed spring water); or (ii) within a ground water conservation area; Right for the storage of water in, or the abstraction of water from, a dam constructed in any channel or depression which WRMA has		Penalties on neglects or fails to comply with any order or requirement given or imposed on abstraction of groundwater water shall be guilty of an offence and liable on conviction to a penalty not exceeding one hundred thousand shillings

	declared, by notice published in the Gazette, not to constitute a watercourse; Other use of water upon which a permit has been issued by WRMA		
			Contravention of any, or of any specified, conditions prescribed by or under the Water Act 2002 as conditions of licences shall constitute an offence punishable by a penalty not exceeding one hundred thousand shillings
			A person who is guilty of an offence under the Water Act, or under any rules or regulations made under the Water Act, shall, if no other penalty is prescribed in respect of the offence, be liable to a fine not exceeding one hundred thousand shillings or to imprisonment for a term not exceeding

			twelve months, or to both
	Determination of the requirements of the reserve for each water resource		
	Identification of areas which should be designated protected areas and ground water conservation areas		
	For conflict resolutions the act provides for the establishment of a Water Appeals Board hear and determine appeal concerning a license or permit and disputes. In addition, water resources users associations are also empowered to carry out conflict resolution and co-operative management of water resources in catchment areas *Source: (GoK, 2002)*		
Irrigation Act	Minister to make regulations on the rates payable for, the use of water on national irrigation scheme		Any regulations made under this section may provide for such penalty for the breach of any provision thereof, not exceeding a fine of ten thousand shillings and imprisonment for one year, as the Minister may think fit.

	The Minister may, by notice in the *Gazette*, designate any area of land to be a national irrigation scheme, In respect of land, other than Trust land, in a national irrigation scheme, the Minister, shall, in accordance with the law for the time being relating to the compulsory acquisition of land, take such steps as may be necessary to acquire the right, title or interest in such land and to vest it in the Board for the purposes of this Act, In the case of Trust land forming part of a national irrigation scheme, the Minister, on behalf of the Board, may take the land on lease, on terms to be agreed between the Minister and the county council (now county government) concerned.		
	Source: (GoK, 1966)		
Water Rules of 2007	Permitted uses of water resource in Kenya include: dam/ weir construction; hydropower generation; supply of water for domestic, public, commercial or industrial use; irrigation among others.		

	Dam and weir operators to make designs that would ensure compensation flow[5] is maintained		
	The operator of any dam shall notify the WRMA and persons downstream likely to be affected in the event of any discharge from the dam that might result in damage downstream and also be responsible for taking adequate measures to protect persons, infrastructure and environment downstream likely to be affected in the event of any discharge from the dam that might result in damage downstream		Failure to comply is an offence punishable through a fine not exceeding fifty thousand shillings or imprisonment for a term not exceeding three months or both.
		Late submission of the application for the renewal of permit……..	….which attracts a penalty of five hundred shillings per month;
		Failure to comply with rules governing the dam/weir water discharges/ release	Fine not exceeding fifty thousand shillings or to imprisonment for a term not exceeding six months or both.
	Applicants intending to abstract ground water shall make an application for the approval of the		Any person who contravenes the provisions of the rule on ground

[5] compensation flow is the flow released from a dam or weir which is required for downstream uses and the Reserve

	Authority		water authorisation shall be guilty of an offence and shall be liable to a fine not exceeding ten thousand shillings or imprisonment for a term not exceeding three months or both
		undertaking any activity that damages or hinders the proper functioning of water resource monitoring network[6] and failing to make good the damage or cover the costs of repair…….	…….which attracts a fine not exceeding fifty thousand shillings or to an imprisonment for a term not exceeding three months or to both
		Failing to notify WRMA of variation of water permit ……	…….attracts a fine not exceeding ten thousand shillings or imprisonment for a term not exceeding three months or to both
	Provisions for implementation and enforcement of the water rules include; a water resource inspector who is empowered to inspect water resource related works before permits are issued or renewed; use of permits, review of public complaints *Source: GoK, 2007b)*		

[6] the set of equipment, infrastructure established for the purpose of monitoring the quantity and quality of the water resources

Annex 5: Water Sector Related Laws

Laws/Regulations	Permitted/required action	Prohibited action	Sanctions authorized for rule breaking
Agriculture, Fisheries, Food Authority Act	The Cabinet Secretary, on the advice of the Authority, and in consultation with the National Land Commission, for the purposes of the conservation of the soil, or the prevention of the adverse effects of soil erosion on, any land, may, prescribe national guidelines for any or all of the following matters— (a) prohibiting, regulating or controlling the undertaking of any agricultural activity including the firing, clearing or destruction of vegetation when such prohibiting, regulating or controlling is deemed by the Cabinet Secretary to be necessary for the protection of land against degradation, the protection of water catchment areas or otherwise, for the preservation of the soil and its fertility; (b) requiring, regulating or controlling— (i) the afforestation or re-afforestation of land; (ii) the drainage of land, including the construction, maintenance or repair of drains, gullies, contour banks, terraces and diversion ditches; (iii)	Where an owner or occupier against whom a land preservation order is made refuses or fails to comply with the terms of the order, the county government may authorize another person or body of persons, to enter upon the land to which the order relates and to carry out such works on or to place such things in, on or over the land as are required to be done by the order or which are otherwise necessary to comply with, and any person who obstructs the execution of any such works, or any part thereof, or the placing of any such things in, on or over the land commits an offence.	The expenses incurred in or about the exercise of the powers conferred by subsection (1) shall be a debt due to the Government from the owner or occupier of the land affected, as the county government may determine, or from the owner and occupier of the land affected in such proportions as the county government may determine.

	salination, acidification and saltification of soil; (c) requiring the uprooting or destruction, without payment of any compensation therefor, of any vegetation which has been planted in contravention of a land preservation order; (d) requiring the supervision of unoccupied land; (e) prohibiting, restricting or controlling the use of land for any agricultural purpose excluding livestock.		
			A person who contravenes or fails to comply with the terms of any land preservation order duly served upon him or her commits an offence and shall be liable, on conviction, to a fine not exceeding two hundred thousand shillings or imprisonment for a term not exceeding one year or both, and in addition, in the case of a continuing offence, to a fine not exceeding one hundred shillings for each day on which the offence continues.

	Source: (GoK, 2013a)		
Crop Act	Soil and water conservation will be conducted by the county governments		
	The Cabinet Secretary shall, with the advice of the Authority, develop rules for identifying agricultural land suitable for the production of each of the scheduled crops		
	The process of identifying agricultural land shall be based on valid representations in accordance with constitutional principles of participation of, the people, good governance, transparency and accountability		
	The county governments may from time to time, through the relevant county executive committee member, identify land suitable for the production of each of the listed crops		
	Source: (GoK, 2013c)		
Forest Act 2005	Forests is recognized to play a vital role in the stabilization of soils and ground water, thereby supporting the conduct of reliable agricultural activity, and that they play a crucial role in protecting water catchments in Kenya and moderating climate by absorbing greenhouse gases. Water is recognized as one of the produce of a forest		
	All indigenous forests and woodlands shall be managed		

	on a sustainable basis for purposes of: - conservation of water, soil and biodiversity; riverine and shoreline protection; cultural use and heritage; sustainable production of wood and non-wood products; carbon sequestration and other environmental services; and habitat for wildlife in terrestrial forests and fisheries in mangrove forests.		
	The Minister in charge of forests can make rules for- controlling the harvesting, collection, of forest produce; prescribing the amount of royalties or fees payable generally or in particular cases; regulating the use and occupation of state forest land for the purposes of residence, cultivation, grazing, tourism, recreation, camping, picnicking, cultural activities, industrial or any other similar activities; regulating entry into a nature reserve		
	Source: (GoK, 2005)		
Environmental Management and Coordinated Act, 1999	The Minister may, by notice in the Gazette, declare a lake shore, wetland, coastal zone or river bank to be protected area and impose such restrictions as he considers necessary, to protect the lake shore, wetlands, coastal zone and river bank from environmental degradation. In declaring a	No person shall, without prior written approval of the Director-General given after an environmental impact assessment, in relation to a river, lake or wetland: Erect, reconstruct	Any person who – hinders or obstructs an environmental inspector in the exercise of his duties under this Act or regulations made thereunder; misleads or gives

	lake shore, wetland, coastal zone or river bank a protected area, the Minister shall take into consideration the following factors – (a) the geographical size of the lake shore, wetland, coastal zone or river bank; and (b) the interests of the communities resident around the lake shore, wetland, coastal zone or river bank concerned.	place, alter, extend, remove or demolish any structure or part of any structure in, or under the river, lake or wetland; Excavate, drill, tunnel or disturb the river, lake or wetland; Deposit any substance in a lake, river or wetland or in, on, or under its bed, if that substance would or is likely to have adverse environmental effects on the river, lake or wetland; Direct or block any river, lake or wetland from its natural and normal course; Drain any lake, river or wetland	wrongful information to an environmental inspector (h) fails, neglects or refuses to carry out an improvement order issued under this Act by an environmental inspector; commits an offence and shall, on conviction be liable to imprisonment for a term not exceeding twenty four months, or to a fine of not more than five hundred thousand shillings, or both.
	The Minister may, by notice in the Gazette, issue general and specific orders, regulations or standards for the management of river banks, lake shores, wetlands or coastal zones and such orders, regulations or standards may include management, protection, or conservation measures in respect of any area at risk of environmental degradation and		Any person who fails to submit a project report contrary to the requirements of section 58 of this Act; fails to prepare an EIA report in accordance with the requirements of this Act or

	shall provide for – (a) the development of an overall environmental management plan for a lake, river, wetland or coastal area, taking into account the relevant sectoral interests; (b) measures for the prevention or control of coastal erosion; (c) the conservation of mangrove and coral reef ecosystems; (d) plans for the harvesting of minerals within the coastal zone, including strategies for the restoration of mineral sites; (e) contingency plans for the prevention and control of all deliberate and accidental discharge of pollutants into the sea, lakes or rivers; (f) plans for the protection of wetlands; (g) the regulations of harvesting of aquatic living and non-living resources to ensure optimism sustainable yield		regulations made thereunder; fraudulently makes false statements in an EIA report submitted under this Act or regulations made thereunder; commits an offence and is liable on conviction to imprisonment for a term not exceeding twenty four months or to a fine of not more than two million shillings or to both such imprisonment and fine.
	The Authority shall, in consultation with the relevant lead agencies, issue guidelines for the management of the environment of lakes and rivers.		Any person who – contravenes any environmental standard prescribed under this Act; contravenes any measure prescribed under this Act; (c) uses the environment or natural resources in a wasteful and destructive manner

			contrary to measures prescribed under this Act; commits an offence and shall be liable upon conviction, to a fine of not more than five hundred thousand shillings or to imprisonment for a term of not more than twenty four months or to both such fine and imprisonment.
	The Minister may declare the traditional interests of indigenous communities customarily resident within or around a lake shore, wetland, coastal zone or river bank to be protected interests.		Any person who discharges any dangerous materials, substances, oil, oil mixtures into land, water, air, or aquatic environment contrary to the provisions of this Act; pollutes the environment contrary to the provisions of this Act; discharges any pollutant into the environment contrary to the provisions of this Act; commits an offence and shall on conviction, be

			liable to a fine not exceeding five hundred thousand shillings.
			Any person who commits an offence against any provision of this Act or of regulations made thereunder for which no other penalty is specifically provided is liable, upon conviction, to imprisonment for a term of not more than eighteen months or to a fine of not more than three hundred and fifty thousand shillings or to both such fine and imprisonment.
			When an offence against this Act, is committed by a body corporate, the body corporate and every director or office of the body corporate who had knowledge of the commission of the offence and who did not exercise due diligence,

			efficiency and economy to ensure compliance with this Act, shall be guilty of an offence.
	Management tools include, Environmental Impact Assessment and Environmental Audits for the following activities and projects: major changes in land use, **Transportation including –** all roads in scenic, wooded or mountainous areas and wetlands, water transport; **Dams, rivers and water resources including –** storage dams, barrages and piers, river diversions and water transfer between catchments, flood control schemes, drilling for the purpose of utilising ground water resources; Mining, including quarrying and open-cast extraction; **Forestry related activities including –** timber harvesting, clearance of forest areas, reforestation and afforestation; **Agriculture including –** large-scale agriculture, use of pesticide, introduction of new crops and animals, use of fertilizers, irrigation; **Natural conservation areas including –**creation of national parks, game reserves and buffer zones; establishment of wilderness areas; formulation or modification of forest management policies; formulation or modification of water catchment management policies; commercial exploitation of natural fauna and flora		
	Source: (GoK, 1999)		

Annex 6: Patterns of Interactions

Actors	Patterns of Interactions
Relationships among direct resource users (community members)	
Pastoralists, farmers, Fisher Folks, Hunters and Gatherers, Water Suppliers	There is no homogeneity among the communities in the Tana delta, with difference being seen in cultural practices, economic mainstays, religious affiliations, and ethnic composition/ diversity There are potential conflicts largely between pastoralist and farmers. Farmers occupy lands adjoining the river and other water resource, and pastoralists need to access water in the river and lush pasture along the river during drought and this usually causes conflicts. However, conflicts are never reported between different resource users of the same religion. There is close linkage between pastoralists and farmers during the dry seasons in which pastoralists move in their livestock to the delta for river water and lush pasture which causes collision with farmers who reside next to the river for small scale irrigation farming. Small scale irrigators are happy if there are no floods which would otherwise destroy their crops, which is contrary to the aspiration of the flood recession farmers who need flood waters for their crops.
Relationship among director resource uses and water sector institutions	
Direct resource users (Farmers, pastoralists, Fisher folks, hunters and gatherers)	• Small scale irrigation farmers obtain permit from WRMA to abstract water from River Tana • Large scale farmers are hosted in the TARDA irrigation scheme

Relationship among direct resource users and the water sector related institutions	
Farmers and the Hydro dam	There is a general feeling by the direct resource users and inhabitants of the Tana delta that flooding in the delta only becomes an hazard when the hydropower dam operators release the dam waters usually during rainy seasons, such floods displace settlers and destroy crops, water suppliers mainly in Garsen town also decry that such floods also destroy their water supply facilities. On other hand, a no flood situation is not good either, farmers in Ozi reported increased salinity during dry seasons on their farmers largely due to salt intrusion from the ocean water during high tides, these are usually moderated by the river water which they call 'maji baridi' which would translate to mean cold river waters, effects of cold river to neutralize salinity is enhanced by the flood water.
Regional Authorities	River water users are concerned that application of pesticides and disease control chemicals in the irrigations scheme cause pollution of the river water resulting into health implications for the aquatic fauna
Wildlife institutions	Wildlife poaching was banned in 1975 which essentially mean that one of the sources of livelihoods for hunters and gatherers has been declared illegal, reports indicate that the hunters and gatherers are diversifying their livelihoods to bridge the gaps occasioned by the ban.
Relationship among water institutions and the non-water institutions	
Water institutions and flood management institutions	• This is an area that is interlinked, whereas the water Act of 2002 that made a lot of reforms did not come strong on flood management, WRMA has since been tasked with the mandate of flood management • WRMA also requires dam developers to ensure that their activities do not cause flood destruction to downstream communities.
Water institutions and energy generating institutions	• Hydro electricity generators build/ operate dams for power generation and WRMA requires dam operators to; have permits, ensure that the river flow is maintained, give flood warning in case of discharge to downstream communities. However, in case dam operator is a government scheme, they are not expected to require permit to operate according to the Water Act 2002.

Water institutions and agriculture institutions	The Agriculture Authority's role of advising the CS on agriculture for prescribing guidelines and regulations on any land for the protection of water catchment areas, and afforestation and reforestation of any land presents an opportunity that can see actions that individual land owners required to take measures that would reduce catchment degradation emanating from poor farming practices, what is lacking is the provision for liaison with other lead agencies as to whether the lead agencies can cause the authority to action.
Water institutions and forest institutions	Both WRMA and KFS have similar mandates on some issues such as to manage and protect water catchments. WRMA is mandated to liaise with other bodies for the better regulation and management of water resources
Water institutions and Environment Institutions	• NEMA has powers to direct any lead agency to perform any of the duties imposed upon the lead agency, in the field of environment and if the lead agency fails to comply with such directions, NEMA shall itself perform or cause to be performed the duties in question, and the expense incurred by it in so doing shall be a civil debt recoverable by the Authority from the lead agency • Some activities permitted by WRMA on water resource development require NEMA's approval through environmental impact assessments and audits • There are certain overlaps in mandates of WRMA and NEMA concerning water resources which on one hand can create checks and balances and on the hand can be a source of conflict like in the case of effluent discharge where the two institutions require payments for discharge and conflicting standards on charges
Water institutions and wildlife institutions	KWS is a partner of WRMA for a number of activities that WRMA needs to undertake such as; assessment and classification of both surface and ground water sources that are located in National parks and reserves which is a jurisdictional domain of the KWS.
Water institutions and the	WRMA and NEMA will need to work with County government to ensure that there is proper refuse dumps and solid waste disposal that does not pollute water resources.

County Government	
Water Institutions and Regional Development Authority (TARDA)	• There is massive overlap and conflict on jurisdictional functions and mandate between WRMA and TARDA concerning water resource management; TARDA has mandate of setting up effective monitoring of abstraction and use of water in the Tana Catchment while WRMA also has a similar role of monitoring and enforcing conditions attached to permits for water use; TARDA also has the mandate to collect, assemble and correlate all such data related to the use of water and other resources within the area for the efficient forward planning of the Area, which is similar to WRMA's role of gathering and maintaining information on water resources and publishing forecasts, projections and information. • Whereas TARDA has the mandate to ensure close co-operation between all agencies concerned with the abstraction and use of water, WRMA's mandate is to liaise with other bodies for the better regulation and management of water. This looks like reversed roles between the institutions. • Unlike WRMA whose main role is in regulation, conservation, protection and monitoring, TARDA is mandated to further engage in water development works in Tana catchment making it to be a referee and a player in water resource management.

Annex 7: Market Price Questionnaire

SECTION A: QUESTIONNAIRE IDENTIFICATION

Division……Location……Sub-location……..

Village…… Date……

Interviewer……

SECTION B: MANGROVE PRODUCTS PRODUCER SURVEY

Question 1. Do you collect mangrove products / and or make goods from mangroves?	
01. Yes	
02. No	If No ,Go to question 12
Question 2. When you were/are in mangrove forest, which of the following things did/do you do? (Tick all that apply)	
01. Collected Firewood	
02. Charcoal burning	
03. Collected / made poles for fencing	
04. Collected poles for building huts/ built hut using mangroves	
05. Collected poles for building / built boat traps using mangrove poles	
06. Collected poles for boat construction/ constructs (ed) boats	
07. Made dyes from mangroves	
08. Medicinal herbs	
09. Fodder	
10. Poles for Furniture/made furniture	
11. Honey	
12. Fish	

Question 3. Which one of following best describe what you did with products you collected and or made			
	Used at home	Sold	Both
01. Collected Firewood			
02. Charcoal burning			
03. Poles for fencing			
04. Poles for/ building huts			
05. Poles for/ building boat traps			
06. Poles for/constructed boat			
07. Dyes			
08. Medicinal herbs			
09. Fodder			
10. Poles for Furniture /furniture			
11. Honey			
12. Fish			

Question 4.

State the quantity of mangrove products that you harvested/made last year from Kipini

product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
01. Collected Firewood												
02. Charcoal burning												
03. Poles for fencing												
04. Poles for building huts												
05. Poles boat traps												
06. Poles for boat construction												
07. Tannin and dyes												
08. Medicinal herbs												
09. Fodder												
10. Poles for Furniture												
11. Honey												
12. Fish												

Question 5.

How much did you sell the products (in Ksh.) sold per bundle/ pole/ item/ sack/ of mangrove products that you harvested last year from Kipini

product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
01. Collected Firewood												
02. Charcoal burning												
03. Poles for fencing												
04. Poles for building huts												
05. Poles for boat traps												
06. Poles for boat construction												
07. Dyes												
08. Medicinal herbs												
09. Fodder												
10. Poles for Furniture												
11. Honey												
12. Fish												

Question 6.

Do you use some of the product (s) you harvest/ make locally at home? If yes, what quantity and at what rate do you consume it? What is the price of its substitute?

Products	Amount used at home	Rate of use e.g. weekly	Substitute product	Price of the substitute product
01. Firewood			e.g. kerosene	
02. Charcoal			e.g. kerosene	
03. Poles for fencing				
04. Poles for building huts				
05. Poles for building boat straps				
06. Poles for building boats				
07. Tannins and dyes				
08. Herbs				
09. Fodder				
10. Furniture				
11. Fish				
12. Honey				

Question 7.

Do you use mangrove as an herbal medicine? If yes which ailments do you treatment with it?

01.	……
02.	……
03.	…….
04.	……

Question 8. a. How much time do you spend to collect/ make the following products?	
01. Firewood	
02. Charcoal burning	
03. Poles for fencing	
04. Poles for building huts	
05. Poles for building boat traps	
06. Poles for boat construction	
07. Tannin and dyes	
08. Medicinal herbs	
09. Fodder	
10. Furniture	
11. Honey	
12. Fish	

b. Are there variations in time taken during certain periods of the year? If yes then indicate time per product per month below												
Product	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
01. Firewood												
02. Charcoal												
03. Fencing poles												
04. Hut build. poles												
05. Boat building poles												
06. Boat straps pole												
07. Tannin & dyes												
08. Herbs												
09. Fodder												
10. Furniture												
11. Honey												
12. Fish												

Question 9. What equipment do you use to harvest and or make the products? Are they hired, bought or owned by family?				
	Equipment	bought	hired	Owned by family
01. Firewood				
02. charcoal				
03. Fencing poles				
04. Hut building				
05. Boat strap making				
06. Boat building				
07. Tannin and dyes				
08. Herbs				
09. Fodder				
10. Furniture				
11. Honey				
12. Fish				

Question 10. What are your sources of labour when harvesting/making the mangrove product (s)			
Product	Hired labour	Family labour	Amount paid
01. Firewood			
02. Charcoal			
03. Fencing poles			
04. Hut building			
05. Boat strap making			
06. Boat making			
07. Tannins and dyes			
08. Herbs			
09. Fodder			
10. Furniture			
11. Honey			
12. Fish			

Question 11.

Do you pay charges for harvesting or selling the product (s)? If yes how much and how frequent?

Product	**charges**	**Amount paid**	**Frequency**
01. Firewood			
02. Charcoal			
03. Fencing poles			
04. Hut building			
05. Boat strap making			
06. Boat making			
07. Tannins and dyes			
08. Herbs			
09. Fodder			
10. Furniture			
11. Honey			
12. Fish			

SECTION B: MANGROVE PRODUCTS CONSUMER SURVEY

Question 12. Do you use the following mangrove products?

	Yes	No
01. Firewood		
02. charcoal		
03. Timber		
04. Furniture		
05. Building materials		
06. Boat constructed from mangrove poles		
07. Boat strap made of mangrove		
08. Dyes made of Mangroves		
09. Fish		
10. Honey collected from mangrove forest		
11. Herbal medicine from mangrove		
N/B- If respondents say no to both question 1 and 12 then terminate the interview and look for the next respondent		

Question 13. State the quantity of mangrove products that you used last year from Kipini												
Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
01. Firewood												
02. Charcoal												
03. Timber												
04. Furniture												
05. Building materials												
06. Boat (s)												
07. Boat strap												
08. Tannin and dye												
09. Fish												
10. Honey												
11. Herbal medicine												
12. Fish												

Question 14. How much did you buy the products bought per bundle/ pole/ item/ sack/ of mangrove products last year from Kipini												
Product	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
01. Firewood												
02. Charcoal												
03. Timber												
04. Furniture												
05. Building materials												
06. Boat (s)												
07. Boat strap												
08. Tannin and dye												
09. Fish												
10. Honey												
11. Herbal medicine												
12. Fish												

Question 15.	
If you use herbal medicine from Mangroves, which diseases/illness did u treat using the herbs	
01	……..
02	……..
03	……..
04	……
05	……..
06	……..

SECTION C: HOUSEHOLD CHARACTERISTICS:

I would like to ask you some questions about yourself. This will help me understand why respondents' opinions may differ. ***Please be assured that your answers are anonymous and all information collected is confidential***

Question 16. What is your age? (write the exact in the box)	
Age in Years	
Question 17. What is your gender?	
01. Male	
02. Female	
Question 18. How many people live in your household, including yourself? (Please count separately the number of adults and children supported by your household)	
01. Adults	
02. Children (below 18 years)	

Question 19. What is the highest level of education you have obtained (until now)?	
01. Never went to school	Years……
02. Primary	Years……
03. Secondary	Years……
04. Diploma	Years……
05. Certificate	Years……
06. University degree	Years……
07. Post-graduate degree	Years……
Question 20. Which of the following describe your source of domestic water (tick one only)	
01. Piped into dwelling	
02. River/stream	
03. Borehole	
04. Shallow well	
05. Spring	
06. Sand dam	
07. Water pan	
08. Other (specify)	
Question 21 Do you belong to any environmental or social group?	
01. Environmental organisation	
02. Fishing Industry	
03. Tourism industry	
04. pastoralism	
05. Agricultural industry	
06. Other (specify)…….	

Question 22. What is your main source of income? (Tick one only)	
01. Fishing	
02. Crop farming	
03. Pastoralism	
04. Business	
05. Salary	
06. Wages	
07. Remittance	
08. Other (specify) ……..	
Question 23 What is the distance in km from your place of residence to the nearest market?	
Question 24. Do you have access to loan?	
01. Yes	
02. No	
Question 25. Annual household income – Please indicate the approximate total **annual income** (before taxes) by all members of your household. The ranges between brackets are annual income. As for all your answers, information provided here is **strictly confidential**!	
01. Under Ksh. 28,800	
02. Ksh. 28,801- 60,000	
03. Ksh.60,001-120,000	
04. Kshs. 120,001- 180,000	
05. Kshs. 180,001-240,000	
06. Ksh.240,001-300,000	
07. Kshs.300,001-360,000	
08. Ksh.360,001-480,000	
09. Ksh.480,001-600,000	
10. Ksh.600,001-1,200,000	
11. Above Kshs. 1,200,001	

THANK YOU

Annex 8: Choice Experiment Questionnaire

ECONOMIC VALUATION OF ECOSYSTEM SERVICES OF MANGROVES AT KIPINI FOREST

SUB SAMPLE 3

SECTION A: QUESTIONNAIRE IDENTIFICATION

Division…….Location……Sub-location……

Village……Date…….

Interviewer……

SECTION B: INFORMATION AND HOUSEHOLDSS VIEWS OF MANGROVES

KNOWLEDGE OF MANGROVES IN KIPINI

I would like to know how familiar you are with the mangrove forest in Kipini

B1: Have you ever visited the mangroves forest in the last 5 years? (Tick inside box)	
01. Never visited	
02. Visited once	
03. Visited between one and 10 times	
04. Visited more than 10 times	
05. I live within the 5 five kilometres radius from the mangrove forest	

B2

In a scale of 1 to 5, do you agree that mangroves provide the following services to the people?

Service	Fully disagree 1	disagree 2	Somewhat agree 3	agree 4	Fully agree 5
Nursery and breeding ground for fish					
Shoreline Protection					
Flood Control					
Tourism and Recreation					

B3. Think about the status of mangroves in Kipini. Which box do you think best describes the condition of the forest in terms of degradation? (Please tick one box)

01. Heavily degraded	
02. Somewhat degraded	
03. Good State	
04. Excellent state	

B4. In a scale of 1 to 5, to what extent are you aware of the following projects in the Tana River Basin; High Grand Fall Dam, Million acres scheme, and Lamu Port.?

Where 1 = never heard, 2 = vaguely heard, 3 = heard, 4 = know something, 5 = well informed

	never heard 1	vaguely heard 2	Heard 3	know something 4	Well informed 5
01. High Grand Falls Dam					
02. A million acres irrigation scheme					
03. Lamu Port					

Mangroves need flooding water so that they are able to provide more of nursery and breeding ground for fish, shoreline protection, tourism and recreation and flood control. However, if an additional dam is constructed upstream and more irrigation projects set up there will be reduced flooding in the area and the mangroves will also be deprived freshwater. This will eventually lead to decline in these services.

B 5.

In a scale of 1 to 5, how do you rate the availability of the following mangrove services if an additional dam and irrigation scheme are developed upstream (where 1 = more worse, 2 = worse, 3 = I don't know**,** 4 = better, 5 = much better

	more worse 1	worse 2	I don't know 3	better 4	much better 5
01. Nursery and breeding ground for fish					
02. Shoreline Protection					
03. Flood Control					
04. Tourism and Recreation					

SECTION C: CONTINGENT VALUATION AND CHOICE EXPERIMENT METHODS

Mangroves provide a number of services such as nursery and breeding ground for fish, flood control, tourism and recreation, shoreline protection among others like ground water recharge, and storm protection. They are also able to thrive in a salty environment; however, there is a limit on the extent to which they can do well in salinity. They therefore, need freshwater that dilutes the saline waters from the ocean to be able to thrive. Such freshwater normally come from the flooding of the Tana River delta during the long rains when the river breaks its banks.

In order for the community to enjoy better mangrove ecosystem services, there is need for more regulated flooding in the mangroves and the people must also increase their commitment to improve mangrove forest cover through planting and sustainably harvesting the mangrove forest products.

The following section gauges some of the benefits that you/ your community derives from the mangroves services and also asks how much maximum time you are willing to commit in volunteering for mangrove conservation on a monthly basis.

C1 **C1a: Nursery and breeding ground for fish**	
Do you depend on fish from the mangroves or fish that breed at the mangroves	Yes
	If No go to C1b.
Do you harvest fish from the mangroves or fish that breed at mangroves	
How often do you harvest fish in a month	
what is the average catch you make per trip (kg)	
What quantity of the catch do you sell?	
How much (Kshs.) do you sell the fish per kg?	

C1b. Shoreline Protection				
How long have you lived in this area/village				
Have you witnessed shoreline getting eroded?	Yes			
	No			
If yes, how many metres of shoreline do you think have been eroded				
Has there been any intervention to address the problem from (community, government or NGOs)	Yes			
	No			
C1c. Flood Control				
What has been the frequency of floods in your village (e.g. twice a year)				
What has been the severity of the floods on damage to property in the village (in a scale of 1 to 4) 1= not severe, 2= moderate, 3= severe, 4 = very severe	Note severe 1	Moderate 2	Severe 3	Very severe 4
Have you ever been personally affected by the floods?	Yes			
	No			
iv. If yes, what has been the extent of the loss of property? (in a scale of 1 to 4) 1= no loss, 2=minimal , 3= severe 4= total loss)	No loss 1	Minimal 2	Severe 3	Total Loss 4
C1d. Tourism and Recreation				
How often do you see tourists in your village/Tana River (per month)				
Does any member of your family work in the tourism industry in Kipini				
What income generating services does your community offer to tourists				
C2. How many hours do you work in a day?				
C3. How much do you earn per day?				

C4: Contingent valuation question answer

Write the answer to question on contingent valuation card in the box below

……hrs

Choice Experiment

I will show you a sequence of cards. Each card has three options, A, B and C. Each option has the levels of potential benefits you may get from each of the mangrove services. On the cards, you will also see the amount of time in hours per month that you will be required to volunteer in working for the conservation of mangroves to be able to enjoy the services that mangroves provide.

Consider the details on the cards to be able to understand the services better.

[Show the overview card and explain the attributes and their levels]

You will be first shown an example card.

[Show the respondent the example card and explain the process.]

On this card you see Management option A in which there are many fish caught (6000 T), more tourists (600), moderate flood control (4 times in 10 years) and good shoreline protection (only 1m width will be eroded in future) and more volunteer time (10hrs/month) you are required to contribute to help in mangrove conservation for better enjoyment of the services. In the second option (B) there is less volunteer time compared to option A (5hrs/month) and the benefits are also slightly less, being 4000 T of fish caught, floods occurring 8 times in 10 years, 5 m width of eroded shoreline and 400 tourists per year.

The third option C is the business as usual, how the future will look like if all the planned upstream projects go as planned and the current mangrove management strategies remain the way they are. Here you will be required to contribute the least amount of time (1 hr/month). It is said that the additional dam upstream will control flood. However, the mangroves will decline because salty water will increase due to lack of flooding, this will in turn lead to less fish catch (2000T) in future, tourists will be few because hippos and crocodiles will move away from the

salty water and birds will also move to other thick forests elsewhere, there will be increased shoreline erosion (15 m) from tidal waves because there will be little mangrove trees for protection. Again, the area will be vulnerable to future floods that come from laghas when the mangroves shall have declined.

Which option do you prefer?

When deciding the options you prefer, please consider how and on what, you usually spend your time. You should be willing and able to volunteer the amount of hours indicated on the option of your choice. If the time is too much please choose another option.

Is this example clear? If not, what is not clear exactly? (Continue until the choice task is 100% clear). If so, I will now show you six cards. Each card shows 3 different options. Please carefully look at each card and the 3 options described and tell me which option you prefer.

Note that every card should be considered separately from the previous one. The cards are not related to each other and should be considered independently. On every card you are asked to make a new choice. While making your decision, please keep in mind your useful time.

Also, note that for the cards, the values/levels in Option A and B will keep on changing and it is not that A will always be better than B. You will have to evaluate A and B differently in each Card.

Answers for Cards

Card Number	Tick box below the chosen option		
	Option A	Option B	Option C (Business as usual)
Card 13			
Card 14			
Card 15			
Card 16			
Card 17			
Card 18			

I would like to understand how you made your choices in Card 13 to 18

C2 When answering questions, did you always choose option C (BAU)?	
Yes	
No	go to Question C3
If you always chose options C, which of the following statements best describe your main reason for doing so? (Please tick one box only)	
I don't believe that mangrove services will increase under new management	
I support new management, but I am not the only one who will benefit from	
I was looking for the least time for conservation	
I don't believe that the mangrove services will decline	
Some other reason (please specify) ……	
C3 Which characteristics did you consider when making choices? (Please tick one box only)	
01. I considered all characteristics	
02. I considered the least volunteer time for mangrove conservation	
03. I considered the highest benefit for shoreline protection	
04. I considered the highest benefit for tourism & recreation	
05. I considered the highest benefit from nursery and breeding ground for fish	
06. I considered the least frequency of flooding	
07. Some other reason (please specify)……	
C4 a. Was there any characteristic that you considered not important?	
01. yes	**Answer question b.**
02. No	**If No, go to question C5**
b. Please tick the characteristic that you considered not important	
01. Shoreline protection	

02. Nursery and breeding ground for fish	
03. Tourism and reaction	
04. Flood control	

C5 How confusing was it for you in making choices in card 13 to 18	
01. Very easy	
02. Easy	
03. Neither Easy nor confusing	
04. confusing	
05. Very confusing	

SECTION D: CHOUSEHOLD CHARACTERISTICS

I would like to ask you some questions about yourself. This will help me understand why respondents' opinions may differ. ***Please be assured that your answers are anonymous and all information collected is confidential***

D1 What is your age? (write the in the box)	
Age in Years	

D2 What is your gender?	
01. Male	
02. Female	

D3 How many people live in your household, including yourself? (Please count separately the number of adults and children)	
01. Adults	
02. Children (below 18 years)	
D4 What is the highest level of education you have obtained (until now)?	
01. Never went to school	Years….0
02. Primary	Years…….
03. Secondary	Years…….
04. Diploma	Years ……
05. Certificate	Years…….
06. University degree	Years……
07. Post-graduate degree	Years ……

D5. Do you belong to any environmental or social group?	
01. Environmental organisation	
02. Fishing Industry	
03. Tourism industry	
04. pastoralism	
05. Agricultural industry	
06. Other (specify)…….	

D6. Which of the following describe your source of domestic water (you can tick more than one)	
01. Piped into homestead	
02. River/stream	
03. Borehole	
04. Shallow well	
05. Spring	
06. Sand dam	
07. Water pan	
08. Other (specify)	

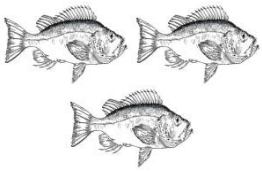
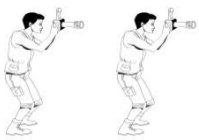
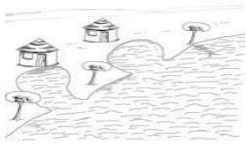
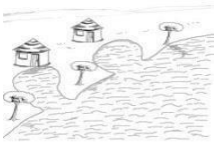
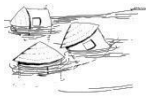
D7 What is your main source of income? (Tick one only)	
01. Fishing	
02. Crop farming	
03. Pastoralism	
04. Business	
05. Salary	
06. Wages	
07. Remittance	
08. Other (specify) ……..	
D8. What is the distance in km from your place of residence to the nearest market?	
D9. Do you have access to loan?	
01. Yes 02. No	
D10. Annual household income – Please indicate the approximate total **annual income** (before taxes) by all members of your household. The ranges between brackets are annual income.	
01. Under Ksh. 28,800	
02. Ksh. 28,801- 60,000	
03. Ksh.60,001-120,000	
04. Kshs. 120,001- 180,000	
05. Kshs. 180,001-240,000	
06. Ksh.240,001-300,000	
07. Kshs.300,001-360,000	
08. Ksh.360,001-480,000	
09. Ksh.480,001-600,000	
10. Ksh.600,001-1,200,000	
11. Above Kshs. 1,200,001	

THANK YOU SO MUCH FOR YOUR TIME AND COOPERATION

Annex 9: Sample Choice Experiment Card

Example of the cards used for choice experiment data collection, total number of cards were 48

CARD 13

	Option A	**Option B**	**Option C Business as Usual**
Volunteer community time	 10hrs/month	 20hrs/month	 1hr/month
Nursery and breeding ground for fish	 4000T	 6000T	 2000T
Tourism and Recreation	 200 tourists	 400 tourists	 200 tourists
Shoreline Protection	 15 m of eroded shoreline	 5m width of eroded shoreline	 15 m of eroded shoreline
Flood Control	 8 times in 10 years	 2 times in 10 years	 Every year
Which option do you prefer? (Tick one one)	☐	☐	☐

Annex 10: Checklist for Institutional Analysis for Integrated River Basin Management at the Tana Delta using IAD Framework

The Biophysical Attributes	
Attributes	**Findings**
1. Climatic characteristics	
2. Topographical features	
3. Hydrological features	
4. Soil	
5. Biodiversity richness	
6. Salinity	
Community Attributes (Direct Resource Appropriators)	
1. Diversity of the resource users	
2. Livelihood characteristics	
3. Culture, tradition and religion of the resource users	
4. Conflicts over water resource	
Community Attributes (Stakeholders)	
1. Functions and mandate as stipulated in legal frameworks	
2. Powers in relation to resource use	
3. Projects, and activities being implemented	

Water policies and Strategies	
1. Does the policy clarify the roles of government and other stakeholders in achieving overall goals	
2. What resource issues have been identified and priorities set	
3. Is the policy set to prioritize fulfilment of basic needs first	
4. Does the policy make explicit the links between land use, economic activities, and other ecosystem policies?	
5. Does the policy provide for engagement of stakeholders	
6. Does the policy recognize the potential of conflicts and provide tools for conflict resolution	
7. Does the policy recognize the importance of subsidiarity, so that water resource allocation decisions are taken at the lowest appropriate level	
8. Does the policy take into account trade-offs between short term costs and long term gains.	
9. Does the policy make functional arrangements and cost allocations	
10. Does the policy provide for assessment of the relative environmental, economic and social values of water	
11. Are there provisions for flexible drought and flood management strategies	
12. Does the policy provide for multi-agency coordination with other sectors affecting the water resource	
13. Has an assessment of water resources and needs in Tana delta and Tana basin conducted	

Water Related Policies with effects on water resource	
1. What are the direct impact of non-water policies on water use and management?	
2. Do the policies take into account the implication of their implementation on the water resource	
3. Are there planning processes where recognition of water resource sector needs and priorities are made explicit	
4. Are there provisions for multi-sectoral co-ordination of policies that ensures their water implications are taken into account and at what level have these been set	
5. Are the sectoral interests of these sectors/policies recognised in water policies?	

Water Laws		
Criteria	**Description**	
1. Multi-sectoral coordination	Does the law make for coordination with other water affecting sectors explicit	
	Is there existing an establishment of institutional structures, such as: Inter-ministerial co-ordinating bodies (e.g. in the Office of the President, deputy president), national bodies for water resources, catchment co-ordination bodies, Local co-ordinating teams.	
2. Does the law cover economic, environmental, ecosystem, social and cultural aspects of water	Are the water related laws include provisions and operational mechanisms regulating multiple uses and aimed also at the conservation and protection of the resource	
3. What are the permitted use of water resource		
4. Water Rights and allocation	Does the law prescribes who is entitled to use what water, when, where and how	

5. How are the water rights being implemented?	e.g. through ownership of land, prior usage, customary system, licensing or permitting	
6. Participation		
7. Subsidiarity		
8. What are the prohibited use water resource		
9. What sanctions and penalties have been set for violation of prohibited actions	administrative, civil, or criminal prosecution	
	Formal administrative orders, formal notices of non-compliance, administrative consent orders, fines and other financial penalties, facility closure, imprisonment.	
	Are the Sanctions graduated to reflect the degree of offence e.g. from administrative fines to imprisonments?	
10. Resource conservation	Have the legislations taken into account flow regime, water quality, land use and freshwater fauna and flora	
	Which tools are in place for conservation e.g. permits, quotas, and restrictions on harvesting methods, endangered species protection, habitat protection and regulation against invasive species.	
11. Are there provisions for conflict and dispute resolution		
12. Implementation and enforcement	Measures taken to ensure that violators are identified and brought back into compliance (e.g. reporting, inspections, self-monitoring by regulated entities, monitoring, sampling, and reviewing citizen complaints.)	

Water Related Laws with effect on Water Resource	
1. Are there permitted actions that have impact on water resources in the Tana Delta	
2. Are there prohibited actions that have impacts on water resource in Tana delta	
3. Are there sanctions and do they have implications on water laws sanctions	
4. What fines and penalties are there for violations and what impacts do they have water laws and water resources	
5. Are there explicit provision for coordination with water resource organisation and cross-references to water laws	
6. Is water resource duly recognised as an important resource for the sector?	
7. Which management tools (EIA, SIA, CBA, are set out in the laws that have implications on water resource	

Patterns of interactions	
Actors	**Patterns of interaction**
Relationships among direct resource users (communities)	
1.Pastoralists, farmers, fisher folks, hunters and gatherers, water suppliers	
Relationship among direct water resource users and water sector institutions	
2. Pastoralists, farmers, fisher folks, hunters and gatherers, water suppliers	
Relationship among direct resource users and the water institutions	
3. Farmers and the Hydro Dams	
4. Regional Authorities	
5. Wildlife Institutions	
Relationship among water sector institutions and water sector related institutions	
6. Water institutions and Flood Management Institutions	

7. Water institutions and Agricultural Institutions	
8. Water institutions and Forest Institutions	
9. Water institutions and Wildlife Institutions	
10. Water institutions and the County Government	
11. Water institutions and Regional Authorities	

Evaluation for IRBM

Criteria	Description	Evaluation
Efficiency	Adequate- education and communication for resource users; application of economic incentives; subsidies, use of economic assessment tools, infrastructure systems	
Ecological Sustainability	an iterative process in which ecosystem requirements are defined, refined, and modified to meet ecosystem sustainability now and in the future	
Fiscal equivalence	The extent to which the beneficiaries of a public good or service are expected to contribute toward its production.	
Congruence	Between appropriation and provision rules (for fairness considerations) and fitness to local conditions (for practicality).	
Monitoring compliance	The monitors are accountable to appropriators (or are the appropriators themselves).	
Graduated sanctions	Are applied to rule violators (in increasing levels of intensity).	
Dispute resolution	Available to participants at low cost	

Participation	Minimal recognition by "higher" authorities that appropriators have rights to self-organize and devise their own institutions, Subsidiarity/ Participation in planning and management	
Subsidiarity	Central authority should only perform those tasks which cannot be performed at a more local level. It takes the form of de-concentration, delegation and devolution	
Social equity	This may include support for effective water users' associations, involvement of marginalized groups, and consideration of gender issues. Use of social impact assessment tools	
Cross sectoral coordination	Utilizing an inter-sectoral to decision-making, where authority for managing water resources is employed responsibly and stakeholders have a share in the process.	
Basin wide planning		
Nested enterprise	Management of water resource must be done within the broader basin framework which is usually large and with many participants, hence nested enterprises that range in size from small to large enable participants to solve diverse problems involving different scale economies	

Annex 11: Consent Letter

(The following statement must be read to every respondent)

May I have a minute of your time?

The University of Nairobi is conducting a study on Economic importance of the Mangroves at Kipini in Tana River Delta. Therefore, it is important to obtain information from the communities living around the forest like you. The information is being collected for academic purposes only and there are no personal benefits or risks to your participation.

The information you give will be treated with confidentiality and only the aggregate data will be used. The interview takes approximately 1 hour. You may terminate the interview at any point if you do not wish to proceed. If you would like to know more about this study, please contact Mr. Philip Otieno at 0724 857 647.

Consent Granted: YES (proceed with interview)

NO: (Thank the person and look for next respondent. You are required to keep this questionnaire whether the respondent agreed to participate or not).