ECONOMIC VALUATION OF COASTAL AND MANGROVE ASSOCIATED FISHERIES, KWALE COUNTY, KENYA

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DECLARATION

I, Hassan Abdirizak Ahmed, declare that this project report is my original work and has not been submitted for the award of a degree in any other university.

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LIST OF ACRONOMEYS

ASCLME	Agulhas and Somali Current Large Marine Ecosystems
BAU	Business As Usual
BMU	Beach Management unit
CBO	Community Based Organization
CCD	Climate Compatible Development
CDA	Coastal Development Authority
CFA	Community Forest Association
CM	Choice Modeling
CV	Contingent Valuation Method
DPSIR	Drivers, Pressures, States, Impact and Response
EEZ	Exclusive Economic Zone
FAO	Food and Agricultural Organization
ICZM	Integrated Coastal Zone Management
IPCC	Intergovernmental Panel on Climate Change
KFS	Kenya Forest service
KMFRI	Kenya Marine and fisheries Research Institute
LMMA	Locally Managed Marne Areas
MA	Millennium Ecosystem Assessment
MPA	Marine protected areas
NEM	North East Monsoon
NEMA	National Environmental Authority
PES	Payment for Ecosystem services
SEM	South East Monsoon
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
UNEP	United Nations Environmental Programme
WWF	World Wildlife Fund

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ABSTRACT

Coastal fisheries are essential to the livelihoods of the coastal communities in Kenya. They are a source of food, employment and income and also support other auxiliary industries. Despite the socio-economic importance of coastal fisheries, they are threatened by host of anthropogenic and climate change impacts. Fish habitats including mangroves, sea grasses and coral reefs are threatened by human activities such as mangrove extraction, unplanned expansion of coastal cities, aquaculture and marine pollution. Coastal fisheries are also usually neglected in key policy making agendas which is attributed to lack of data and inadequate information on the socio-economic contribution to coastal communities engaged in coastal fisheries. The study aimed to estimate the economic value of mangrove ecosystem based coastal fisheries in Kwale county in order to provide crucial information for policy making. The study also sought to establish the trend of coastal fishery production for the past decade, estimated the economic value of mangrove ecosystems to fishery production and projected the future of coastal fisheries based on business as usual (BAU) and climate compatible development (CCD) scenarios. A combination of primary data from interviews with 242 respondents and secondary data including, 10 years of fish catch data were analysed. The catch data exhibited a continuous increase in coastal fishery production, from 1908 tonnes in 2004 to 2450 tonnes in 2013. The annual value of coastal fisheries was estimated to be Ksh. 182 million (US$ 2.2) after deduction of all fishing related costs in the year 2013. The study also estimated that mangrove ecosystems support the production of 160kg/ha/year corresponding to Ksh. 11610/ha/year (US$ 198/ha/year). The estimated values could be much higher than the calculated since a considerable amount of fish caught is unrecorded. Future projections reveals that the Business As Usual (BAU) scenario is not sustainable and hence the study calls for a shift to Climate Compatible Development (CCD) scenario, which incorporates climate change adaptation and mitigation measures as well as investment in infrastructure. The study recommends review of the existing fishery policies to consider the unique characteristics of coastal fisheries to address the challenges facing them and ensure sustainable exploitation. The research also recommends further economic studies conducted on value chain of coastal fisheries.

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CHAPTER ONE
INTRODUCTION

1.1 Background

Ecosystems provide various products and services that are essential to human welfare (MA, 2005; Spalding *et al*., 2010; TEEB Foundations, 2010; Groot *et al*., 2012). Despite the role ecosystems and the services they provide, play in human wellbieng, there is continous loss of across the globe. Since species underpin ecosystem functions, their loss leads to reduced ecosystem functions, undermines their ability to withstand shocks and hence results lowered ability to support livelihoods through provision of goods and services (de Groot *et al*. 2012).

Despite the importance of natural capital, the benefits attained from environmental goods and services are often undervalued in the decision making process. This is attributed for the reason that individuals and organizations often consider market prices which might not reveal the true economic values (Campus & Schuhmann 2012). Lack of consideration of the true monetary value of natural capital, conservation of natural resources may be discriminated against other competing alternatives such as exploitation and development.

Economic valuation generates essential information on the real economic costs that arise from habitat degradation and species loss and benefits that accrue from conservation and rehabilitation activities. This information is most often conveyed in monetary terms, since this (in theory) provides a 'universal currency' that can be easily understood by policy makers and hence provide vital data that can inform decision making on the appropriation of limited resources (Turner *et al*., 2003).

Globally, coastal marine ecosystems and estuarine are among the most endangered ecosystems (Halpern et al., 2008). Because of intensive and expanding human activities, half of salt marshes, 35% of mangroves, 30% of coral reefs, and 29% of sea grasses have been either degraded or lost since 1950 (MA, 2005; FAO, 2007; Barbier *et al*., 2011). The degradation of these environs has resulted in the decline of the critical services they provide globally, including 33% decline in fisheries production, 69% reduction in habitat provision (e.g. oyster reefs, sea grass and wetlands) and 63% deterioration in services such as purification and filtering functions coastal wetlands (Barbier et al., 2011).

Degradation and decline of coastal ecosystems services negatively affects the livelihoods of communities in coastal areas and the national economies of countries, with particular negative impacts on developing countries in which the largest portions of their populations directly rely on the utilization of natural capital for income generation.

Coastal fisheries have a critical role in the livelihoods of many coastal communities in the developing world where other economic opportunities are limited. Coastal fisheries are characterized as labour intensive, low capital use, confined to coastal areas and multispecies (Béné *et al*., 2007). These fisheries are source of food, generate employment and income for coastal communities and thus contribute to coastal economies and are also attached to the socio-cultural values of the societies in coastal settings. However, coastal fisheries are endangered by the growing pressures on coastal zones (UNEP 2011a)

Habitat destruction is one of the major challenges facing coastal fisheries. Mangroves, sea grasses and coral reefs which are important fish habitats are endangered by anthropogenic activities, marine pollution, unplanned expansion of coastal cities, aquaculture and mangrove extraction. These threats coupled with climate change impacts are having profound impacts on the future of coastal fisheries and hence the livelihoods of coastal communities in the developing world.

Mangrove forests, which are usually found in the coastlines of tropical and subtropical regions, are one of the most productive ecosystems on the planet, providing a host of economic and environmental products and services. In addition to the products derived from the mangrove forests, they also hugely support coastal fishery production. Over the past decades conversion and cutting of mangrove forest has resulted in a global decline of these ecosystems (FAO, 2007; Spalding *et al*., 2010) having both environmental and economic adverse impacts in the coastal areas.

Mangrove forests are susceptible to the negative effects of climate change but also have got huge potential in climate change mitigation and adaptation. They protect shorelines from storms and prevent flooding. Mangroves are also important carbon sinks and their removal contributes to global warming by releasing large carbon stocks, which are trapped in the biomass of mangroves and sediments beneath them (Siikamäki *et al*., 2012).

Coastal fishery production is highly associated with intact mangroves habitats. (Hamilton *et al*., 1989; Rönnbäck, 1999). Fish utilizes varying habitats in their different life span cycles. Mangroves provide a habitat functionality to various fish species. Predation on juvenile fishes may be reduced due to the turbidity and dense structure formed by mangroves, the parts above the ground of mangrove trees including aerial roots, trunks and branches; these are submerged at high tide and inhibit predators through impending movement and vision of predators (Huxham *et al*.,2004; (I. Nagelkerken *et al*., 2008). Hence degradation of mangrove ecosystems by human activities including infrastructure development can result in unforeseen effects on recruitment of juvenile fish into adult. This makes fish stocks more vulnerable to fishing pressure.

Although mangrove habitats have a vital role in fisheries production, they are exploited for the direct products they provide such as timber production, aquaculture and fire wood and are removed to give way for coastal tourism infrastructure development and other uses. Clearance of mangrove forest for intensive prawn farming especially in Asia has reduced the coastal buffering ability and increased the vulnerability of such areas to storm surges and tsunamis. It is therefore critical for the future conservation of mangrove forests that we understand clearly the relationships between fish, prawns and mangroves and exactly why mangroves are important aquatic ecosystems. The extent in which fish catch is attributed to the availability of mangrove forests is variable among different geographical locations. In the state of Florida, USA, and regions of South East Asia 80-90% of fish catch is associated with the presence of mangroves (Rönnbäck, 1999; Nagelkerken *et al*., 2008).

Like other mangrove forests in other countries, the mangroves of Kenya have an essential role play a significant role in sustaining the productivity of the coastal fishery. Studies carried out by Little *et al*.(1988), in Tudor creek and at Gazi bay by Kimani *et al*., (1996), Wakwabi, (1999), Huxham *et al*., (2004), emphasized the importance of mangrove systems in the ecology of coastal fisheries of Kenya. At Gazi bay, 109 different species of fish which belonging to 44 families were identified as being associated with mangroves. Out of these, 78.5% comprised Gerreidae, Atherinidae, and Clupeidae families. Furthermore, Huxham *et al*. (2004) and Mirera *et al*. (2010), recorded more fish species richness in forested than un-forested mangrove sites while the densities were similar.

The economic value of mangrove forests is usually not readily recognised. This is due to two major factors (Hamilton, Dixon, & Miller 1989): (i) a number of products and services derived from mangrove forests are not sold markets and (ii) some of the produces and services supported by mangrovesvusually occur in distant areas and hence not easily associated with mangrove ecosystems. This has encouraged the development of mangrove areas for alternative uses that are traded in markets, such as aquaculture. However, such choices fail to consider the costs associated with mangrove loss. Economic valuation of ecosystem products and services offers a detailed information on their value and hence inform to sound policy making, planning and more informed decision-making.

1.2 Problem statement

Traditionally, communities in the coastal regions of Kenya rely on the exploitation of coastal fisheries and mangrove forests for their livelihoods (ASCLME project, 2011). Coastal fisheries in Kenya are artisanal (traditional) in nature, more labour intensive, less capital intensive, multi-gear, multi-species and are usually confined to coastal or inshore waters since their traditional gears cannot withstand the roughness of the deep sea.

Coastal fisheries are of essential importance to the wellbeing of coastal populations. They are sources of food, employment and income generation. Coastal fisheries also support auxiliary industries such as: boat making and repair, net making, aquaculture through seed and feed provision, transport, sports and recreation (Japp, 2011).

Coastal areas are susceptible to the adverse effects of climate change particularly in developing countries where there is high dependence on industries which are prone to the negative impacts of changing climate including coastal fisheries, coastal farming and tourism combined with weak governance and poor communication infrastructure. It is therefore, necessary for these countries to invest in climate compatible development, i.e. development initiatives that ameliorate the impacts of climate change and generate development benefits (Tompkins et al., 2013).

Considering the substantial role of the coastal fisheries in nutrition and food intake and buffering against poverty and how they are endangered by pressure from anthropogenic effects and climate change, sustainability of coastal fisheries through efficient resource management is of a paramount importance for a developing country like Kenya.

Despite their importance, coastal fisheries are often neglected in policy making (Benards, 2010). This neglect is attributed to lack of data and adequate information on the socio-economic contribution to coastal communities engaged in coastal fisheries. This problem may arise because fish landing sites are geographically remote or inaccessible due to poor infrastructure and landing is sporadic, which makes collecting official catch data difficult. Many catches are also landed and consumed directly without being traded.

Although many researches were undertaken on the biological aspects and the contribution of mangroves to fisheries production in Kenya, few studies in limited geographical locations analysed the value of mangrove associated fisheries. UNEP (2011b), estimated the economic contribution of mangroves to fisheries production in Gazi bay, Kenya, as US$ 44/ ha/year. Kairo *et al*. (2009), also calculated the economic value of reforested mangroves forest in Gazi bay and estimated their contribution to fisheries production to be US$113.09/ha/yr. So far, to the best knowledge of the researcher, no research was conducted to estimate the economic value of coastal and mangrove associated fisheries in Kenya.

An economic valuation of coastal fisheries can provide crucial information for policy makers in understanding the potential of coastal fisheries in economic development through wealth generation and social welfare. This information will enable the formulation of good policies, attracts investment and helps facilitate sustainable utilization of coastal fisheries.

1.3 Research Objectives

a) General objective

The overall objective of the study is to estimate the economic value of coastal and mangrove-associated fisheries in Kwale County, Kenya.

b) Specific Objectives

1. Determine trends of coastal and mangrove- associated fisheries production in the past 10 years for Kwale County.
2. Identify mangrove-associated fish species from catch data and estimate their economic value
3. Estimate the economic value of coastal fisheries annually in Kwale County.
4. Project the future of coastal and mangrove- associated fisheries based on Business As Usual (BAU) and Climate Compatible Development (CCD) scenarios.

1.4 Significance of the study

Economic valuation of coastal fisheries provides significant information that can be used for comparing the various benefits generated from them and inform their wise exploitation and management. The failure to calculate the value of coastal fisheries lies in the heart of fishery policy and practice problems (Hanna, 2011).

Mangrove forests occur in the intertidal zones of coastal areas in the tropics and subtropics. Mangroves ecosystems offer various services including provisioning (fish, medicines and timber), supporting (habitat for biodiversity, fish nursery & nutrient cycling), regulating (storm protection & carbon sequestration) and cultural (spiritual & tourism). Regardless of their economic and ecological values, mangroves forests are continually being destroyed at a rate of 0.7% yr^{-1} globally as well as in Kenya (FAO 2007; Kirui et al. 2013; Spalding, Kainuma, & Collins 2010). Mangrove areas are being degraded through unregulated extraction and clearing for alternative land uses. This is attributed to undervaluation of the benefits associated with mangrove ecosystems.

Mangrove forests are economically, ecologically and environmentally essential in the world (FAO 2007; Spalding, Kainuma, & Collins 2010). However, the role of mangroves in coastal fishery production is undervalued due to the mere focus on their first hand extractive resources, such as wood for construction, energy and export, without appreciating their role as an ecosystem and the products and services they support such as fish assemblage and production and coastal protection. Underestimation of their value has resulted to wider economic benefits being under considered in the conservation and development.

Lack of understanding of the full value of coastal fisheries and the role mangrove habitats to their production implies that their conservation would be unfairly discriminated against other exploitation decisions, because they will appear less valuable. Economic valuation of coastal and mangrove associated fisheries proposed in the current study will help policy makers at macro or sectoral levels to consider environmental resources management.

The study was conducted in the coastline of Kwale County, Kenya. The county has the highest of prevalence coastal fisheries in the country with the largest number of fishing craft (1,053), highest number of fish landing sites (46) and the highest population of fishermen accounting for more than 26% of total marine fishermen in the country (Republic of Kenya, 2012).

This study will contribute to the scarce economic literature for Kenya in this area ecosystem valuation and particularly coastal ecosystems and offer quantitative results in a way that may facilitate the concerned authorities for better planning and management of mangrove forests and coastal fisheries. Furthermore, the results may be used as an input for comprehensive and rigorous policy oriented research work around mangrove associated fisheries.

1.5 Scope and limitations of the study

The study is subject to both financial and time constraints. Therefore, the study is restricted to estimating the economic value of coastal and mangrove associated fisheries by using market price approach of economic valuation in Kwale County as a case study. The study does not consider the chain value addition of coastal fisheries and the other services provided by mangrove ecosystems in the study site other than their contribution to fisheries production. Lack of prior researches on the economic value of coastal fisheries in Kenya and in the wider east Africa region was among the major challenges faced during the research undertaking.

1.6 Operational definitions

Coastal fisheries: referred to the production system of fisheries that are characterised as labour intensive, low capital intensive, practised by coastal communities and limited to the inshore or coastal areas.

Mangrove associated fisheries: fish species that utilize mangrove habitats at least one stage in their life cycle.

Climate Compatible Development (CCD): refers to the development that minimizes the adverse impacts of climate change and maximizes on development opportunities through low emissions and more resilient development.

Economic valuation: refers to the methodology of quantifying the values of ecosystem services, both direct and indirect values, to human well-being. It enables to estimate the gains and losses of human welfare due to change environmental conditions resulting from either from anthropogenic or natural factors.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter covers the theoretical and empirical literatures of economic valuation of coastal and mangrove dependent fisheries and presents the conceptual framework of the study. The theoretical part will outline a detailed description of economic valuation, its rationale and methodology it also discusses the theoretical framework for environmental valuation techniques that can be used in this study. The empirical literature part presents a review of some of the empirical studies undertaken by other scholars in the subject area.

2.2 Theoretical Literature Review

2.2.1 Economic valuation

Ecosystems supply a flow of various goods and services which are of critical importance to human wellbeing for survival and livelihoods. The millennium ecosystem assessment (MA), which was a worldwide exercise to investigate how the change in ecosystems is affecting human wellbeing and identify conservation and sustainable use measures, grouped ecosystem services in four major categories of services; provisioning, supporting, regulating and cultural (MA, 2005).

The degradation and depletion of ecosystems and biodiversity reduces the functionality and furthermore their capacity to supply ecosystem services. The threats of degradation and depletion of ecosystems are anticipated to increase with the negative effects of changing climate, unsustainable exploitation and increasing pollution. Thus, the costs associated with the degradation of ecosystems has to be thought of in decision making through valuation (Costanza *et al*., 1997; TEEB Foundations, 2010; Groot *et al*., 2012).

Economics provides the required information on relative level of resource scarcity through valuation. Economic valuation of ecosystems reveals the societies' willingness to pay for environment and natural capital conservation. It also reflects the fact that ecosystem services and biodiversity are scarce and hence there are costs associated with their degradation and depletion. If these costs are not considered in policy making, it would result misallocation of resources to non-priority investment options and hence make the society worse off (TEEB Foundations, 2010).

Money is used as the "measuring rod" in economic valuation. Quantifying the value of the services provided by ecosystems helps in measuring the trade-offs among competing alternatives e.g. conversion of a wetland for agricultural production or retaining it for flood protection and provision of clean water. The measurement of trade-offs also helps in the identification of suitable land use from the society's perspective and could also be used in arbitration of conflicts (Pearce, 1995).

2.2.2 Rationale for economic valuation of natural resources

The main reason why we should value biodiversity and ecosystem services is because they are life supporting systems that are of high importance to human welfare. Despite their importance, only a portion of ecosystem products and services are priced and transacted in markets. Hence, markets fail to provide comprehensive information on the ecological value of ecosystems to inform policy and decision making (MA, 2005).

The monetary value of natural ecosystems is extremely important because it enables government institutions and natural resource users and managers to make calculated decisions. The economic awareness usually supports decision making by providing ecosystem monetary values around which policy makers can negotiate and make better decisions. In this way, the monetary value coordinates political discussions instead of relying on other inconceivable details whose policy impact is usually low. However, economic valuation of ecosystems is important even beyond policy making because the public are more likely to respect and protect their local ecosystems more vigilantly if they know the monetary value. Consequently, the IBRD/World Bank declared that the continued inability to determine and clearly project the monetary value of environmental goods and services is expected to lead to continued degradation of valued ecosystems which is detrimental for world societies and the economy (Pagiola, Ritter, & Bishop 2004).

The complexity in measuring the value of many goods and services provided by ecosystems leads to information failure which makes comparison with other economic services and manufactured capital difficult (Costanza et al., 1997). Furthermore, economic valuation is much more attractive because it allows nature to be considered in development policies and research and it also facilitates sustainable resource use, rehabilitation of degraded ecosystems and supports efforts of conservation (Admiraal *et al*., 2013).

Stating ecosystem services in money metrics also enables in acknowledging the preferences of users and the value that present generations attach to services from ecosystems. Determination of these monetary values helps in decision making process in efficient resource allocation while bearing in mind that the estimated values are derived from the current markets which ignore the values for the generations to come (Farley, 2008). In addition, calculation of the monetary values of ecosystem services at an extensive scale would incentivise budgeting required for protection and sustainable consumption, for example payment for ecosystem services (PES), through creation of transaction mechanisms, markets, for ecosystem services (Leimona, 2011).

2.2.3 Methods of economic valuation

The economic value of ecosystem services is measured in the Total Economic Value (TEV) framework. This framework takes into consideration the use and non-use values that people gain or lose due to marginal change in ecosystem services (Defra, 2007). The word “Total” in Total Economic Value doesn’t mean the “value of the entire resource”, but rather the “sum of all types of economic value” for the resource (UNEP-WCMC, 2011).

An accurate valuation requires the comprehensive partitioning of the ecosystem goods and services based on their mode of access and utilization for which the two principal categories of direct and indirect benefits are usually recognized according to the TEV framework (Figure 2.1). The direct use benefits are those which require close and direct interaction with ecosystems to access their consumptive benefits (e.g. irrigation, fishing, grazing, and logging) and non-consumptive benefits (e.g. game watching, nature photography and worship). The indirect use benefits, on the other hand, are associated with the intangible or invisible services such as weather and climate moderation, biogeochemical cycling and air quality moderation which do not require close interactions between the ecosystem and its beneficiaries. Some experts have argued that ecosystem value and benefits should be considered beyond the direct and indirect uses by also including the non-uses (MA, 2005). This additional dimension is usually associated with non-materialistic and non-anthropocentric doctrines where intangible benefits of ecosystems such as the option, existence and bequeath values are appreciated. The option values are related to the undiscovered or futuristic opportunities such as undiscovered goods (e.g. medicines and fossil fuels), while the existence value is associated with the ecologistic and religioustic doctrines which recognize that all elements in an ecosystem are important and relevant, even without utilization. The bequeath value on the other hand is associated with the desire to reserve ecosystem goods and services for future use including bequeathing them to the future generations. The non-use values of ecosystems have so far been very difficult to integrate in economic valuations probably because of their very diverse and personal nature.

Under the TEV frame work the value of goods and services are split in to use and non-use, which are further subdivided into various values as shown in figure 2.1 below.

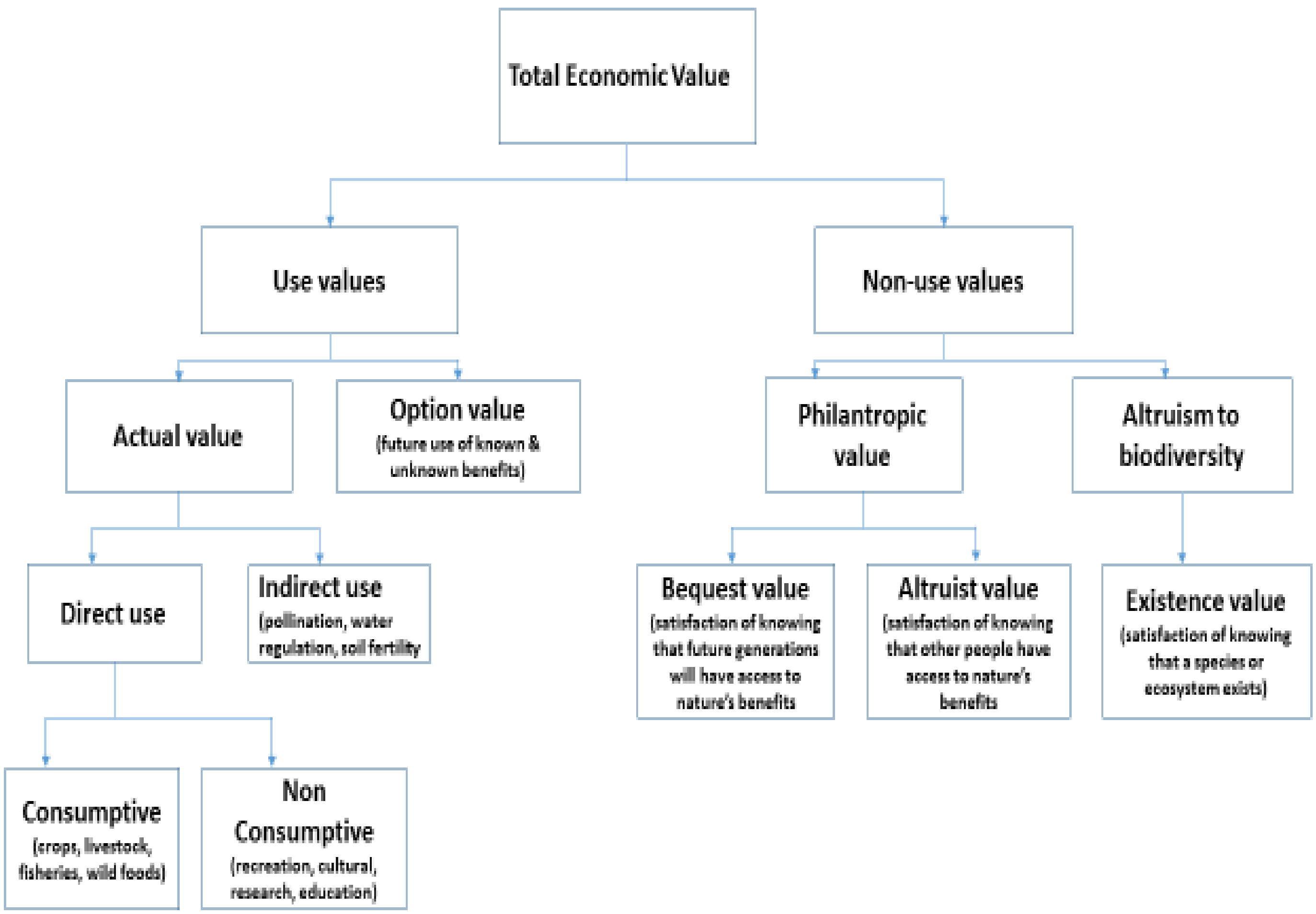

Figure 2.1 Total Economic Value (TEV) framework *Source: Modified from* (TEEB Foundations, 2010)**.**

Use values comprising of direct and indirect use and option values:

Direct use values are directly used by human beings; they are either consumed or non-consumed. The consumed use includes the extraction of food (fish), wood/poles for building and medicines which are all directly harvested from the environment. Non-consumptive use refers to the use of environmental services without extraction of the resources such as recreational and cultural activities, and landscape amenities. Direct use value usually accrue to adjacent communities or visitors of ecosystem services (Pagiola *et al*., 2004).

Indirect use values are the benefits from ecosystem services which support and protect economic activities and livelihoods. Their values are easily quantifiable but they are not usually noticed until they are degraded or lost. Examples of these services are: water filtration by wetlands, storm protection and nursery habitats for fish by mangrove forests and pollination crops by insects (Barbier et al., 2011).

Option values are the value that individuals place on conserving resources for future use either by themselves or for future generations. Example people are eager to for the conservation of national park without even visiting the park but to just keep the option of visiting it in some future time.

Non-use values (passive use) these include bequest value, altruist value and existence value:

Bequest value the value that the people place on the state of environment and resources that will be transferred to future generations.

Altruist value the value individuals attach to resources since other people in the current generation benefits from them.

Existence value is the esteem people put on the presence of ecosystem goods and services, even though they have no intention of using them.

Under the total economic value framework, ecosystem services are valued in direct market valuation, revealed and stated preference approaches. These techniques are differentiated by the source of valuation data. When data is directly obtained from market transaction which captures individual behaviour, the direct market valuation approach is used. If there are no direct market values, price information is gotten from comparable market prices that are related with the product to be valued and the revealed preference approach is used. With the lack of both direct and indirect price information, hypothetical markets are constructed to draw out values and the stated preference approach is applied for valuation (TEEB Foundations, 2010).

Economic valuation methods differ in reliability, validity, applicability as well as in terms of resource requirement, both time and money. Thus, choice on the valuation method has to be made in the light of the limitations, local circumstances and the resource to be valued (UNEP, 2011b). According to TEEB Foundations (2010), the above mentioned valuation methods are described as follows:

2.2.3.1 Direct Market Valuation Approaches

The valuation approaches under this method are subdivided in to market price, cost and production function based methods. These approaches use market prices to measure the economic value of the ecosystem service under consideration. The merit of these methods is that they show real preferences or expenses to people since their data is obtained from the actual markets.

Market price-based approaches are usually utilized to value ecosystem product or service, e.g. fish and timber, are bought and sold in market. In perfect markets preferences and marginal cost of production are captured in a market transaction price and can be considered as the value of the product. Therefore, market prices are can easily show the value of ecosystem service under consideration.

Cost-based approaches are based on the cost of infrastructure that would replace damaged ecosystem. For instance, valuing the coastal protection of mangroves in comparison with the cost of building walls for coastal protection.

Production function-based approaches: the value of an ecosystem service in supporting another ecosystem is estimated. The production function (PF) is based on the contribution of ecosystem services in increasing productivity and income generation. According to Barbier, (2000), the application of the production function involves two key steps. First, the physical impacts of changes in an ecosystem service on the production of an economic activity must be measured. Secondly, the effects of the changes in production is measured considering the physical change on the ecosystem which supports the production. In nutshell, PF method built on causal and effect relationship between the value of an output and the ecosystems that support it using scientific knowledge.

The market valuation approaches have got limitations particularly when either markets do not exist or are not properly functioning i.e. market failure. When markets do not exist the required data for valuation are not available. If there is market failure or distortion, due to subsidy or lack of competitiveness in the market, the preferences and marginal costs are not reflected in the price. Hence, leading to bias in the calculation of the value of ecosystem services and provide unreliable information for policy making.

2.2.3.2 Revealed Preference Approaches

These approaches are based on how economic agents and clients "reveal" their choices through their behaviour and buying. The choices of individuals are observed in an existing market, which are related to a product or service that are subjected to valuation. The two major methods of revealed preference approaches are:

Travel cost method (TC) is mostly employed to determine the recreational value of biological diversity and ecosystem services (Russi et al., 2013). This method is based on the fact that visiting recreational sites is associated with direct costs and the opportunity costs of time. Through estimating the demand function the value of a recreational site can be easily estimated. For instance, estimating the value of a park or a reserve by the time and cash visiting individuals spend.

Hedonic pricing (HP) in this method surrogate markets are utilized to measure the value of goods that are not sold in market. The value of property in a location is used to measure the hidden price paid for environmental attributes in that location (UNEP-WCMC, 2011).

2.2.3.3 Stated Preference Approaches

In stated preference method markets are created to estimate the societies' preferences through administering of surveys, questionnaires, interviews and/or ranking exercises. The main methods of stated preference technique are:

Contingent valuation method (CV) It entails requesting individuals to say the amount of money are willing to pay for the conservation of a product that is not exchanged in markets or agree to its decrease in supply to determine the economic value of this good.

Choice modelling (CM) models the decision-making process of individuals. Participants are given two or more choices with common characteristics of the ecosystem services under valuation, but with varying levels of attributes (Philip & MacMillan, 2005).

Every valuation method has its own strengths and weaknesses, and the selection of one method over the other depends on type of good or service to be valued (use or non-use), data availability, the purpose of valuation and limitations of the various methods. It is therefore, the responsibility of the researcher to determine valuation method fits best in the study under consideration, while bearing in mind the strengths and limitations of each method (Naber *et al*., 2008). Table 2.1 below outlines the strengths and limitations of the main valuation techniques.

Table 2.1 strengths and limitations of valuation methods

Valuation method	Strengths	Limitations
Market price	• Price, quantity and cost data are easily obtained for products and services that are transacted in markets • Employs observed data of real preferences • Uses standard economic techniques	• Markets are not always perfect and hence may not show true value • Fails to consider seasonal variations in price • Markets must exist for the ecosystem service
Cost-based	• It is easy to estimate the cost of generating benefits as opposed to the benefits • Markets are mostly available for computing the costs • Less data and resource intensive	• Utilizes costs to estimate benefit, which may not be correct • Preferences of society not considered • may exaggerate true value
Production function	• Can measure the value of ecosystem services that are easily known to people • Required data often available • Easy estimation methodology	• The good or services must be an input to produce a traded product • Requires broad scientific knowledge
Travel Cost	• Results easy to interpret and explain • High accuracy in measuring the value of recreational sites and easily justify their conservation	• Only applied to recreational benefits • Data intensive • Difficulty when destinations are many
Hedonic Pricing	• based on actual choices • Data easily available	• limited to things related to property or housing prices. • Requires high degree of statistical knowledge • Model specification determines the results

Contingency Valuation	• Both use and non-use values are captured • Results easy to analyze and interpret	• Many potential biases may arise • Measurements of non-use values are difficult to validate • Resource-intensive method
Choice Modeling	• Measures both marketed and non-marketed products • tradeoffs are considered which may be easier than directly expressing dollar values	• Requires expertise in data analysis • Evaluating tradeoffs may be difficult to respondents • Bias in responses may arise
Benefit transfer	• Cheap and time saving • Used to determine whether full valuation should be conducted or not	• results may not be accurate • similar studies may be available • values of existing studies get outdated

Source: modified from Pagiola *et al*., 2004; and UNEP, 2010

2.2.4 Economic valuation of coastal fisheries

Fisheries which are categorised as being labour intensive, low capital intensive in production, practiced by coastal communities and less mobile are referred to as 'small scale', 'artisanal' 'coastal' or 'inshore' fisheries (Berkes *et al*., 2001; Pauly, 2006; UNEP, 2011b). Although these terms are used interchangeably, this study will mainly use the term coastal fisheries for the above description.

Coastal fisheries happen in various regions of the world, but are dominant economic mainstay in the coastal zones of the tropics, less developed countries. They are described as, multi-gear, multi-species and are mostly for subsistence production in nature. Coastal fisheries are of fundamental importance to the sustenance and welfare of coastal communities, source of food, employment and income, in less developed countries. Half of world's fish food production comes small scale fisheries and it is calculated that 90% of global fishers are small scale fishers (Béné *et al*., 2007; Teh *et al*., 2011).

Although marine fisheries are facing various challenges globally, coastal fisheries are threatened by other challenges which are outside the fisheries industry but in the wider socio-ecological system. These challenges include: (a) negative impacts from foreign and industrial fleets, who deplete fish stocks at the coastal areas and sometimes destroy fishing gear, (b) degradation of fish habitats by marine pollution, urban development, aquaculture, tourism and cutting of mangrove forests, all resulting in reduced fish stocks, (c) transportation challenges of fish products, and (d) global challenges, climate change and globalization of fish trading, that can adversely affect coastal fisheries (McConney & Charles 2009). These challenges coupled with weak institutions and poor law enforcement, which are common in developing countries; threaten the livelihoods of millions of coastal communities.

Inaccessible landing sites and dispersed marketing activities impede data collection on the scope and economic value of coastal fisheries. Even in situations where data is available, little attention is given to converting it to information that can be used for policy making. This has resulted in the neglect of coastal fisheries in the formulation of fisheries policies across the globe. Furthermore, since the importance of coastal fisheries to country and regional economies are undervalued and hence they are ignored in national planning and policies (Salas *et al*., 2007; McConney & Charles, 2009).

Coastal fisheries have some inherent characteristics that offer opportunities on one hand and create challenges on the other hand. Coastal communities are more dependent on fishery resources than in other resources, this might lead to overfishing or community stewardship, of the important fish stock. The labour intensiveness of coastal fisheries makes effort reduction hard but also implies less capital use and hence no debt repayments, this makes coastal fisheries more flexible to policy changes compared to industrial fisheries. Furthermore, although coastal fisheries are capable of causing damages to the aquatic ecosystems, they provide room for environmental improvements compared to the fuel intensive large industrial fleets (UNEP, 2011b). All these points indicate that coastal fisheries offer opportunities for future sustainability if appropriate institutions and policy frameworks are put in place.

Like most other developing countries, Kenya's marine fisheries are mostly small scale fisheries that operate in the coastal near-shore (Samoilys *et al*., 2011). Kenya is endowed with 640km of coastline stretching the Kenyan and Somalia border to the north and Kenyan and Tanzanian border to the south and has jurisdiction over 200 nautical miles of exclusive economic zone (EEZ). The most productive areas in the Kenyan are Kiunga coastline and Lamu islands in the north, Tana River delta, Ungana Bay and Malindi and Shimoni, Funzi Island, Vanga and coral reef areas in the south coast (Fondo, 2004; Munga et al., 2012).

Coastal fishery in Kenya are multispecies, hence various simple fishing crafts/vessels and gears are used in their exploitation. Gillnet, shark nets, hook and line, beach seine, spear gun and traditional traps especially the basket traps are the most commonly used gears (Ochiewo, 2004; M. Samoilys et al., 2011). The use of these gears sometimes varies with the fishing seasonality, the north east monsoon (NEM), hot, dry and calm sea, suitable for fishing and south east monsoon (SEM), cool, windy and rough sea, less fishing activities due to turbulent waters (Maina, 2012).

Marine fish production is estimated to contribute 2% - 6% of national fish production and 95% is from coastal fisheries (Republic of Kenya, 2008). The production of coastal fisheries has remained between 4,336 tones – 8,736 tons annually in the past 20 years, estimated at Kshs 135 million in 1990 and Ksh 737 million in 2008 (Maina, 2012). It is also calculated that Kenyan marine waters have got the potential to produce 150,000 tons (Republic of Kenya, 2008). Being labour intensive coastal fisheries offer employment opportunities to coastal communities who mainly rely on them for their economic well-being.

Despite their importance to the economies of local coastal communities and to the national economy, coastal fisheries are facing a wide range of challenges. Since the landing sites of coastal fisheries geographically scattered, this made data collection difficult and resulted in neglect of coastal fisheries in policy making because their true economic value is underestimated. In many cases there is lack of adequate data because mostly collected data on coastal fisheries is not publicly available or buried in reports which are hardly converted to information that can be used in policy making and planning.

Due to increasing demand for fish food, population growth and lack of alternative livelihoods, there is increasing effort on fishing which threatens the sustainability of coastal fisheries (Ochiewo, 2004). Poor infrastructure such as roads in the coastal strip of Kenya limits access to markets and causing spoilage of fish. Additionally, there is high demand for land in the coastal areas for tourism infrastructure development, limiting access to fishing sites. Furthermore, destruction of coastal habitats is another major constraint to artisanal fisheries. Mangroves ecosystems which are critical habitats of fish are continuously under pressure by the ever-expanding tourism industry infrastructure, pollution, and cutting of mangroves for construction and fuel wood.

It is therefore, necessary to overcome these challenges through more favourable fishery development policies and strategies and adoption of ecosystem based coastal management approaches. This would result in sustainable development of coastal fisheries which are of paramount to socio-economic development of coastal areas.

2.2.5 Mangrove ecosystems and fisheries

Mangrove ecosystems, found in the intertidal zones of the tropics and subtropics, provide all the four major categories of ecosystem services: provisioning services (fish, timber, fire wood, honey, medicine), regulatory services (protection against storms, flood control, climate regulation), supporting (habitat for biodiversity, fish nursery, nutrient cycling) and cultural services (tourism, educational research) (Kathiresan & Rajendran, 2005; Barbier, 2007; Uddin *et al*., 2013). Mangrove forests are essential to the livelihoods of coastal communities as well as to national economies of developing countries. Despite their ecological and economic importance, the existence of mangrove ecosystems are threatened due overexploitation, for the direct products they provide including: hardwood for construction and fire wood and clearing of mangrove forests for aquaculture and development of tourism infrastructure (Spalding *et al*., 2010).

Fishery species that utilize mangrove ecosystems are subdivided into permanent residents, spend their whole life span in mangrove ecosystems, temporary long-time residents, use mangrove systems at least one point in their lifecycle and temporary short term residents, incidental users of mangroves (Robertson & Duke, 1990). These definitions are however debatable particularly on the degree dependence.

Mangroves form complex habitats for numerous fish prey through their pneumatophores, prop roots, branches and fallen leaves. This complex habitat also provides shelter for fish and their predators. Mangrove are also nutrient rich of because of their high primary productivity (Spalding, Kainuma, & Collins, 2010).

Fish often migrate from one habitat to another due to distinct requirement at different life stages which includes diverse ecological processes (Bosire *et al*., 2012). Many fish species utilize mangroves as nursery at their early critical life stages, i.e. larvae and juveniles, before shifting to adjacent ecosystems, e.g. coral reefs. The presence of juveniles in mangroves attracts carnivorous fishes for feeding (Walters et al., 2008).

In comparison to offshore habitats where fish adults are found, juvenile fish are frequently situated with higher numbers and chances of survival in mangrove ecosystems. This points out that mangroves are important nursery ground for fish and contribute to their recruitment to adult populations (Nagelkerken, 2009). According to Nagelkerken *et al*. (2008), there are three potential reasons why mangroves are attractive fish habitats and particularly for the juveniles:

Reduced predation juveniles in mangroves suffer less predation which attributed to: turbid waters impede the vision of large predators, shallow waters that exclude large predators, and the structural complexity of mangroves enables juveniles to hide from predators.

Availability of food mangroves are important source of food for fish due to availability of detritus and abundance of micro fauna and flora. Furthermore, most juvenile fish feed on zooplankton which is abundant in mangroves than in other areas.

Shelter and living space: the structural complexity and shade formed by the pneumatophores and prop roots create habitat for fish. The composition of fish species in mangroves varies with mangrove species and substrate type.

Many economically valuable fish species that utilize mangrove habitats at one point in their life cycle are captured in coastal and deep sea waters. Below is a list of the most important ones in table 2.2. Mangrove mud crabs, sergestid shrimps, and giant freshwater prawn are among the profitable crustaceans that utilize mangroves as habitat at some points in their life cycle. Mollusc species are also supported by mangroves and form an important in situ fishery. Edible species of oysters, mussels, cockles, and gastropods are among the species collected as food by women and children from the mangroves for domestic consumption (Walters et al., 2008).

Table 2.2 Fish families that utilize mangroves as habitat during their life cycle and are of economic importance to fisheries

Family name	**English name**	**Family name**	**English name**
Megalopidae	Tarpons	Clupeidae	Herrings, sardines, pilchards
Chanidae	Milkfish	Engraulidae	Anchovies
Ariidae	Sea catfishes	Mugilidae	Mullets
Plotosidae	Eel catfishes	Centropomidae	Barramundi, snooks
Serranidae	Groupers, sea basses	Sillaganidae	Sillagos
Leiognathidae	Soapies	Carangidae	King fishes
Lutjanidae	Snappers	Haemulidae	Rubberlips, grunts
Gerridae	Mojarras	Sparidae	Breams
Polynemidae	Threadfins	Mullidae	Goat fishes
Scianidae	Drums, croakers	Cichlidae	Cichlids
Gobiidae	Gobies	Siganidae	Rabbit fishes
Scatophagidae	Scatties	Sphyraeinidae	Barracudas
Stromateidae	Ruffs	Cynoglossidae	Tonguefishes

*Sour*ce: modified from Rönnbäck, 1999

Mangroves also indirectly support fish species that do not use mangrove habitats in their Lifecyle. In combination, mangroves, sea grass beds, unvegetated shallows, and coral reefs form a highly productive integrated ecosystem (Rönnbäck, 1999). Furthermore, mangroves support aquaculture by supplying seed, brood stock, and feed inputs. They also function as nursery grounds for the early life cycle stages of aquaculture species such as penaeid shrimps, mangrove mud crabs, sea-perch, snapper, grouper and milkfish (Nagelkerken *et al*., 2008; Rönnbäck, 1999; Walters *et al*., 2008).

2.2.6 Economic importance of mangroves fisheries

Mangrove ecosystems through habitat provision contribute to the production of fisheries as one of their major marketed products (Walters et al., 2008). They support commercial, recreational and coastal fisheries. The degree of relationship between commercial catch and mangroves varies with species, geographical location and time frame. Estimated figures show that the quantity of commercially viable fish catch attributed to the presence of mangroves range from 20 – 90% (Nagelkerken *et al*., 2008).

In Florida, USA, 80% of the marine species that are of commercial and recreational value, were identified to be associated with mangrove estuarine at point in their life cycle. In eastern Australia, mangrove dependent species constituted 67% of the total commercial catch. Additionally, 49% of the demersal fish species in the southern Malacca Strait, 30% of the fish catch and almost 100% of shrimp catch in ASEAN countries, were identified to be associated with mangrove systems (Walters et al., 2008).

The non-marketed coastal fisheries which are associated with various habitats are not included in fishery statistics. However, substantial amounts of these coastal fisheries associated with mangrove ecosystems in developing countries are overlooked in policy making as well as in valuing mangrove associated fisheries. It was estimated that coastal fisheries generated $610 in Fiji and $900 in Indonesia for each household (Walters et al., 2008).

In Kenya, high fish catch in marine areas was recorded in association with mangrove systems (Wakwabi, 1999). Kimani *et al*. (1996), recorded 128 fish species in Gazi bay using beach seines and found Gerreidae, Atherinidae and Clupeidae being the most abundant making 78.5% of the total catches. Crona & Rönnbäck (2007), also recorded 49 species using stake nets in Gazi bay. Although, these studies show the existence of mangrove associated fisheries in Kenya, little attention has been given to determine their economic value to coastal fisheries.

2.2.7 Climate compatible development (CCD) and scenario development

2.2.7.1 Climate compatible development

The development that minimizes the adverse effects of climate change and maximizes on development opportunities through low emissions and more resilient development is referred to as climate compatible development. In other words, it is development that creates ‘triple wins’ by generating adaptation and mitigation measures to climate change as well as development benefits (Mitchell & Maxwell 2010).

Adaptation is referred to the actions that ameliorate the effects of climate change. Adaptation can be achieved through reducing vulnerability, building adaptive capacity, risk management and building long term resilience. Adaptations are reactive to both real and perceived climate threats. They are driven by government actions focusing on reducing vulnerabilities and capacity building (Tompkins et al., 2013).

Climate change mitigation is referred to as the actions that result in the reduction of net carbon emissions and limit long term climate change. The pathways for mitigation activities are: efficiency in energy use, exploiting renewable energy sources, carbon sequestration and reducing emissions (Tompkins et al., 2013). Although research on mitigation measures in developing countries mostly focused on the role of tropical forests as carbon sinks in the past, the importance of coastal wetlands as major carbon stores has recently emerged, with particular attention to mangrove forests.

Combining adaptation and mitigation strategies with development strategies that are aligned with the changing climate and its impacts creates the triple wins of climate compatible development (fig.2.2).

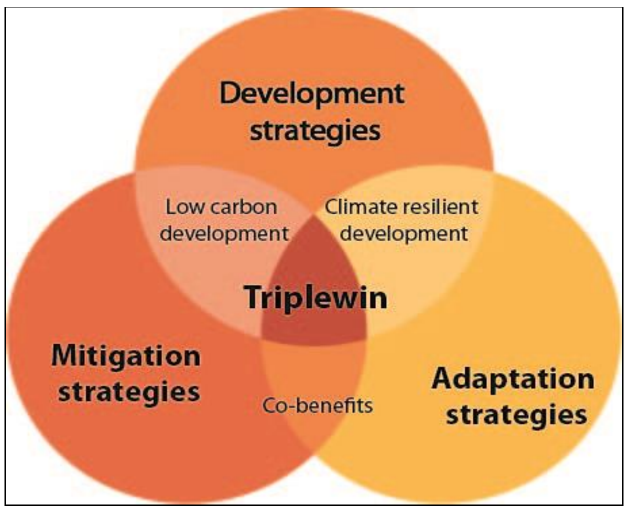

Figure 2.2 Climate Compatible Development *Source*: Mitchell & Maxwell, 2010

2.2.7.2 Scenario development

This section undertakes scenario analysis under business as usual (BAU) and climate compatible development (CCD) scenarios to identify priority challenges and promising policy options and their plausible trajectories. It also explores the emerging and future relationships in the management of coastal fisheries and mangroves through the DPSIR framework (Drivers, pressures, states, impacts and responses). The purpose is to reveal potential management options that would safeguard environmental conservation and connected human wellbeing.

Scenarios are defined as plausible descriptions of how the future may develop or look like, considering a sound and internally reliable assumptions about key connections and main drivers (e.g. rate of innovation changes and costs) (Nakicenovic et al., 2000) The use of scenarios is necessitated by the fact that predictions on ecological and environmental systems are difficult and almost impossible because of the complexities and uncertainties involved with them. The complexity of ecosystem systems is due to heterogeneity, non-direct flow, and cross-scale connections. In addition, ecological predications are made more difficult because of their dependence on unpredictable drivers (e.g. human behaviour). With all these difficulties on predicting the future, policies and decisions have to be made which have consequences for the future. The uncertainty on future can be dealt with scenario development (Alcamo et al., 2005).

Scenario analysis is a creative thinking of complex futures with qualitative and quantitative aspects. Scenarios give a storyline or description of changes while considering the driving forces and time horizon. The need for building scenarios in ecosystem service assessments is becoming more appreciated since previously conducted studies depict fixed representation in a dynamic world. Scenario generation is particularly important in economic valuation because it enables obtaining the marginal values associated with changes in service delivery (TEEB Foundations, 2010).

Comparing the outputs of different scenarios will contribute to policy and decision making on the welfare gains and losses under the different scenarios. For plausible scenario the implications of the direct drivers on the current status and institutions and future directions of ecosystem have to be analysed (TEEB Foundations, 2010).

Therefore, this study projects the future of coastal fisheries under business as usual scenario (continuation of the current trend, no interventions are made) and climate compatible development (interventions are made through various mechanisms e.g. policies, institutions and new investments to achieve the triple wins of adaptation and mitigation of climate change and development benefits).

2.3 Empirical Literature Review

Barnes-Mauthe *et al*. (2013), analysed the economic value of coastal fisheries and categorized their after-landing trends in Velondriake, Madagascar. They further sought to determine both commercial and subsistence values of the fisheries. In doing so, they constructed yearly fish landings and characterized ecological and socio-economic attributes such as habitat utilization, fishing methods, revenue and employment generation and reliance on the fisheries.

They collected data using various methods and utilized the direct market price approach of economic valuation. Their results showed that small scale fisheries employed 87% of the work force, generated 82% of household income and provided 99% of household protein intake. Furthermore, the study showed that in the year 2010, 5524 tons of fish and other marine species invertebrates were extracted from coral reef areas, 83% of this catch was commercially traded making about $6.0 million in revenue. The subsistence value of fish catch was estimated at $6.9 million annually.

O'Garra (2012), studied the economic value of a long-established fishing area around Suva, Fiji. By using contingent valuation, secondary data, and catch surveys, the fisheries value, bequest value and the role of mangroves and coral reefs in coastal protection were calculated at over $1,795,000 annually. The protection to coastal areas offered by the mangroves and coral reefs constituted more than half (55%), fisheries made 44% and bequest value made 1% of the TEV.

Aburto-Oropeza *et al*. (2008), illustrated in their study that there is positive relationship between fish catch and productive area of mangroves that are used both as feeding grounds and nursery by commercial species in the Gulf of California (USA). Mangrove associated fisheries and crab species make 32% of the coastal fisheries in the region. The yearly median economic value of mangroves to coastal fisheries was estimated to be $37,500/ha/yr, which is higher compared to other estimates in other parts of the world on mangrove services all together.

UNEP (2011a), conducted a study on the TEV of mangrove ecosystems in Gazi Bay, Kenya. The study calculated TEV of mangroves in Bay as 1,092.30 US$/ha/yr, a quarter of this (US$ 275.2 /ha/yr) were direct use values, the value of mangroves to fisheries production was estimated at US$ 44/ ha/year. Indirect values consisted of 20% and non-use values comprised of 55% (US$ 594.4/ha/yr) of TEV.

Kairo *et al*. (2009), conducted an economic study on a rehabilitated mangrove forest, Rhizophora mucronata plantation, at Gazi Bay in Kenya. The plantation, 12 years old, provides various goods and services. The major ones being: fuel wood, building poles, coastal protection, ecotourism, research, carbon capture and on-site fisher species collection. The total economic value of the plantation was computed to be US$2902.87/ha/yr. The contribution of this plantation to fisheries was calculated to be US$113.09/ha/yr.

2.4 Overview of literature

From both the theoretical and empirical literatures, it is established that coastal fisheries are of huge socio-economic importance to the livelihoods of coastal communities. Despite their importance, it can be deduced from the reviewed literature that very little attention was given to estimating the economic value of coastal fisheries and their associated habitats in Kenya. The few economic analyses that have been so far conducted are site specific and hence do not provide broad analysis that can inform policy and decision making. This study provides the much-needed comprehensive information, at county level, on the historical trend, habitat association, annual economic value and future projections under different scenarios (BAU and CCD) of coastal fisheries to contribute to sound policy making and management.

2.5 Theoretical and Conceptual Framework

a) **Theoretical framework**

The market prices of goods and services are dictated by interaction of supply and demand in a market. In economic theory, resources are efficiently and optimally allocated under the condition of perfect competition in which and consumers and producers maximize utility and profit respectively. In perfect competition markets are at equilibrium and pareto optimality, representing the highest level of welfare condition, is achieved. However, markets fail due to various reasons and result in sub-optimal allocation of resources. Among the causes of market failure is the existence of public goods which are non-rivalry and non-excludable in consumption. Ecosystem services are good examples of public goods (Ndebele, 2009).

Ecosystem services are either not provided through markets and thus not valued or are provided through markets but their value is under estimated despite their importance to human life. In economic terms a good or service has an economic value if individuals are willing to forego something to get or enjoy it. Economic valuation of ecosystem services addresses this problem by estimating the economic value of ecosystem services in monetary units.

b) Conceptual framework

The conceptual framework of the study is based on the role of ecosystem services to human welfare. Ecosystem services contribute to human well-being by providing a supply of ecosystem services such as; provisioning (food), regulating (flood regulation), supporting (nutrient cycling) and cultural (educational). These ecosystem services improve human wellbeing through a chain of benefits and values that societies derive from the ecosystem services these include; economic, ecological and social benefits and values. The provision of ecosystem services and benefits depends on deeper structures and procedures which result from complex interaction of biotic (living organisms) and abiotic (physical and chemical) components of ecosystems through the universal deriving forces of matter and energy (Groot *et al*., 2002). For instance, primary production (process) is required to maintain a feasible fish production (function) which can be caught for food (service).

As indicated in the conceptual framework below (fig.2-3), governance and decision making structure determine the use and management of ecosystems, this influences the composition and functions of ecosystems through direct, indirect as well as external drivers. These drivers further lead to both quantitate and qualitative changes of ecosystem services and hence further impacting human welfare and the total economic value they derive from ecosystem services. Knowing the economic value of ecosystem services provides critical information that can lead to restructuring of institutions and sound decisions that can enhance the conservation of ecosystems and hence the services they provide to the society.

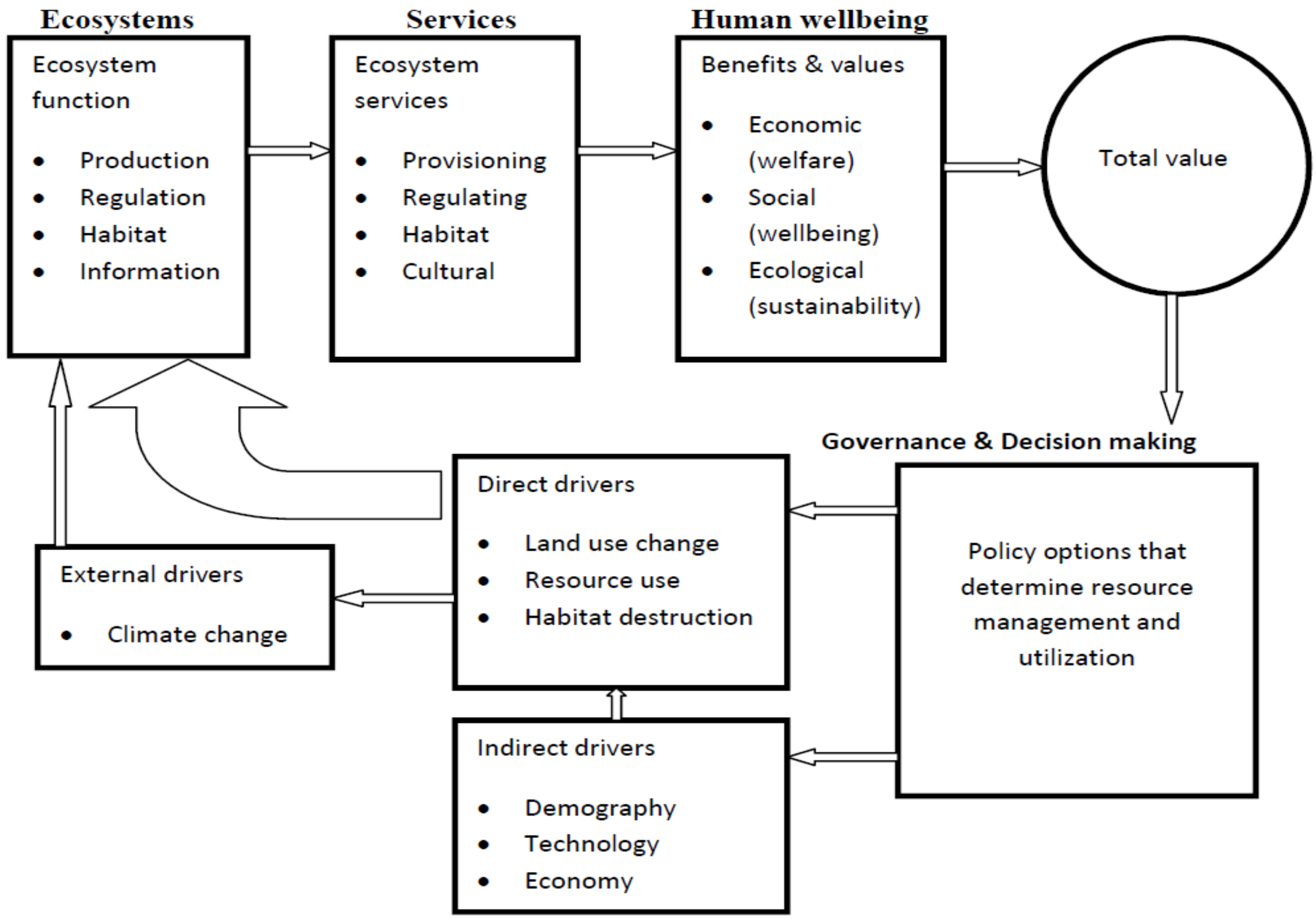

Figure 2.3 Conceptual framework source: Modified from (TEEB Foundations, 2010)

CHAPTER THREE
STUDY AREA

3.1 Introduction

In this chapter the details of the study area are covered. It describes the geographical location, demographic characteristics, climate, fisheries and mangrove ecosystems in the study area.

3.2 Geographical Location and Demographic Characteristics

The study area was located along the coastline of Kwale County as shown in the map below (fig. 3-1), Kwale county is in the southern coast of Kenya, neighbouring the republic of Tanzania toward the south west, and the following counties: Taita Taveta toward the west, Kilifi toward the north, Mombasa toward the north east and the Indian ocean toward the east. The county covers 8270.2 km^2 and accounts for 1.42% of Kenya's total surface area. The county has a population of 649,931 (49% male and 51% female), with a growth rate of 2.6% annually and a population density of 79 people per km^2.

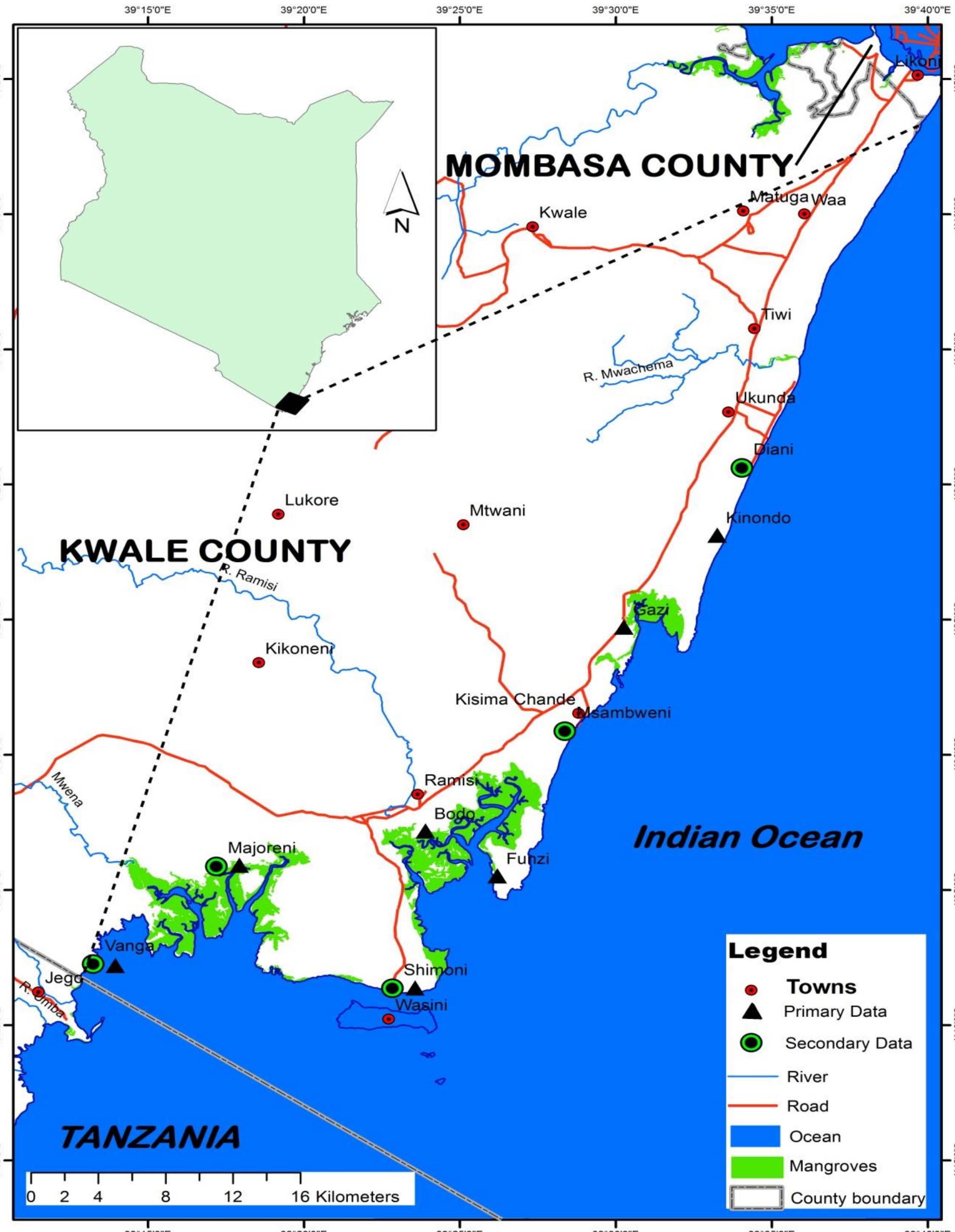

Figure 3.1 Map of the coastline of Kwale County

3.3 Climate

The climate of Kwale County is warm and humid especially along the Coastal strip. The climate of the county is influenced mainly by the two prevailing winds including the North-East Monsoon winds prevailing from months of November to March and South-East Monsoon winds which prevail from April to October. These two winds bring changes in rainfall and temperatures. The average annual precipitation along Kwale County coast lies between 1000–1600 mm, humidity is usually high throughout the year, reaching a peak between April-July (UNEP, 1998).

During the past 100 hundred years, the average temperature on the Earth surface has increased slightly but an increase of Earth's temperature by 1.4-5.80C is expected during the 21st century. The Fourth Assessment Report of IPCC recognizes the threat posed by climate change to the developing world (IPCC, 2007). The climate change elements that are important for Kenya are rainfall (distribution and amount) and temperature (especially the minimum and maximum). The possible impacts of the impending climatic change are many including accelerated melting of glaciers in the polar belts which can significantly raise sea levels which could place many coastal towns and islands such as Mombasa, Lamu, Malindi, Mada and Zanzibar at great risk of elimination through submergence. The National Climate Change Response Strategy has projected the following impacts of climate change on the coastal and marine environment including that of Kwale county (Goverment of Kenya, 2010).

a) Approximately 4600 ha or 17% of the land mass in Kenya will be inundated due to sea level rise of only 0.3m thereby affecting coastal development sectors especially tourism.
b) Sea level rise will lead to the submergence and displacement of coastal wetlands, and result in accelerated erosion of the shorelines, high salinity, due to the intrusion of saline water into coastal aquifers.
c) The distribution of mangrove forests will change thereby jeopardizing the livelihoods of coastal communities who depend on the mangroves particularly for fisheries, wood/timber products and coastal hazard buffering.
d) Increased risk of floods and high tides in lower-lying coastal areas.
e) Coral reef bleaching may increase due to global warming thereby affecting the coral reefs ecosystems which are key attractions for the tourism sector.

3.4 Coastal Fisheries

Kwale County has a coastline which is approximately 110 km long. Along this coastline coastal fisheries are the major source of livelihood to the coastal communities, by providing food, employment and generating income. The coastal fisheries in Kwale county are characterised as labour intensive, less capital intensive, multispecies and multi-gear and tied to coastal the communities and settlements. The fishing activities in the county are limited to the near shore, approximately around 15KM from the shore, since the locally crafted vessels cannot withstand the deep rough seas. The county has a total of 46 fish landing sites most of them in remote areas with limited infrastructure, only one landing site at Vanga has an operational fish storage with cooling system(Republic of Kenya, 2012). Tourism industry is another contributor to the economy of the county particularly in Northern part of Kwale's coastline where there is intensive tourism infrastructure. Agricultural production is practised mainly in the hinterlands of the county and contributes to the county's economy.

3.5 Mangrove Ecosystems

Mangrove forests occur along the coastline of Kwale County. These forests are adjacent to terrestrial forests on the land side and connected with seagrass beds and coral reefs on the sea side. The county has approximately 6490 ha of mangrove forests concentrated in four major areas, Gazi, Funzi, Shimoni and Vanga (fig.3-1). All the nine mangrove species that are found in Kenya also occur in Kwale county with Rhizophora mucronata, Ceriops tagal and Avicennia marina being dominant species (Mark Huxham et al., 2015). Mangrove forests are of great ecological as well as economic importance to the county. They are nutrient rich ecosystems which directly and indirectly support a wide range of food chains and function as habitats and feeding ground for fish and invertebrates and support the production of coastal fisheries in the county. Mangroves forests are also exploited for extractive uses such as timber, firewood and medicine.

CHAPTER FOUR
RESEARCH METHODOLOGY

4.1 Introduction

This chapter describes the approaches and methods employed in the study including sample size and sampling procedure, data sources and economic valuation method.

4.2 Sample Size and Sampling Procedure

A sample of 242 fishermen were randomly selected, by first obtaining the list of fishermen in each village form the respective beach management units from seven major fishing villages; Vanga, Majoreni, Shimoni, funzi, bodo, Gazi and Kinondo were interviewed. The fishermen were interviewed at the fish landing sites before they started their fishing expedition in the morning or after landing their catch in the afternoon.

4.3 Data collection

4.3.1 Primary data

Primary data was generated using questionnaire survey, focused group discussions and key informant interviews.

4.3.1.1 Questionnaire survey

Questionnaire survey was used as one main tool for information and date gathering. The questionnaire survey (Appendix 1), was divided in three major parts. Part one was on the personal information of the fishermen to establish the characteristics of coastal fishermen. Part two focused fishing specific questions such as seasonality and cost of fishing (boat ownership, buying price, maintenance costs, gear ownership and costs, and labour costs) and third part of questionnaire was on the management measures (permits and licenses) and opportunities for climate compatible development (CCD) in coastal fisheries. The questionnaire survey was administered in six fish landing villages (Vanga, Majoreni, funzi, bodo, Gazi and Kinondo).

4.3.1.2 Focus group discussion

Focus group discussions were utilized to collect qualitative data by forming groups (7-10 people), consisting of fishermen, youth and elders, to prompt free discussion with the participants and probe for answers concerning the research questions of the study. For the scenario analysis, scenario panels were constructed consisting of experts from stakeholders including the local communities, government agencies and NGOs to build storylines for the coastal fishery sector under both business as usual (BAU) and climate compatible development (CCD) scenarios for the next 20 years.

4.3.1.3 Key informant interviews

Key informant interviews were employed used to collect data from individuals who considered to be the opinion leaders in the villages and government officials.

4.3.2 Secondary data

Secondary data mostly obtained from Kenya Marine and Fisheries Research Institute (KMFRI) and the fisheries department was used in the study. This data was used to construct annual fish landings datasets which details the amount of fish landed in kilograms (Kg), the auctioning prices of fish at the landing site in Kenyan shillings (Ksh) and the species of fish landed, over a period of 10 years to enable trend analysis. In addition, the study also utilized published scientific literature and expert knowledge to identify mangrove associated species from the catch data.

3.2.2 Economic valuation methodology

Although a wide range of valuation methods can be applied, the production function and market price approaches to economic valuation are commonly used in the valuation of coastal and mangrove-associated fisheries, since they fall under the provisioning category of ecosystem services (Barbier, 2000, 2007; TEEB Foundations, 2010).

The production function treats the biological resource or ecological function of an ecosystem as an input to the production of a marketed output and hence its value is determined by equating it to the change in output (Barbier, 2000). However, the application of this method has demanding data requirements, both ecological and economic data, and also makes various assumptions such as: a Cob-Douglas production function which puts limitations on the elasticities of substitution among inputs, an optimal catch of fisheries model and long-run competitive equilibrium. This approach fails to consider the reality of insufficient data and the conceptual problems with biophysical models of ecosystem services (Parks & Gowdy, 2013).

Due to lack of the specific data required for the adoption of the production function and its inherent complexities, the study uses the market price approach because of its suitability to the circumstances surrounding the study e.g. the kind of data available.

3.2.3 Data Analysis

Descriptive statistics were done to determine the characteristics of coastal fisheries between sites in terms of average counts. Graphical analyses and representation were done on Excel 2007. The below estimation model was utilized to undertake data analysis and estimate the economics value of coastal and mangrove associated fisheries in Kwale County.

3.2.3.1 Estimation model

$$V = \sum P_{s,y} \times Q_{s,y} - \sum C_{i,y}$$

Fish price ($P_{s,y}$) = market price of fish species *s* in year *y* (Ksh/kg)

Fish catch ($Q_{s,y}$) = quantity of fish species *s* in year *y*

Fishing cost ($C_{i,y}$) = Cost of boat + operating costs + cost of gear + labour costs

Where:

Cost of vessel and gear = $\frac{P_{v,g}}{l_{v,g}+r_{v,g}}$, for boat and gear owners.

$P_{v,g}$ = price of vessel or gear, $l_{v,g}$ =life span of vessel or gear in years, $r_{v,g}$ = repairing costs for vessel and gear

For non-boat owners, the cost of renting a boat was considered.

Operating = fuel used, if the motorized.

Cost of gear = the cost of buying or renting gears such as nets.

The profitability of coastal fisheries was estimated as the ratio of annual fishing income to annual fishing revenue (Teh et al., 2011).

$P = \frac{NI}{TR}$ Where, $NI = TR - TC$

P = profitability, NI = net income per year, TR = total revenue per year and TC = total cost per year.

3.2.3.2 Scenario analysis

In building storylines under the BAU and CCD scenarios, firstly the current management regime of coastal fisheries was analysed and secondly a scenario panel was constructed consisting of multidisciplinary experts from stakeholder organizations, institutions and representatives. The panel comprised of government officials from (fisheries department, KMFRI, NEMA, KFS and CDA), NGO (WWF and wetlands international), corporate (Base Titanium) and academia. The panel under the guidance of the researcher identified the drivers and descriptors of change and discussed the focal questions of the scenarios. The scenario building process was based on the two assumptions which were; under the BAU scenario assumed a continuation of the situation surrounding the coastal fisheries of Kwale County while under the CCD scenario it assumed that major policy shifts are made with regards to the management of coastal ecosystems, investing in in programs that integrate development with mitigation and adaptation mechanisms. Based on these, a storyline was developed on how the future of coastal fisheries might look like under BAU and CCD. This approach is in line with the millennium ecosystem assessment methodology for scenario analysis (Alcamo et al., 2005).

CHAPTER FIVE
RESULTS AND DISCUSSION

5.1 Introduction

The chapter presents the analysis and results of the study and provides a discussion on the findings of this study in comparison with those of other similar studies.

5.2 Demographic Characteristics of the respondents

5.2.1 Age and gender

Most of the respondents were aged between 25-34 years, constituting 31% of the respondents. Fishermen below the age of 45 years constituted 78% of the respondents. This indicates that most the fishermen are youthful with an average age 35 years (fig. 5.1). In terms of gender, 100% of the respondents were male, this is due to the fact that females do not go out for fishing but are engaged in fishing related activities such as fish marketing and processing.

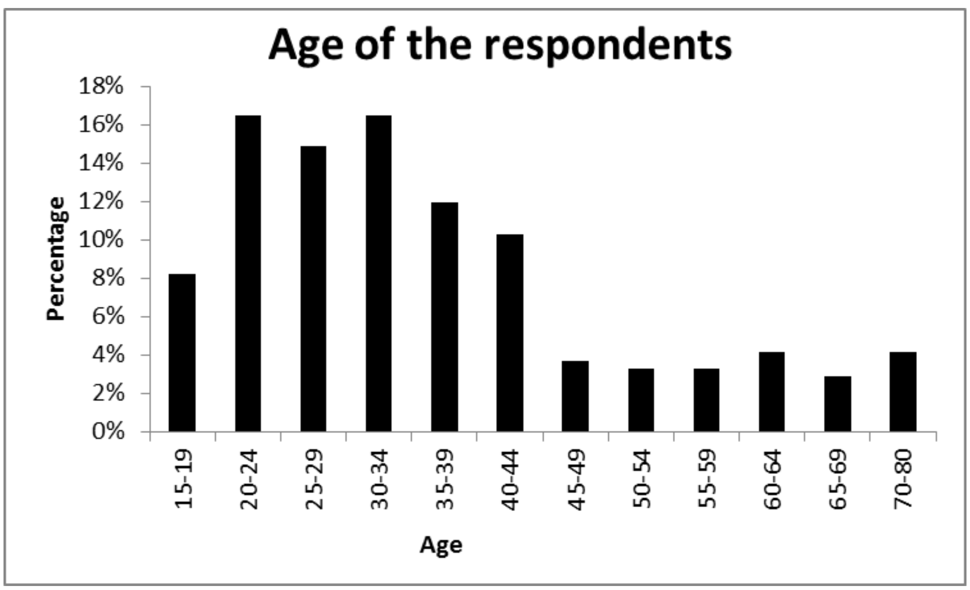

Figure 5.1 Age of the respondents

5.2.2 Education and occupation

Primary school dropouts made 32.2% of the respondents, while 21.5% completed primary school and 14% had no education. The combined percentage of fishermen with no education, incomplete primary and complete primary school made 68% of the respondents. Secondary school dropouts made 4% of the respondents and only 2% completed secondary school. Since the majority of fishermen in Kwale County are Muslims by religion 24% attended madrassa schools (fig. 5.2).

From the above discussion, it can be established that the level of education among the fishermen in Kwale County is low. The number of schools in the coastal areas are few compared to other areas. There is very little motivation for higher education amongst fishing communities as there only few higher graduates to motivate younger generations and there are other competing livelihood activities such as fishing, farming and selling, that youth get engaged in to support their families.

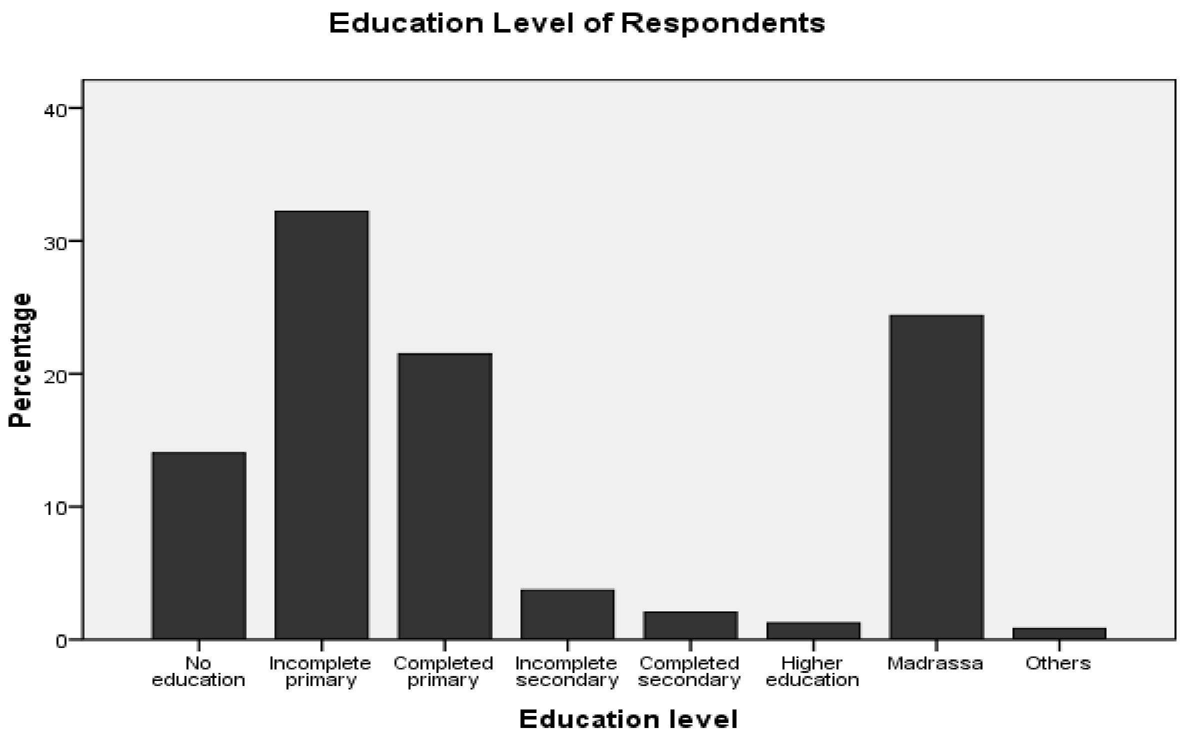

Figure 5.2 Education level of the respondents

In terms of occupation 85% of the respondents reported that fishing was their mainstay occupation while 15% stated that fishing was part time job to them and engaged in other sources of livelihoods such as farming and business (fig.5.3). Due to low of level of formal education, very few individuals are employed to the civil service.

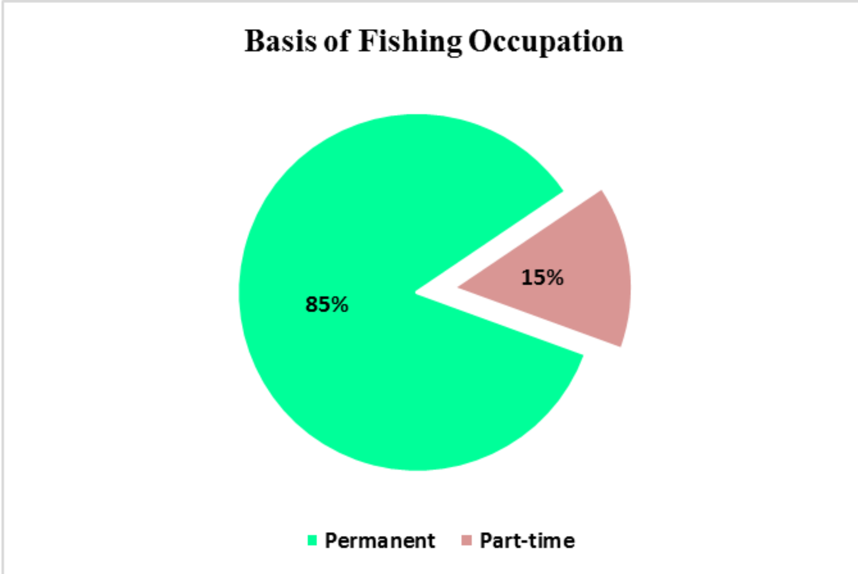

Figure 5.3 Basis of fishing occupation

5.2.3 Vessel and gear types

Multiple vessels and gears are used in the exploitation of coastal fisheries in kwale county. Locally crafted dugout/canoes are most commonly used type of vessel (61%), it was also established that 20% of the interviewed do not use vessels but rather walk to the sea and fish by swimming and diving (Fig. 5.4). Coastal fishermen use several different gears to catch fish from water the water, hand line make 28% of gears used followed by spear guns (15%) and gill nets (13%) (fig. 5.5). The survey data shows that 23% of the respondents use illegal fishing gears (spear gun, beach sien and monofilament net).

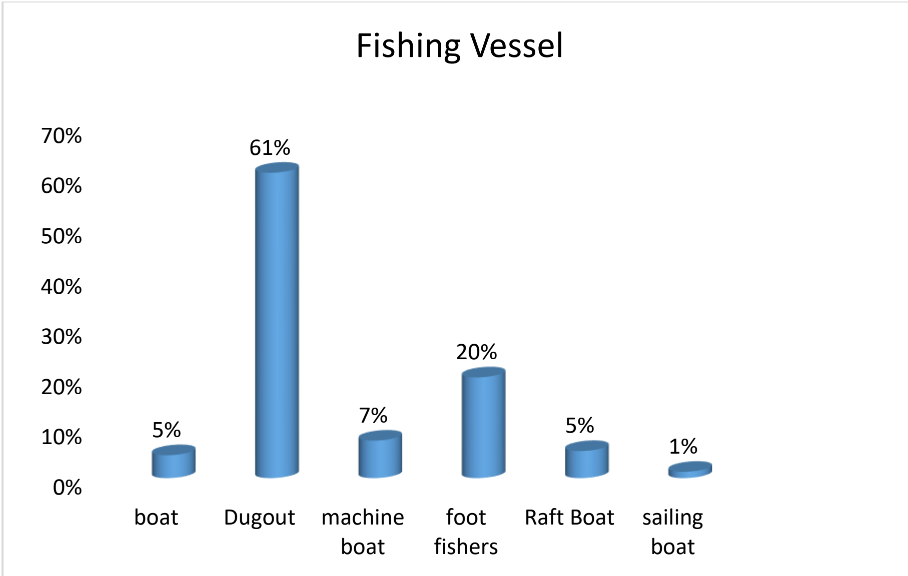

Figure 5.4 Type of fishing vessel used

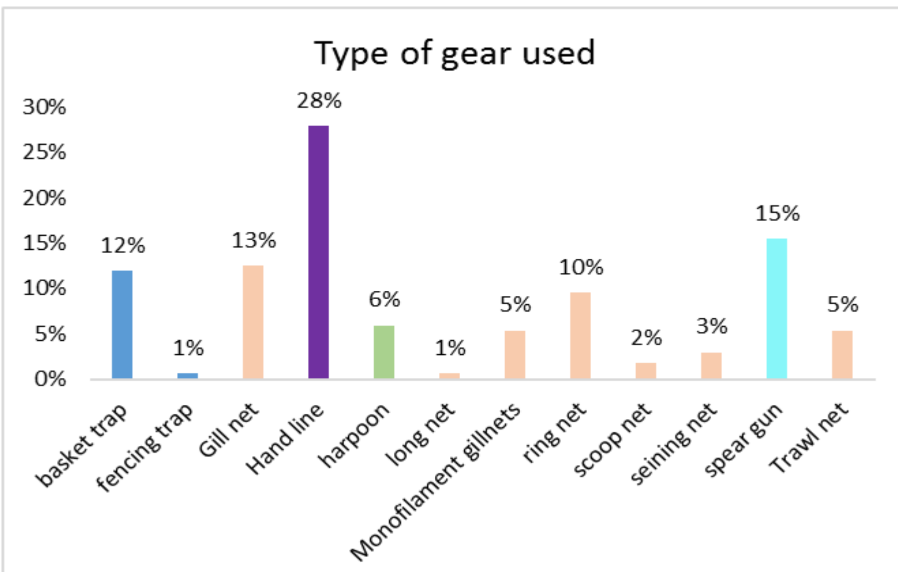

Figure 5.5 Type of fishing gear used

5.3 The trend of coastal fisheries

The trend of annual production of coastal fisheries in Kwale County from the year 2004 to 2013 was variable but generally exhibited an increasing trend with time. Production increased from 1,908 tons in 2004 to 2,450 tons in 2013, production reaching its peak in the year 2009 at 2530 tons. Similarly, the price of catch and revenue generated have shown consistently increasing trend in the past 10 years, reaching maximum revenue generation of almost Ksh 260 million in the year 2013 (fig.5.6).

Demersal fish contributed 48% of total production in 2013, followed by Pelagic fish and Molluscs, which 26% and 11% respectively. On seasonality, the months between April and August recorded the lowest production (fig. 5.7).

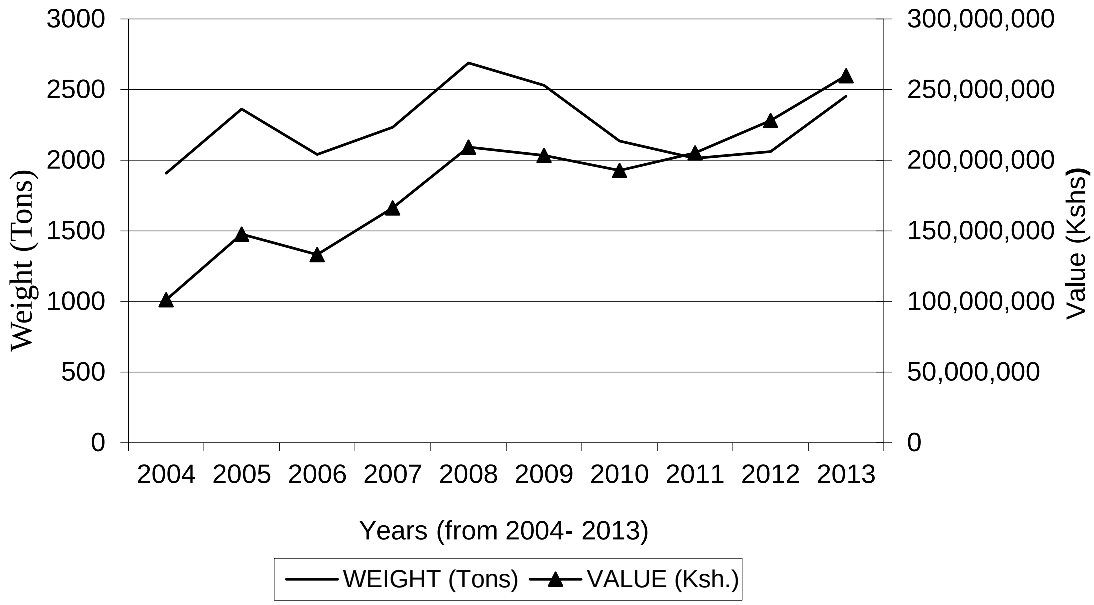

Figure 5.6 Trend of fish production in Kwale County (2004-2013).

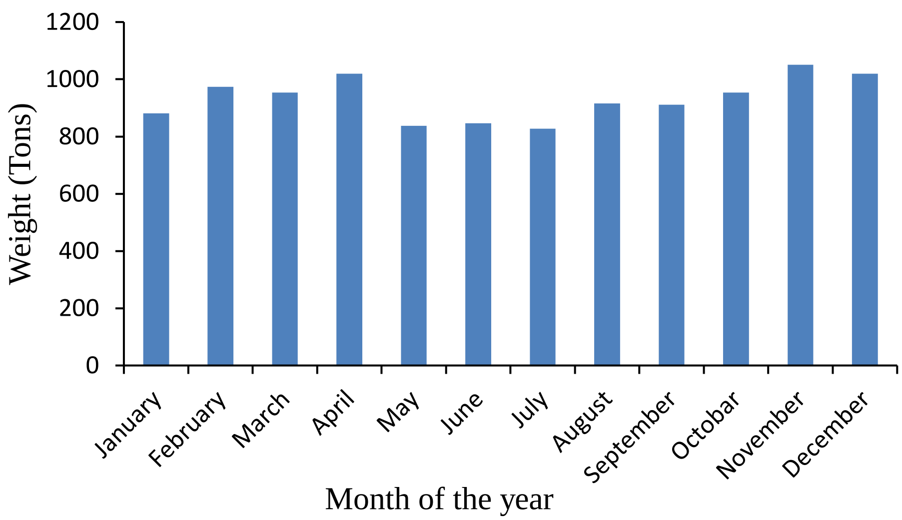

Figure 5.7 Average monthly production of coastal fisheries from 2005-2013

5.4 Economic value of mangrove-associated costal fisheries

The study identified from the catch data that 14 different species of fish caught in Kwale county were associated with mangrove habitats during at least one stage of their life cycle (table 4-1). In the identification of mangrove-associated fisheries published scientific studies were utilized. Mangrove associated fisheries accounted for 1036.7 tonnes (42.3%) of the total catch and Ksh. 107.8 million (41.5%) of the total revenue from coastal fisheries in 2013. Considering that Kwale County has approximately 6490 hectares of mangroves forests, it is estimated that mangroves contribute close to 160 Kg/ha/year of coastal fishery production and Ksh. 16610/ha/year in income generation.

Table 5.1 Mangrove-associated fish species in kwale

	Mangrove-associated species					Total catch landings			
English Name	**Family Name**	Mangrove - associated species	References	% of total Catch	% of total revenue	Weight (Kg)	Revenue (Ksh)	% catch of total catch	% of total revenue
Dermasals									
Rabbit fish	*Siganidae*	*M*	*1,4*	6.4	7.7	157971	19965860	6.4	7.7
Scavengers	*Lethrinidae*	*M*	*1,2,4*	5.2	5.7	127058	14703370	5.2	5.7
Snappers	*Lutjanidae*	*M*	*1,2,3,4*	3.7	3.8	91271	9923450	3.7	3.8
Parrot fish	*Scaridae*	*M*	*1,3,4*	5.7	5.1	138953	13299830	5.7	5.1
Surgeon	*Acanthuridae*	*M*	*1, 3*	2.6	2.2	64092	5773120	2.6	2.2
Unicorn	*Naso brevirosyris*					59230	5105080	2.4	2.0
Grunter	*Haemulidae*	*M*	*1, 3*	0.8	0.7	20269	1897420	0.8	0.7
Pouter	*Cephalopholis argus*					70526	6296470	2.9	2.4
Black skin	*Gaterin sordidus*					104660	10487610	4.3	4.0
Goat fish	*Mulidae*	*M*	*1,2*	1.5	1.7	36059	4317710	1.5	1.7
Streaker	*Aprion virescens*					34084	3130040	1.4	1.2
Rock cod	*Serranidae*					71467	7579850	2.9	2.9

Mangrove-associated species						Total catch landings			
English Name	**Family Name**	Mangrove - associated species	References	% of total Catch	% of total revenue	Weight (Kg)	Revenue (Ksh)	% catch of total catch	% of total revenue
Cat fish	*Aridae*					40499	3881280	1.7	1.5
Mixed dem.						152617	14344910	6.2	5.5
Sub-total						**1168756**	**120706000**	**47.7**	**46.5**
Pelagics									
Cavalla.j.	*Euthynnus pelamis*					40259	4924990	1.6	1.9
Mullets	*Mugulidae*	*M*	*1,2*	3.1	2.8	75602	7370520	3.1	2.8
Mackerel	*Kanaguta*					118355	11396070	4.8	4.4
Barracuda	*Sphyranidae*	*M*	*1,2,3,4*	3.5	3.3	86646	8493780	3.5	3.3
Milk fish	*Chanidae*	*M*	*1,2,4*	1.3	1.2	32330	3115640	1.3	1.2
King fish	*Scombridae*	*M*	*1*	1.0	1.2	23664	3222310	1.0	1.2
Queen fish	*Chorinemustol*					17229	1842090	0.7	0.7
Sail fish	*Istiophoridae*					5660	800480	0.2	0.3
Bonito/tuna	*Arangidae*					69602	7022840	2.8	2.7
Dolphinfish	*Colyphaenidae*					12817	1378860	0.5	0.5
Mixed pel.						154307	16900410	6.3	6.5
Sub-total						**636471**	**66467990**	**26.0**	**25.6**

		Mangrove-associated species				Total catch landings			
English Name	**Family Name**	Mangrove - associated species	References	% of total Catch	% of total revenue	Weight (Kg)	Revenue (Ksh)	% catch of total catch	% of total revenue
Sharks/rays	*Carcharhinidae /others*					50815	4392440	2.1	1.7
Sardines	*Clupeidae*	*M*	*1,2*	4.7	2.3	116212	5981200	4.7	2.3
Mixed/others						101887	7626865	4.2	2.9
Sub-total						**268914**	**18000505**	**11.0**	**6.9**
Crustacea									
Lobsters	*Penulirus spp*					17581	10705350	0.7	4.1
Prawns	*Paenus spp*	*M*	*5*	0.9	1.5	21664	3801400	0.9	1.5
Crabs	*Scyllaridae*	*M*	*5*	1.9	2.3	45406	6001865	1.9	2.3
Sub-total						**84651**	**20508615**	**3.5**	**7.9**
Miscellaneous									
Bech-de-mer	*Holothuroidae*					8796	1340110	0.4	0.5
Octopus	*Vugaris spp*					181334	19967560	7.4	7.7
Squids	*Sepia oligo*					101851	12799370	4.2	4.9
Sub-total						**291981**	**34107040**	**11.9**	**13.1**

Mangrove-associated species						Total catch landings			
English Name	**Family Name**	Mangrove - associated species	References	% of total Catch	% of total revenue	Weight (Kg)	Revenue (Ksh)	% catch of total catch	% of total revenue
Grand total				**42.3**	**41.5**	**2450773**	**259790150**	**100.0**	**100.0**

M- Mangrove associated species; 1 - (Kimani *et al*, 1996), 2- (Huxham *et al*, 2004). 3- (Lugendo *et al*, 2007), 4- (Crona & Rönnbäck, 2007b), 5- (Huxum, 2013)

5.5 Economic value of coastal fisheries

In the year 2013, the base year of the study, a total fish catch of 2450.773 tons was recorded in Kwale County generating estimated revenues of Ksh 260 million (Ksh. 106,091 per ton). To determine the economic values (total revenue generated less the total cost of fishing) of coastal fisheries the cost of fishing operations was estimated. It is estimated that the annual cost of fishing in Kwale county was estimated at Ksh. 78 million. The fishing cost comprises of annual average cost of fishing vessels, annual average cost of fishing gear, operating cost and labour cost. The opportunity cost of labour forms the largest component of fishing at costs Ksh. 52 million (67%). Considering depreciation cost, the annual average cost of fishing vessels and gears were estimated at Ksh. 13 million (17%) and Ksh. 8 million (10%) of the total fishing cost respectively. Operating costs including fuel cost constituting the remaining Ksh. 5 million (7%) of the total fishing cost. The economic value of coastal fisheries is estimated to be, the total revenue from fishing less the total cost associated with fishing activities, Ksh. 182 million in the year 2013. This net income had an average profitability margin of 0.7 annually.

5.6 Coastal Fishery Scenarios under Business As Usual (BAU) and Climate Compatible Development (CCD) Scenario

5.6.1 Business As Usual (BAU) scenario

Under the BAU scenario, data from the survey questionnaire on the current management measures surrounding coastal fisheries and their enforcement are analysed. The derivers of change that could affect the future of coastal fisheries are identified by scenario panel consisting of multidisciplinary experts from stakeholder organizations, institutions and representatives.

5.6.1.1 Management measures

The issues on the current management measures of coastal fisheries such as licensing, occurrence of illegal fishing and changes in catch sizes with time are analyzed in this section to provide baseline information for scenario analysis.

a) Fishing License

The fisheries act (Cap 387) regulates the operations of coastal fisheries and mandates licensing of vessels and boats and fishing permits for fishermen. Among the interviewed fishermen, 51% did not have neither fishing permits nor boat licenses while 27% had fishing permits, 6% owned boat licenses and 16% had both fishing permits and boat licenses (fig. 5.8)

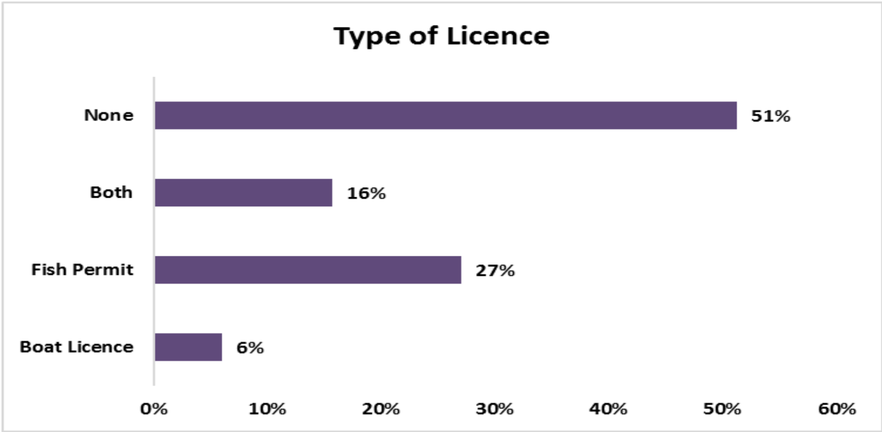

Figure 5.8 Type of license owned

b) Illegal fishing gears

On the occurrence of illegal fishing gears, 47% of the respondents reported the use of illegal fishing gears the major ones being, use of illegal fishing nets (22%) and dynamite fishing (17%) (fig. 5.9) From the FGD and key informant interviews, it was discovered that sometimes the locals/villagers tipoff fishermen who are engaged in illegal fishing on impending patrols of law enforcement agencies. It was also established that the catch from the use of outlawed gears was not landed at the official landing sites in order evade law enforcement officers or BMU.

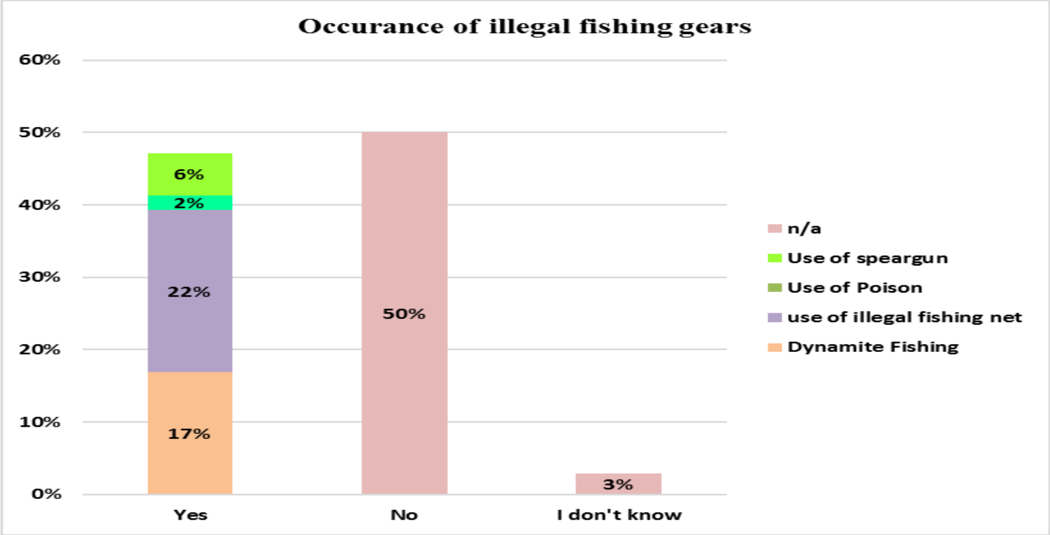

Figure 5.9 Occurrence of illegal fishing gears

c) Changes in Catch size

The catch size of coastal fisheries depends on a number of variables including seasonality, time spent on fishing and the type of fishing vessel and gear employed. Holding these variables constant, 77% of the interviewed fishermen reported there was change in average catch size as it was in the past 10 years while 19% said there was no change in catch (Fig. 5.10). The majority of the respondents who reported the change in catch size (49%) believe that decline fish catch is attributed to climate change and the extreme weather conditions associated with it. The decline on the amount of catch per fisherman has also been confirmed in the focus group discussions. From the key informant interviews it was established that in order to maintain the fish catch, some of the fishermen are increasing the effort by spending more time at sea and employing multiple gears while others get engaged in part-time jobs.

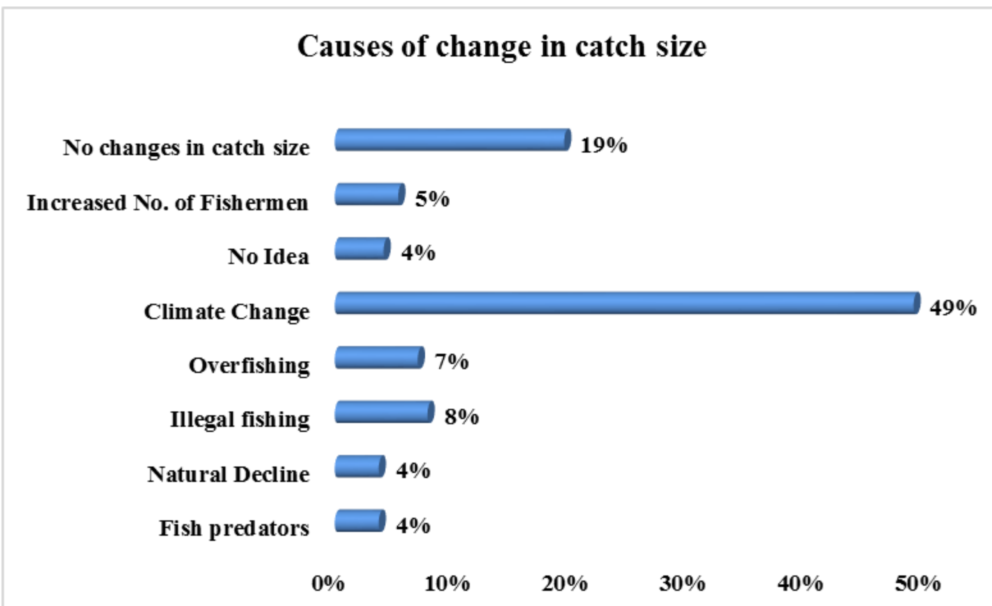

Figure 5.10 Causes of change in catch size

5.6.1.2 Derivers of change

For the scenarios analysis to be plausible both the direct and indirect drivers of change were identified and their likely consequences under businesses as usual and climate compatible development scenarios.

The scenario panel categorized the direct drivers as positive, neutral and negative drivers of change. Positive drivers include ecosystem conservation and restoration (e.g. creation of marine protected areas (MPA), locally managed marine areas (LMMA) and restoration of mangrove habitats), adoption of environmentally sound technologies and sustainable resource management. Land use change in coastal areas, which could have positive or negative impacts depending on the context was identified to be a neutral driver. Negative drivers include habitat destruction (mangroves, coral reefs and sea grasses), over fishing and pollution.

The indirect derivers in the context of coastal fisheries were identified as climate change, population dynamics, unsustainable inland and off shore development, technological innovations and policy instruments. Among the indirect drivers, it was identified that climate change will have the most serious impact on the sustainability of coastal fisheries and their habitats.

5.6.2 Climate compatible development (CCD) scenario

Under climate compatible development, the scenario panel projected, with the assumption that major policy shifts are made with regards to the management of coastal fisheries, in the 20 years to come the Kenyan government organs concerned with environmental protection and development, such as the fisheries department, Kenya Forestry Service (KFS), Kenya Wildlife Service (KWS) and National Environment Management Agency (NEMA), will achieve well-coordinated and integrated working practices which will strengthen policy implementation and law enforcement. This will lead to thorough application of the existing progressive laws which will further strengthen the existing community based organisations and growth of new community based groups, including Community Forest Associations (CFA), Community Based Organizations (CBO) and Beach Management Units (BMU). This will promote community ownership and control of resources, especially in forestry and fisheries, and this will further help address poverty and inequality.

The scenario panel further envisioned that und CCD scenario, the negative effects surrounding coastal fisheries will be addressed through adoption of development strategies coupled with adaptation and mitigation mechanisms. Adaptation measures would include capacity building, climate proofing of infrastructure, adoption of ecosystem adaptation, and disaster preparedness while mitigation measures would entail technical innovations to reduce fossil fuel use, better designing of cooling storages to reduce energy consumption and protection and restoration of mangrove ecosystems. Though decline of temperature sensitive species coastal fisheries will initially suffer from the impacts of climate change. These effects will be addressed through rehabilitation and conservation of important habitats, including mangroves and coral reefs, and the establishment of new marine protected areas and locally managed marine areas. BMUs become more effective in enforcing appropriate fishing methods and avoiding overfishing through effort based management systems. The value of the catch will increase through improved fish processing, new storage and freezing facilities and marketing and value addition chains, coupled with increased demand to fish. The Kenyan would encourage in deep sea commercial fishing creating new employment opportunities and tackle off-shore illegal fishing. Aquaculture production in the region doubles under the CCD scenario.

5.7 Discussion

5.7.1 The trend of coastal fisheries

The increasing trend of fisheries production could be attributed to increasing fishing effort. This concurs with the findings of Ochiewo (2004) and Republic of Kenya (2012), who identified that fishing effort has been increasing with time, the number of fishermen, fishing gear and fishing vessels, over time in Kwale County. The increase in fishing effort is due to increasing demand of fish, population growth and limited other sources of livelihoods.

As shown in (Fig. 2) the study has established that fish production is high in the months between September and March and low in the April and August. This is in line with the findings of Benards (2010) and Ochiewo (2004), who established that fishing activities are influenced by seasonal variations of the monsoon winds. The North-eastern monsoon (NE), blows from September to March, during this season the sea calm and fishing activities are intensive. During the South-eastern monsoon (SE), this blows between April and August, in this period the sea is rough and fishing activities are low since their artisanal vessels cannot withstand the rough sea. In the NE season, migratory fishermen coming from Tanzania with better fishing vessels and gears and expertise also contribute to the higher fish production in this season.

5.7.2 Mangrove ecosystems and their contribution to coastal fisheries production

The contribution of mangroves to the value of fisheries production depends on, among other factors, the species under consideration, site characteristics, climate variability and the presence of predators competitors and their abundance (Faunce & Serafy, 2006; Aburto-Oropeza *et al*., 2008). The results on the contribution of mangroves to coastal fishery production for Kwale County indicate that mangroves are of critical importance to fishery production in the county, 42.3% of the total fish catch and 41.5% of the total revenue generated in the year 2013 are associated with mangrove ecosystems. In other words, mangroves are attributed to the production of 160 Kg/ha/year of fish with a value of Ksh. 16610/ha/year (US$ 198/ha/year).

Although the results of mangrove contribution to fisheries production are consistent with Kapetsky (1989), who estimated that average production of fin and shell fish in mangrove areas to about 90 kg/ha/year with a maximum yield of 225 kg/ha/year, the calculated results in terms of both catch and value are higher compared to the ones estimated by Kairo *et al*.(2009) and UNEP (2011), which were both conducted in Gazi bay, Kenya. Kairo *et al*. (2009), estimated the catch of mangrove associated fin fish to be 94.62 kg/ha/year with a net income of US$ 113.09/ha/year while UNEP (2011), calculated the value of mangroves to fish production to be US$ 44/ha/year. The higher value of mangrove contribution to fisheries production estimated in this study can be explained by the extensive data that was compiled in this study that was not used in the previous studies and the spatial coverage of the study.

The value of mangroves to fisheries production could be much higher than the estimated value since the value of on-site (within the mangrove forests) fisheries are not usually captured in the fisheries data records. On-site fisheries are composed of harvest of resident species such as mangrove crabs and oysters and capture of fish and prawns that use mangroves for feeding during high tide, which are harvested for subsistence throughout the coast of Kenya (Bosire *et al*., 2012) using fence traps, hand lines and range of other gears (Samoilys *et al*., 2011).

5.7.3 Economic value of coastal fisheries

These findings indicate that coastal fisheries are critical to the welfare and livelihoods of coastal communities in Kenya. Coastal fisheries are among the main sources of income generation in Kwale County and also provide food security through consumption of fish and using income derived from fishery activities to buy other stable food such as maize flour. They also support other smaller industries such as boat making and repair, tourism and transport along the coastal villages.

The value of coastal fishery production of Ksh. 182 million in 2013 (US$ 2.2 million), is lower than the value estimated by Barnes-Mauthe *et al*. (2013), who calculated the value of small scale fisheries to be US$ 6.9 million in Velodriake, Madagascar. The higher value in Madagascar could be is because some species (Octopus and sea cucumber) of the production of small scale fisheries are exported to developed countries at high prices. The value of coastal fisheries in Kwale County is higher compared to the value of small scale fisheries in Navakavu, Fiji which was estimated at US$ 790,226 annually by O'Garra (2012). The value of coastal fisheries could be higher than the calculated because there are unrecorded catch data which are landed in smaller landing sites or caught by foot fishers who constitute 20% of fishermen (Republic of Kenya, 2012).

The calculated average profitability ratio (0.7), shows that coastal fisheries in Kwale County are highly profitable and hence buffer coastal communities from poverty. This is consistent with the findings of Barnes-Mauthe *et al*. (2013), who estimated an average profitability ratio of (0.87), for small scale fisheries in Velondriake, Madagascar and Teh *et al*., (2011), who also found out that small scale fisheries in Sabah, Malaysia play a significant role in preventing coastal communities from falling into poverty. The importance of coastal fisheries in poverty prevention was also hypothesized by Béné *et al*.(2007), that coastal fisheries play a major role in food security and poverty prevention in coastal zones.

5.7.4 Business As Usual (BAU) and Climate Compatible Development (CCD) scenarios

The analysis of the current management regime reveals that even though policies and regulatory frameworks exist their enforcement is weak. This weak enforcement of regulations could be attributed to poor financing of the enforcement agencies, shortage of monitoring and surveillance equipment and poor infrastructure in many of the remote fish landing sites. The currently prevailing weak enforcement regime would result in the depletion of the stock of coastal fisheries in the longer-term if not addressed.

The projected changes in climate are also expected to adversely affect coastal fisheries and their habitats. Changes in temperature and salinity which will affect the oceanographic processes such as upwelling and ocean acidification resulting to vulnerability of coastal fisheries in terms of fish catch and diversity. Climatic factors such as increasing water temperature, rising sea level and storms will negatively affect the productive capacity of coastal ecosystems such as mangroves, sea grasses and coral reefs hence affecting the livelihoods of coastal populations. Fishing days are expected to be reduced by bad weather which could also damage fishing vessels and gears.

Stockholm Environment Institute (2009), assessed the impact of sea level rise in conjunction with three IPCC socio-economic scenarios describing population growth and density as well as future GDP (A1FI, A1B and B1) for Kenya (Fig. 5.11). The analysis showed that coastal inundation due to sea level rise will affect 10,000 to 86,000 people in coastal areas and reduce the area of coastal wetlands such as mangrove forests, saltmarshes and coastal forests. The study further estimated that the economic costs associated as $7-58 million per year by 2030 if adaptation measures are not taken.

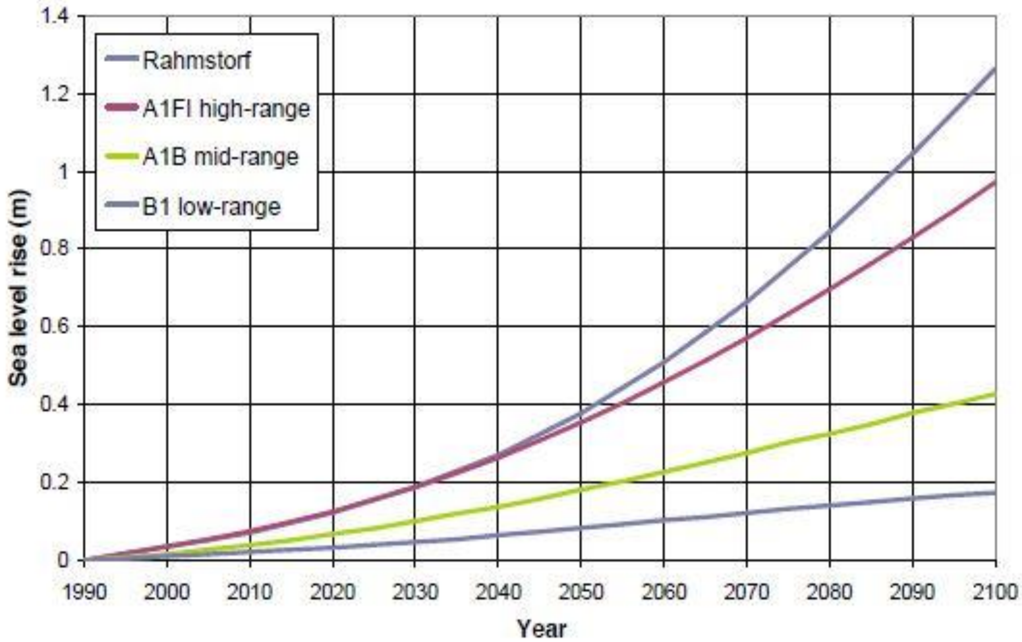

Figure 5.11 Sea level rise scenario

In business as usual (BAU) scenario, both the direct and indirect drivers will behave as they are currently and no changes are introduced. The current population growth coupled with the limited other sources of livelihoods will further increase fishing effort excreted on coastal fisheries and hence may result depletion of the resources. The loss of mangroves from 1992 - 2010 was 13.5 % projecting this forward to the 20 years to come, it is projected that in BAU scenario 43% of mangrove cover in Kwale County will be lost by 2032 (Mark Huxham et al., 2015). This loss of mangroves will adversely affect the other adjacent fish habitats, sea grasses and coral reefs through sedimentation.

The proposed development projects in Kwale county under the country's vision 2030 framework, which include construction of a resort city, bio-fuel project, sugarcane farming and the ongoing titanium mining project are envisaged to have environmental and social impacts. Under the BAU scenario, with poor law enforcement regime, these projects could lead to the degradation of coastal ecosystems, loss of fishing grounds and pollution.

The combined effects of the weak enforcement regime, the impacts direct and indirect drivers, and environmentally insensitive development projects are threatening the sustainability of coastal fisheries under BAU scenario through overfishing, habitat degradation and reduced fish diversity and catch. This further undermines the importance of coastal fisheries to the welfare of coastal communities.

The stakeholders who participated in the scenario building exercise, believed that the current policies and regulations governing environmental matters can contribute to the realization of climate compatible development. In the context of coastal fisheries, identifying and achieving the combination of adaptation, mitigation and development (triple wins) are straightforward. Investments in adaptation measures, such as capacity building, improved infrastructure and disaster risk reduction, and mitigation measures, such as protection and restoration of mangroves and harnessing of clean energy in cooling storages, would address the adverse impacts of climate change and create alternative sources of employment. Since coastal fisheries contribute to the livelihoods of coastal communities their conservation and sustainable utilization would also foster further economic development in coastal areas.

The projections under both BAU and CCD scenarios will affect the catch and revenue of coastal fisheries directly and indirectly. Under the BAU scenario, it is anticipated that mangrove forests, which essential habitat for fisheries, will decline by 43% in the 20 years to come. Assuming a corresponding loss in catch and revenue of mangrove-associated crustaceans and finfish species, this will result in loss of 446 tonnes in catch and Ksh. 46 million in revenue annually. In CCD scenario, through rehabilitation and expansion of mangrove forests, the catch and revenue of mangrove associated fisheries are expected to increase.

CHAPTER SIX

SUMMERY OF FINDINGS, COCLUSION AND RECOMMENDATION

6.1 Introduction

The study findings and conclusions are summarized in this chapter. Based on the findings the study also puts foreword key recommendations for policy formulation and management of coastal ecosystems.

6.2 Summary of findings

6.2.1 Trend of coastal fishery production

The study has established, from the past 10 years' fish catch data that the production of coastal fisheries has been increasing, exhibiting a generally increasing trend. Production has increased from 1,908 tons in the year 2004 to 2,450 tons in 2013. Similarly, the revenue generated from coastal fisheries has also been increasing with time, reaching its peak in the year 2013 estimated at Ksh 260 million. The production of coastal fisheries is at its highest peak during the North-Eastern monsoon (NE) season, which is between September and February, during this season the sea calm and fishing activities are intensive. Migratory fishermen from Tanzania, who usually come to fish in the county during the NE season, also contribute higher production since they are equipped with better fishing gear.

6.2.2 Mangrove ecosystems and their contribution to coastal fisheries production

The study has established from the fish catch data that 14 different species of fish caught in the county are associated with mangrove habitats at point in their life cycle stages. Mangrove associated fisheries constituted 42.3% of the total recorded fish catch and 41.5% of the revenue in the year 2013. It was estimated that mangrove ecosystems contribute 160kg/ha/year of coastal fishery production and Ksh. 16,610/ha/year in income generation. These estimated values are believed to be on the lower bound since the value of on-site (within the mangrove forests) fisheries are not captured in the catch data which is collected at the landing sites.

6.2.3 Economic value of coastal fisheries

The total economic value of coastal fisheries in kwale county was estimated to be Ksh. 182 million (USD 2.2 Million) in the year 2013 after deducting all fishing related expenses such as the average annual costs of fishing vessels and gears and operating and labour costs. The value could be an under estimation since the value of fish catch that are landed in remote and smaller fish landing sites are un accounted for in the fish catch data.

6.2.4 Business As Usual (BAU) and Climate Compatible Development (CCD) scenarios

In the scenario analysis, the current management regime and enforcement of regulations were analysed and the drivers of change were also identified under BAU and CCD scenarios. Under BAU, the combined effects of poor enforcement, negative impacts from the direct and indirect drivers, threaten the sustainability of coastal fisheries through overfishing, habitat destruction, reduced fish catch and diversity and poor management regime. Under the CCD the negative effects surrounding coastal fisheries will be addressed through the adoption of development strategies coupled with adaptation and mitigation mechanisms.

6.3 Conclusion

6.3.1 Trend of coastal fishery production

The fish catch data of the past 10 years reveals that the trend of coastal fisheries has been increasing with time, a continuous increase of the production of coastal fisheries. This is majorly attributed to the ever-increasing fishing effort, resulting from increasing demand for fish and lack of alternative job opportunities for the youth in the coastal areas of the county. The uncontrolled ever increasing production of coastal fisheries could result the depletion and degradation of fish stock in the coastal areas if not checked.

6.3.2 Mangrove ecosystems and their contribution to coastal fisheries production

Mangrove ecosystems provide various ecosystem services such as; provisioning, regulating, supporting and cultural services and are of great ecological and economic importance to coastal areas. This study has found out that Mangroves ecosystems are critical production of coastal fisheries in Kwale county and hence there is dire need to conserve these important ecosystems to support coastal fishery production.

6.3.3 Economic value of coastal fisheries

The estimated value of coastal fisheries indicate that they are significant to the livelihoods of coastal communities and to the economy of kwale county as whole. Coastal fisheries are main source of income generation, provide security and employment and support other axillary industries.

6.3.4 Business as Usual (BAU) and Climate Compatible Development (CCD) scenarios

The scenario analysis reveals that there is a need to shift from current path (BAU), which is not sustainable, to the more plausible scenario under CCD which shows promising future for environmental conservation and development of coastal resources and hence continually contribute to the livelihoods of coastal communities.

6.4 Recommendations

6.4.1 Policy recommendations

The study recommends the review of the existing policies and formulation of new policies targeting coastal fisheries, given their socio-economic importance and unique characteristics, to address the challenges facing them and ensure sustainable exploitation.

6.4.2 Management recommendations

- Prompt implementation of the currently evolving integrated coastal zone management approach
- Implementation of effort based management approach to avoid depletion
- Investment in deep sea fishing to enable coastal fishermen to venture into deep sea fishing to reduce pressure in the coastal areas.
- Investment in cooling storage facilities and transport systems at fish landing sites to preserve fish and stabilize fish price
- Strengthen Beach Management Units in terms of capacity building to increase resource ownership

6.4.3 Research recommendations

The study also recommends further research to be conducted on the value chain of coastal fisheries from the landing sites to the eating table. This will bring out additional information on the value of coastal fisheries in the supply chain of fishermen, traders, processors and final consumers.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE

Questionnaire No:.....

Location ____________________________ **Date:____/____/ 2013**

Part I. Personal Information

Name of the respondent (optional)....................................Residence ....

Age (yrs):..

Sex of respondent: Male (…..) Female (….)

Education level (Tick where applicable): No education (1), Incomplete primary (2) , Complete primary (3) , Incomplete secondary (4) Completed Secondary (5), Higher education (6), Madrassa (7), Other (please specify)8) ....

Size of household ....No. of spouses................No. of children < 18 yrs ....

≥ 18 yrs ....

Main occupation of respondent: …………......................………........……………………………

Basis of employment: Temporal(1), Permanent(2)

Part II: Fishing Specific information

What type of vessel do you use?...

Vessel ownership ? (tick where applicable): (None), (Self), (Shared), (Hired), (Employer's), (Other-specify)...

(a) If a vessel owner:

Vessel type	Buying price	Maintenance cost(day/week/month/year)

		Materials	Labour
1.			
2.			
3.			

(a)What type of gear do you use?...

(b)Gear ownership ? (tick where applicable): (None), (Self), (Shared), (Hired), (Employer's), (Other-specify)...

(c) If a gear owner:

Gear type	Buying price	Maintenance cost(day/week/month/year)	
		Materials	Labour
1.			
2.			
3.			

How much cost do you incur in your fishing operation per day/week?...

....

Do you use automated nets? (tick where applicable)Yes[ ] (ii) No [ ].

What type of energy/fuel do you use?..and how much of it is used per day/week/month?...

How do you process/preserve your fish?..

....

Do you use wood for smoking fish? (tick where applicable) Yes [ ] (ii) No [ ],type of wood used..how much is used per day/week/month?...........................

Details of fishing operations by season:

Item	NEM Season		SEM Season	
	Part time	Full time	Part time	Full time
Number of trips per day				
Number of days per week				
Number of months				
Which months				

How much fish do you land (if fisher)/ buy(if trader) (kgs per day)?

Species landed/bought	NEM season	SEM season

At what price is the fish sold (if fisher) (per kg)?

Species	Price per Kg		Quantity sold		Quantity for home consumption		Quantity given freely to other people for consumption	
	NEM	SEM	NEM	SEM	NEM	SEM	NEM	SEM

At what price is the fish bought and traded (if trader) (per kg)?

Species traded	Quantity bought		Buying Price per Kg		Quantity sold		Selling Price per Kg		Quantity for home consumption	
	NEM	SEM	NEM	SEM	NEM	SEM	NEM	SEM	NEM	SEM

To whom do you (fisher or trader) sell your catch (probe if fish mongers buy from them) ....

Part III: Management Measures: CCD factors for mitigation

Do you have a fishing license? (tick where applicable) Yes [ ] (ii) No [ ].

What type of license do you have? (i)Boat license, (ii)Fishing permit, ((iii)Both boat license and fishing permit, (iv)None , (v) Other(please specify)..

How much does the fishing/trading licence/permit cost?..

....

Do you have to pay any charge for landing fish? Tick where applicable, (i) Yes= [ ]

(ii) No= [ ]If yes, how much? ....

Have there been changes in the catch size and/or composition over the last five, ten, fifteen years? Tick where applicable, (i) Yes= [ ]   (ii) No= [ ]. If yes, why,..

....

when, ...how were you affected ....

and how did you respond?..

....

What made it difficult to, or what helped you, respond to those changes?..

....

Do you know any fisheries regulations? Tick where applicable, (i) Yes= [ ]   (ii) No= [ ]. If yes, which ones?...

....

Are fisheries regulations effective? Tick where applicable, (i) Yes= [ ]   (ii) No= [ ].

If not, why not?...

....

Are there any local rules about fisheries? Tick where applicable, (i) Yes= [ ]   (ii) No= [ ]. If yes, what are they ....

....

and where did they come from?...
Who enforces the local rules?...

....

Are there any illegal fisheries activities that go on in this area? Tick where applicable,

(i) Yes= [ ] (ii) No= [ ]. If yes, what are they?..

....

Do they have any damage on the environment? Tick where applicable,(i) Yes= [ ]

(ii) No= [ ]. If yes, what is that damage?..

....

Are you a member of the Beach Management Unit? Tick where applicable, (i) Yes= [ ]

(ii) No= [ ].

What kinds of activities does the BMU do?...

....

Is there a Marine Protected Area (MPA) or a Community Conserved Area (CCA) in the location? (tick where applicable) Yes [ ] (ii) No [ ]. Please specify which one........................

(i) What proportion of costs for the fisheries sector comes from energy in terms of (e.g. transport, processing) ....

....and

(ii) What opportunities are there for reducing energy intensity and/or carbon intensity?..

....

What is the age range of those involved in the sector? (tick where applicable) (i) below 18 years [ ] (ii) above 18 years [ ].

Where do those involved in the sector originate from (local area, further away)?.........................

What are some of the jobs and skill level available in the area?...

....

How much income do they earn (day/week/month)?..

(including whether seasonal or dependent on level of harvesting).

What types of indirect benefits are obtained from (e.g. providing accommodation to migrants, input industries, transport) and who are the beneficiaries? ....

....

....

Where do entrepreneurs in the area originate from? locally, nationally, outside the country? (need to differentiate between different types/scales of operation within the sector)...

....

Does the fisheries sector involve the poor sections of the local communities in decision-making and planning?(tick where applicable) (i)Yes[ ] (ii) No [ ]? If Yes, to what extent...
....
....

The End.

Thank you for your time.

Interviewer's name:...

Date:...