INFLUENCE OF CLIMATE VARIABILITY ON COASTAL SMALL-SCALE FISHING COMMUNITIES IN KENYA

BY

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DECLARATION

This Thesis is my original work and has not been presented for a degree in any other University or for any other award.

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DEDICATION

This work is affectionately dedicated to my late parents James, Roger Getuba, and Mama Esther Obonyo Getuba, who loved knowledge and wanted the very best for me.

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DEFINITION OF TERMS

Adaptation: Adjustments in natural or human systems to actual or expected climatic stimuli or their effects that moderate harm or exploit beneficial opportunities. It can be *reactive* (taking measures to respond to climate change impacts) or *anticipatory* (taking measures before impacts are observed, IPCC, 2001b). Adaptation can also be defined as actions taken to help communities and ecosystems cope with changing climate conditions, such as the construction of flood walls to protect property from stronger storms and heavier precipitation, or the planting of agricultural crops and trees more suited to warmer temperatures and drier soil conditions (UNFCCC, 2003).

Adaptive capacity: Ability or capacity of the fishery-based livelihood systems to adjust to climate change (including variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007a).

Capacity: A combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster. Capacity may include physical, institutional, social or economic means, as well as skilled personal or collective attributes such as leadership and management. Capacity may also be described as capability (UN/ISDR, 2004).

Climate Change: Shifts in the mean state of the climate or in its variability, persisting for an extended period (decades or longer). Climate change may be due to natural changes or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2001c and 2007b).

Climate Variability: Variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events. Examples of climate variability include extended droughts, floods, and conditions that result from periodic El Niño and La Niña events (IPCC 2001c and 2007b).

Coping: Coping and adaptive capacity can mean the same thing if both concepts

imply natural ability of a system to adjust to climate change. In this interpretation, adaptation measures and adaptation in general will increase this ability. However, if adaptive capacity implies the extent to which the system is capable of adapting, these two concepts are different. Coping capacity can be increased with adaptation measures while adaptive capacity already includes coping capacity plus possible adaptation measures and cannot be increased beyond a certain point.

Coping capacity: The ability of actors to draw on available skills, resources and experiences as an immediate response to manage adverse stress or shocks brought about by climate variability (ISDR, Terminology on Disaster Risk Reduction, 2009).

Economic or financial capital: Refers to the capital base (i.e. cash, credit/debt, savings, and other economic assets) which are essential for the pursuit of any livelihood strategy.

Exposure: The nature and degree to which a fishery-based livelihood system is exposed to significant climatic variations (modified from IPCC, 2001a).

Fisher: Someone who captures fish and other animals from a body of water, or gathers shell fish. The term fisher may be used to describe both man and woman.

Fishery: Refers to (1) part of the sea where fish are caught commercially, for instance, offshore fisheries i.e. at some distance from the shore. (2) business or industry of fishing.

Human capital: Refers to the skills, knowledge, ability to labour and good health and physical capability important for the successful pursuit of different livelihood strategies.

Hazards: Threats that have the potential to harm people (and the things they value) and places.

Impacts of climate change: The consequences of climate change on natural and human systems.

Livelihood: Capabilities, assets and activities required for means of living (Chambers and Conway, 1992).

Mitigation: Actions that reduce the sources or enhance the sinks of greenhouse gases.

Natural capital: Refers tothe natural resource stocks (soil, water, air, genetic resources etc.) and environmental services (hydrological cycle, pollution sinks etc) from which resource flows and services useful for livelihoods are derived.

Perception: Discernment by which fishers in the study area, use their senses to interpret and form an opinion concerning climate variability and how it may affect fish abundance.

Physical capital: Comprises capital that is created by economic production processes. It refers to the basic infrastructure and producer goods needed to support livelihoods.

Potential Impacts: Impacts that may occur given a projected change in climate, without considering adaptation.

Resilience: The capacity of a complex system to absorb shocks while still maintaining function and to reorganize following disturbance (Walker *et al.,* 2004) 'Complex system' in this context refers to a linked socio-ecological system, which is defined as "a system that includes societal (human) and ecological (biophysical) subsystems in mutual interaction" (Gallopin *et al.,* 1989).

Risk: The likelihood of incurring harm, or the probability that some type of injury or loss would result from the hazard or event (Heitzmann, et al., 2002).

Sensitivity: The degree to which a fishery-based livelihood system is affected or responds to climate stimuli (note that sensitivity includes responsiveness to both problematic stimuli and beneficial stimuli) (IPCC, 2007a).

Small-scale (artisanal) fisheries: Relatively labour intensive and using small fishing vessels (if any) operating in near-shore waters for subsistence or commercial purposes

(local consumption or export)

Social capital – Refers to the social resources (networks, social claims, social relations, affiliations, associations) upon which people draw when pursuing different livelihood strategies requiring coordinated actions. Source: (Badjeck, 2004) adapted from (DFID, 2001) and (Scoones, 1998)

Social vulnerability: Focuses on those demographic and socio-economic factors that increase or attenuate the impacts of hazard events on local populations (Tierney *et al.*, 2001; Heinz, 2002).

Vulnerability: The degree to which a system is susceptible to or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (McCarthy *et al.*, 2001 p. 995).

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AMMA	African Monsoon Multidisciplinary Analysis
AR	Assessment Report
AGW	Anthropogenic Global Warming
BMU	Beach Management Unit
CBO	Community Based Organization
CDM	Clean Development Mechanisms
CFAs	Community Forest Associations
CO_2	Carbon Dioxide
CRM	Coastal Resource Management
CTM	Critical Thermal Maximum
CZM	Coastal Zone Management
DFID	Department for International Development
EEZ	Exclusive Economic Zone
EMCA	Environmental Management Coordination Act
EM-DAT	International Disaster Database
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
GCMs	Global Climate Models (or General Circulation Models)
GDP	Gross Domestic Product
GHGs	Green House Gases
ICM	Integrated Coastal Management
ICZM	Integrated Coastal Zone Management
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
ILO	International Labour Organisation
IOD	Indian Ocean Dipole
IOTC	Indian Ocean Tuna Commission
IOZM	Indian Ocean Zonal Mode

IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy for Disaster Reduction
ITCZ	Inter- Tropical Convergence Zone (ITCZ).
KEMFRI	Kenya Marine and Fisheries Research Institute
KFS	Kenya Forest Service
KMD	Kenya Metrological Department
LDCs	Least Developed Countries
MDDP	Malindi District Development Plan
MDGs	Millennium Development Goals
MJO	Madden Julian Oscillation
MoDDP	Mombasa District Development Plan
MoFD	Ministry of Fisheries Development
MTEF	Mid-Term Expenditure Framework
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NCAR	National Centre for Atmospheric Research
NCCAP	National Climate Change Action Plan
NCCS	National Climate change Secretariat
NCCRS	National Climate Change Response Strategy
NCDC	National Climate Data Centre
NCEP	National Centre for Environmental Prediction
NEAP	National Environmental Action Plan
NEM	North East Monsoon
NEMA	National Environment Management Authority
NEP	National Environmental Policy
NPP	Net Primary Production
OND	October- November-December
PAR	Pressure and Release
PDO	Pacific Decadal Oscillation
PIPs	Policies Institutions and Processes
SEC	South Equatorial Current
SEM	South East Monsoon
SIDs	Small Island Developing States
SLA	Sustainable Livelihood Approach

SLR	Sea Level Rise
SOC	State of Coast Report
SOI	Southern Oscillation Index
SST	Sea Surface Temperature
SWIO	South West Indian Ocean
TAR	Third Assessment Report
UNHABITAT	United Nations Human Settlements Programme
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN/ISDR	United Nations /International Strategy for Disaster Reduction
WIO	Western Indian Ocean
WMO	World Metrological Organization
WWF	World Wide Fund

ABSTRACT

Globally, fisheries support the livelihoods of over half a billion people. Around 90% of the 38 million people recorded globally as fishers are classified as small-scale. Small-scale fishers are considered vulnerable to the negative impacts of climate variability and change. There is limited understanding of how climate variability currently affects the livelihoods of small-scale fishing communities in Kenya. This study investigated the extent of climate variability in Mombasa and Malindi in Kilifi County and its influence on fish catches and the livelihoods of fishing communities. The study also examined the coping mechanisms developed by small-scale fishing communities; factors influencing their coping strategies; institutional capacities to deal with current and future climate extremes; and the perceptions of small-scale fishers on fish abundance and influencing factors. The study adopted a descriptive study design. Stratified random sampling was used to select a sample of 218 fishers from a total population of 240. Primary data were collected by use of semi-structured questionnaires, interview schedules, direct observation and Focus Group Discussions. Data were analyzed statistically ($p<0.05$). Pearson Correlation was used to analysis the correlation between sea surface temperature, rainfall and fish catches. The analysis yielded an inverse correlation between sea surface temperature and fish catches (parrot fish r= -0.565; cavilla jacks r= -0.431; shark r= -0.481); and a positive correlation between fish catches and rainfall (parrot fish r=0.159; cavilla jacks r=0.237 and shark r=0.220). In terms of livelihood assets, results of the study showed no significant association (χ^2 =36.27, df=36, p=0.456) between gear type and education level. Spearman correlation analysis between gear type and income level showed a strong interaction (r=1.00, $p<0.05$). Results of binary logistic model of selected variables established that education level (Wald =0.013, df=1 p=0.909) and period in fishing (Wald=0.017, df=1, p=0.895) were not significant determinants influencing migration as a coping strategy to climate variability. However, age, (Wald=6.614, df=1, p=0.01), and vessel ownership (Wald=5.003, df=1 p=0.025) were. Education level (χ^2= 8.346, df =6, p=0.214; age χ^2= 1.323, df=2, p=0.516) and period in fishing (χ^2=1.210, df=6, p=0.976) had no significant association with using the same gear but fishing inshore as a coping strategy. Ordinal logistic regression model indicated that level of education (Wald= (0.960, 0.004, 0.593) with associated p-values of 0.327, 0.948, 0.441 and experience in fishing (Wald= (0.002, 1.690, 0.092) with associated p-values of 0.965, 0.194 and 0.761 were not significant determinants that influenced the perception of fishers on temperature variability, being a key factor that influences fish abundance. However, age (Wald= 12.150, p= 0.000) was. The study recommends increasing fishers access to educational, physical, financial and livelihood opportunities to help reduce their vulnerability to the adverse effects of climate variability.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Problem

Fisheries and aquaculture support the incomes and livelihoods of 660-820 million people globally according to the report of the United Nations Food and Agriculture Organization (FAO, 2012). FAO showed that the fisheries sector has an important role to play in gender equality, poverty and food security. With global fish supply over 150 million tonnes, more than 85 percent of this supply is used directly for food; supplying 15 percent of the world's protein and essential nutrition for around 4.3 billion consumers (FAO, 2012). Fish forms at least 50% of the essential animal protein and mineral intake for 400 million people from the relatively poorer African and South Asian countries (World Bank, 2004; FAO, 2007a).

Fisheries and aquaculture contribute in meeting the Millennium Development Goals (MDGs) through employment, provision of nutritious food, generation of revenues for local and national government from licences and taxation on landings, from export revenues, and from various upstream and downstream multipliers (Béné *et al.*, 2007; Heck *et al.*, 2007). The increase in employment in fisheries and aquaculture sector outpaces world population growth and employment in traditional agriculture (FAO, 2010). The sector generates first sale values of over US$ 218 billion annually, and about 38 percent of production is traded internationally (FAO, 2012).

Fisheries as natural resources are known to be influenced by climate variability (Zhang et al., 2012). Climate variability thus refers to variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2001c; 2007b). It includes seasonal variability as well as interannual variability, sometimes manifested in extreme events such as droughts, floods, cyclones, heat and cold waves (Joubert and Hewitson, 1997).

The dominant global mode of interannual climate variability, the El Niño-Southern Oscillation (ENSO), is a coupled ocean-atmosphere system in worldwide climate and weather centred in the tropical Pacific Ocean (Allan *et al*., 1996). It is associated with

distinct oceanographic, temperature, rainfall and cyclonic conditions associated with the two phases: El Niño - when the equatorial divergence is located well to the east of the Pacific, and surface waters are warmer than usual, and La Niña - when the equatorial divergence occurs across much of the region and temperatures are cooler. The divergence brings nutrient-rich waters to the surface and enhances the production of phytoplankton and zooplankton that supports fisheries. The effect of ENSO on fisheries can be replicated in the Indian Ocean basin, including East African region, and other oceanic basins which are teleconnected to ENSO (Lehodey *et al.,* 2006).

The Indian Ocean Dipole (IOD) which also affects Indian Ocean climate is a basin-scale mode of sea surface temperature (SST) and wind anomalies occurring on interannual timescales in the equatorial Indian Ocean (Saji *et al.,* 1999; Webster *et al.,* 1999). Saji *et al* (1999) and Webster *et al* (1999) further suggest that the dipole modulates rainfall in East Africa and Indonesia, and suggest that this dipole operates independently of ENSO. Previous studies by Saji and Yamata, 2003; Wang *et al.,* 2006 have proved that the dipole mode exerts a major impact on seasonal climatic conditions in nations around the Indian Ocean (The IOD has been associated with October to December wet seasons in East Africa (Bowden and Semazzi, 2007; Abram *et al*., 2008; Nakamura *et al.,* 2009). Both ENSO and IOD can co-occur in the Indian Ocean basin or independently (Kayanne *et al.,* 2006; Abram *et al.,* 2008). The SST and rainfall fluctuations associated with IOD also affect fisheries (Marsac, 2008).

Climate variability, short-term pulses, decadal-scale regime shifts, and long-term presses, is a constant challenge to sustainable fisheries management because of its profound effect on fish population and the fisheries. It affects the spatial and temporal distribution, patterns of migration, reproduction and recruitment of economically important species (Zhang *et al.,* 2012). Increase in temperatures, altered precipitation patterns, sea-level rise, ocean acidification, and changes in dissolved oxygen concentration all affect the structure and productivity of marine and coastal ecosystems and fish populations (IPCC, 2007a; Drinkwater *et al.,* 2010). These impacts have already extended to fishery-dependent people in some regions, especially in developing countries, affecting people's lives on a daily basis (IPCC, 2007a; Perry *et al.,* 2009). Extreme weather events such as cyclones and floods may further intensify these impacts by disrupting fishing operations and land-based

infrastructure (Westlund *et al.,* 2007). These impacts may result in vulnerability of fishery-dependent livelihoods (Sarch and Allison 2000; Coulthard, 2008; Iwasaki *et al.*, 2009; Perry *et al.*, 2009).

About 90% of the 38 million people recorded globally as fishers are classified as small-scale (Béné *et al.*, 2007). Small-scale fisheries, also referred to as artisanal, can be defined as relatively labour intensive and using small fishing vessels operating in near-shore waters for subsistence and commercial purposes (FAO, 2005). Small-scale fishing communities are considered especially vulnerable to the negative impacts of climate variability and change (Downing *et al.,* 1997; IPCC, 2007a). Many fisheries worldwide have also declined sharply or have already collapsed over the last decades due to overfishing (Pauly *et al.,* 1998). Moreover, major fishing grounds in the world are concentrated in only a few areas of the oceans and inland waters, in zones threatened by pollution, mismanagement of freshwater and coastal development (Nellemann *et al.,* 2008).

Climate variability and change as forms of climate stress affect the livelihoods of the poor to which people have to cope in the short term and adapt in the long term. Problems that are experienced by poor people due to droughts and heat waves, for example, include those of feeding and watering animals, and a lack of water for crops, as well as water scarcity for consumption and health problems both in rural and urban areas. Flooding, heavy rainfall, cyclones and hurricanes and sea level rise destroy property and productive assets, as well as causing injuries and deaths (Mallick *et al.,* 2005).

Developing countries, mainly in Africa, are seen as being the most vulnerable to climate change and variability. High levels of vulnerability and low adaptive capacity in the developing world have been linked to a high reliance on natural resources, limited ability to adapt financially and institutionally, low per capita GDP and high poverty, and a lack of safety nets (Thomas and Twyman, 2005). Flooding has been experienced in East Africa which has highlighted the vulnerability of these nations and the need to develop adaptive strategies for extreme weather events management and mitigation (Kennedy, 2002).

Kenya's fisheries resources contribute to the national economy through employment creation, foreign exchange earnings, and food security support. It has been estimated that the fisheries sector makes up almost 5% of the GDP (agriculture and tourism contribute the most). It is estimated that a total of 40,000 people depend directly on marine fisheries. An average of 7000 metric tons of marine fish, crustaceans and molluscs valued at 348 million Kenya shillings are landed annually. This amount is harvested mostly by artisanal fishermen who restrict their operations to the continental shelf, as they are not sufficiently equipped to venture into the deep sea (Wakwabi *et al.,* 2003). Kenyan coastline has been impacted by the effects of climate variability through floods, droughts and temperature fluctuations which makes them vulnerable and hence the need for the small-scale fishers to develop adaptation strategies.

1.2 Problem Statement

The majority of the world's 200 million fisher folk depend for a major part of their livelihood on resources whose distribution and productivity are known to be influenced by climate variability (Allison *et al.,* 2005). As indicated in Hawkins (2010), it is clear that both the historical observations and temperature projections exhibit variability. Some of the effects of variability include prolonged drought conditions that affect agricultural production; heavy rains that lead to flooding and affect agricultural activities, navigation and fishing activities; and the outbreak of diseases as a result of flooding and increased temperature. Climate variability tends to change the seasons from normal to unpredictable trends. This in turn disrupts the timing of the planned economic activities such as agriculture and fishing. As a result, the livelihoods of the communities depending on the two sectors, agriculture and fishing, are negatively affected (FAO, 2007b).

The IPCC reports that African continent is likely to be severely impacted by climate variability and change (Boko *et al.,* 2007). Food production in the Western Indian Ocean region is likely to be reduced through coral bleaching caused by increased SST events that will affect reef fish targeted by fishers (Graham *et al*., 2007; Cinner *et al.,* 2009a). Changes in monsoon conditions and yields from rain-fed agriculture could be

reduced by up to 50% by 2020 because shifting, irregular, and declining rainfall along the African coastline will reduce the total and per capita production (Boko *et al.,* 2007; Bowden and Semazzi, 2007; Funk *et al.,* 2008). High intensity storms, such as cyclones, are also likely to increase in frequency and shift in distribution and have localized but considerable impacts on food production. Fish landing records for Kenya showed a decreasing trend in the period 1981-2000. Available information shows that catches in inshore waters are declining (McClanahan, 1996; Obura *et al.,* 2002). There is, therefore, need to better understand some of the factors that may be causing the decline in fish catches.

Kenya's major coastal city, Mombasa, currently faces significant threats from direct and indirect impacts of climate change and its variability. The city has a history of extreme climatic events including the flooding due to intense precipitation in October 2006 which affected about 60,000 people in the Mombasa County (Awuor *et al.,* 2008). It has been estimated that, a 30 centimetres rise in sea level could cause 17 percent (about 4,600 hectares of land area) of the city to be submerged, making large areas uninhabitable (Awuor *et al.,* 2008). Recent rapid population growth and infrastructure development in the coastal area are at risk from these processes (Okemwa *et al.,* 1997).

The 1998 interaction between El-Niño and the IOD produced one of the warmest years in the past century (McPhaden 1999; Saji *et al.,* 1999; Webster *et al.,* 1999). This warm water caused extensive coral bleaching and mortality throughout the Western Indian Ocean (Strong *et al.,* 1998; Wilkinson *et al.,* 1999; Goreau *et al.,* 2000). During the IOD phenomenon in 1997/98 as well as in 2006, flooding and massive sedimentation caused extensive damage to infrastructure of the Kenyan Coast and inland and impacted diverse natural resources (Kitheka *et al.,* 2002; Bosire, 2006). There was extensive mangrove die-back in a number of areas along the Kenyan coast (Kairo *et al.,* 2001). Whereas the response of coral reefs to this natural catastrophic phenomenon in the Western Indian Ocean has been well documented (Wilkinson *et al.,* 1999; Wilkinson, 2000; Obura, 2005), not much has been done to document its effects on the livelihoods of the local fishing communities in Kenya. It is likely that livelihoods have been affected by the decline in harvestable resources from marine and coastal ecosystems. Further, knowledge about the future society's adaptive

capacities is one of the most important missing links in making predictions about the effect of climate change (Lutz, 2008). Additionally, not many studies have been done on the aspects that shape the perception fishers have on climate variability and the socio-economic effects of small-scale fishers on coping or adaptive capacities to changing climate conditions.

Although the inshore fishing provides employment and livelihoods to thousands of households, there has been a lack of knowledge on the vulnerability of small-scale fishing communities to climate-induced changes in the fishing sector along the Kenyan coast. The purpose of the study was to determine the relationship between climate variability, livelihood vulnerability and coping or adaptive capacity as experienced by small-scale fishing communities in Kenya.

1.3 Research Questions

The study set out to answer the following research questions, which emerged from the background of the problem in regard to the effects of climate variability on coastal small-scale inshore fishing communities in Kenya.

i) What climate variability has been experienced in the study area for the last 20 or so years and what is the relationship between fish catches and climatic factors such as sea surface temperature, rainfall and wind?

ii) How have fishers managed to cope with their vulnerabilities, what factors influence their coping strategies and what institutional capacities are in place to deal with current and future climate extremes?

iii) What perceptions do small-scale fishers have on climate variability as a key factor determining the abundance of fish and what factors influence their perception?

1.4 Objectives of the Study

The broad objective of this study was to investigate the extent to which climate variability has affected small-scale fishing communities along the Kenyan coastline

and what coping strategies they may have. The specific objectives were to:

i) Determine the extent of climate variability (SST, rainfall and wind) experienced in the study area and its influence on fish catches and the livelihoods of fishing communities.

ii) Investigate the mechanisms developed by small-scale fishing communities to cope with their vulnerabilities, factors influencing their coping strategies and institutional capacities in place to deal with current and future climate extremes.

iii) Assess the perceptions of local small-scale fishers on fish abundance and influencing factors.

1.5 Research Hypotheses

The following hypotheses were tested in this study:

i) There is no relationship between fish catches and climatic factors such as sea surface temperature, rainfall and wind.

ii) There is no significant association between age, education level, period in fishing and migration and gear as coping strategies.

iii) The perception of small scale fishers' towards climate variability and its influence on fish abundance is not influenced by age, education and period in fishing.

1.6 Justification

Most research on climate variability and fisheries is targeted at a detailed understanding of the mechanisms causing fluctuation in fish stock size and distribution (Cushing, 1982; Glantz, 1992). While most studies in the past have focused either on national scale of vulnerability of fisheries systems (Allison *et al*., 2009; Quest Fish, 2012) or of agricultural livelihoods (Vincent, 2007; Eakin and Bojo´rquez-Tapia, 2008; Paavola, 2008; Sissoko *et al.*, 2011), changes in artisanal

fisheries due to climate dynamics and the human dimension of these changes have in the past received little attention by researchers and policy makers (Allison *et al.*, 2005). Climate change and projected increased climate variability are likely to place additional stress on fish production systems, many of which are already threatened by overexploitation and habitat degradation (FAO, 2008; Nellemann *et al.*, 2008).

Although climate impacts on food production are known, there is limited understanding of how climate variability currently impacts fishery and their associated livelihoods (Ziervogel and Calder, 2003). Research empirically examining the impacts of climate variability on the livelihoods of small-scale fishing in Kenya communities is still sparse.

In order to improve fisheries management in a changing environment, fisheries managers need to understand the endogenous changes such as fishermen's responses to climate variability (Smith, 2010). Maintaining or enhancing fisheries benefits under variable climate regimes will improve small-scale fishers' livelihood through sustainable utilization and management of coastal and marine resources. Studies in the past focused on the ecological impacts of global climate change on aquatic resources. There is a need to extend this effort to improve the understanding of the socio-economic vulnerabilities of coastal fishing communities in Kenya. Predicting how small-scale fishers may respond to future environmental and institutional change can be informed by an understanding of their current adaptation strategies and vulnerabilities.

1.7 Conceptual Framework

In carrying out this study, it was conceptualized that the earth's climate patterns are governed by natural variability. Climate variations happen on all time scales, as well as on all spatial scales, from the regional to the global. As an example, the oceanic El Niño phenomenon is most pronounced in the tropical Pacific off the coast of Peru, but the associated Southern Oscillation in the atmosphere has far-reaching, nearly global implications (Philander, 1990). The combined El Niño /Southern Oscillation (ENSO) variability has a seasonal component, hence the name El Niño, due to its preference for appearing first at Christmas time. It also has a quasi-biennial component, with a

characteristic recurrence time of 2–2.5 years, and a low-frequency one, with a recurrence of 4–5 years. The interaction of these three distinct modes of variability renders the evolution of sea-surface temperatures across the tropical Pacific fairly irregular. An additional cause of the irregularity observed in these temperatures lies in the frequent weather perturbations that affect the ocean's surface.

The important climatic drivers in fish production systems include water temperature, precipitation, oceanographic variables, e.g., wind and wave action. Changes in these climate drivers can bring about significant changes on the ecosystems of the fishery resources hence affecting fish populations (natural capital), fishing operations (physical operations), community livelihoods and the wider society as a whole (Drinkwater *et al*., 2010). Figure 1.1, describes the conceptual framework identifying multiple pathways through which climate variability is affecting or likely to affect fishing-dependent communities. The effects caused by climate variability may force fishers to look for various coping strategies to counter the negative effects of climate variability.

The variations in water temperature and precipitation affect the dynamics of ocean currents, the flow of rivers and the area covered by wetlands. This will have effects on ecosystems structure and function and on the composition, distribution, and production of fish stocks. An increase in sea surface temperature will lead to coral bleaching and this will also affect fish stocks. High temperatures may alter the time of spawning, migration and alter the time for peak performance in fish stocks changing the level of productivity across marine systems. This will lead to reduced production of target species forcing fishing communities to change gears, target species (species diversification), intensify fishing effort or diversify in their livelihoods as coping strategies to climate variability.

In addition, increased incidence of extreme events such as floods, droughts and storms will affect the physical capital of fishing communities, i.e., the safety and efficiency of fishing operations, increase damage and disruption to coastal and riparian homes, services and infrastructure may increase the vulnerability of small-scale fishers leading to a loss of their livelihoods.

In this conceptual framework, it is assumed that increased climatic stresses, i.e., increased precipitation or extreme events and sea surface temperature will cause significant changes in marine ecosystems and hence affect the livelihoods of coastal fishing communities. It is assumed that with changes in climate patterns, fishermen will be forced to respond by having various coping strategies which will enhance their fish catches and reduce their vulnerability.

This conceptual framework further assumes that the five livelihood capitals are interconnected with indicators interacting with each other, and that there is an association between financial capital (income) and physical capital (i.e., fishing equipment). Fishers with increased financial capital will have better physical capital. It is assumed that net incomes are reduced during increased climatic stress, i.e., increased flooding or extreme events because of the shortened fishing period and therefore, those with better financial capital will cope better since they have invested in improved equipment and hence they are able to go further into the sea to deal with reduced yield. It is also assumed that, there is a relationship or an association between human capital (education) and physical capital. Fishermen with enhanced human capital (education, capacity building courses) will have better physical capital (e.g. Gears) and therefore, will cope better with increased climatic stresses. It is further assumed that fishermen with enhanced human capital will have better access to financial (credit) capital and hence will cope better with increased climatic stress. Additionally, fishermen with better social networks (social capital) will have increased financial capital (credit) and therefore, they will cope better with climatic stresses compared with those who don't have social networks. It is further assumed that, the socio-economic characteristics of small-fishers will influence the perception they have on climate variability and their coping strategies.

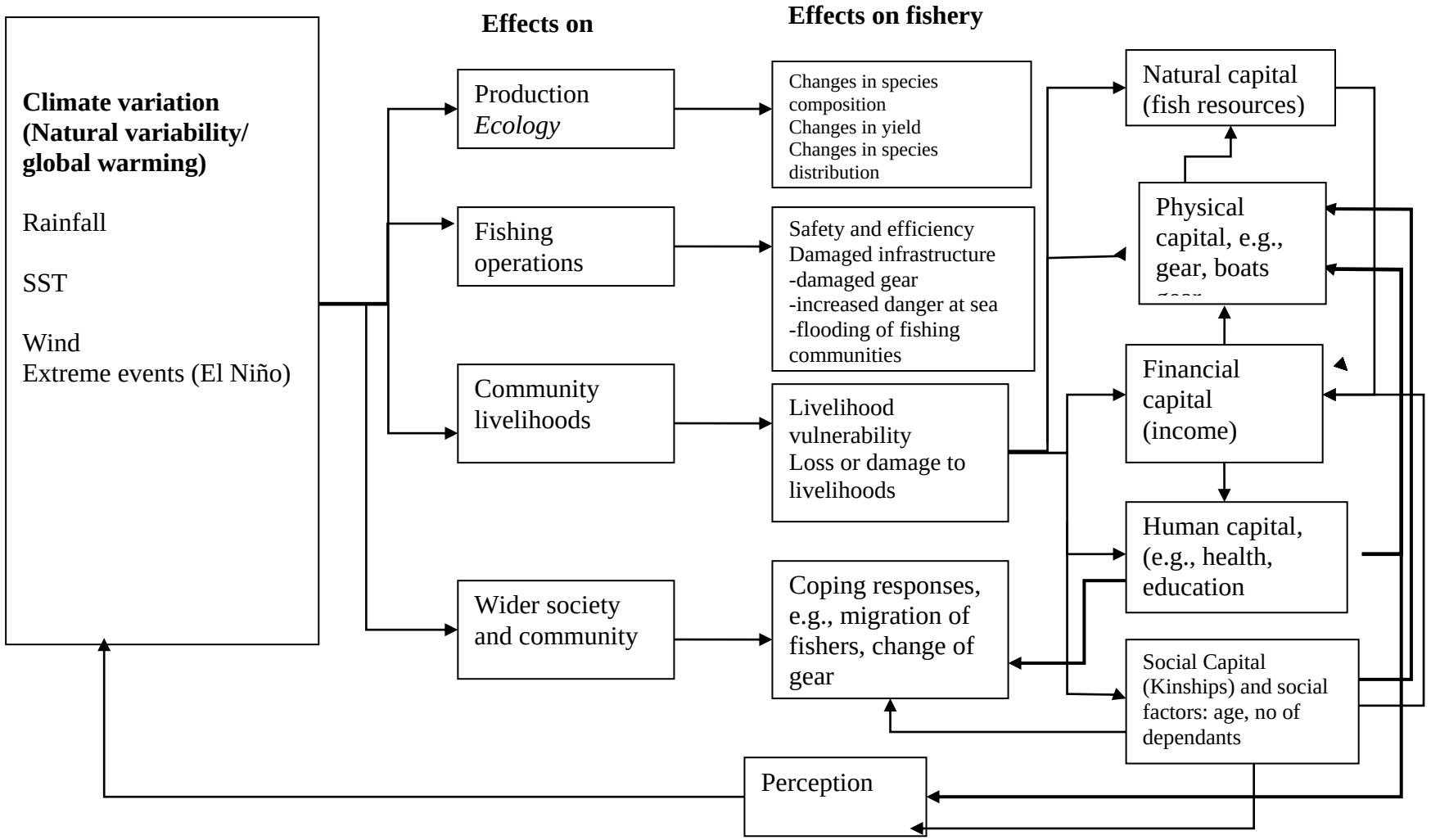

Figure 1.1: Conceptual framework identifying pathways through which climate variability is affecting or likely to affect fishing-dependent communities. (Adapted from; Badjeck *et al.*, 2009)

1.8 Significance of the Study

There are compelling security reasons--both economic and nutritional--for investing in research to guide adaptation planning in fisheries. Worldwide, fishery products provide at least 20% of the protein intake of 1.5 billion people and support the livelihoods of approximately 520 million people. Fishery products are one of the most highly traded food and feed commodities, with an export value of 86 billion dollars in 2006 (FAO, 2009), contributing significantly to both total gross domestic product (GDP) and agricultural GDP as well as food security. The sector is also an important source of livelihood for women: it is estimated that in countries such as India, Cambodia and Ghana, they represent on average half of the fisheries workforce (including post-harvesting activities) (The world Fish Centre, 2008).

Many artisanal fishers are extremely poor. Even in cases where they earn more than other rural people, fishers are often socially and politically marginalized and can afford only limited access to healthcare, education and other public services. Social and political marginalization leaves many small-scale and migrant fishers with little capacity to adapt, and makes them highly vulnerable to climate impacts affecting the natural capital they heavily depend on for their livelihoods. The understanding of fishing communities' vulnerabilities and their strategies to cope with and adapt to climate variability is important to the development of policies and operational rules that can maintain fishing communities' livelihoods and resilient socio-ecological systems.

The significance of the study is three fold: to policy makers, researchers and the community. The results of the study will be important in ensuring that policy makers and the community have an understanding of past and current response mechanisms to climate variability in order to design appropriate policies and management strategies in the fisheries sector to face the new challenges of global climate change. Researchers will benefit in that they can use the results and compare them with other areas of similar climatic conditions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter begins with the general overview of the literature on the genesis of climate change and variability, causes of climate change and variability and theories informing and forming the basis of concepts on climate change and variability. It then reviews regional and local climate variability and domestication of UN climate policies in Kenya. The role of fisheries contribution to food security, global, regional and local trends, in fish production and the potential effects of global climate on marine environments are discussed. The concepts of vulnerability, resilience and adaptation that are key to understanding environmental changes and their effects on human communities and in particular fishing communities, are discussed. Finally, the sustainable livelihood framework and the role of institutions in adaptation to climate variability are also discussed.

2.2 The Genesis of Climate change and Variability

The Earth's climate has changed throughout history. All three major global surface temperature reconstructions show that Earth has warmed since 1880. Most of this warming has occurred since the 1970s, with the 20 warmest years having occurred since 1981 and with all 10 of the warmest years occurring in the past 12 years (T.C. Peterson *et* al., 2008). Even though the 2000s witnessed a solar output decline resulting in an unusually deep solar minimum in 2007-2009, surface temperatures continue to increase (Allison *et al*., 2009).

The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.302 degrees Fahrenheit since 1969 (Levitus, *et al.,* 2009). The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost 150 to 250 cubic kilometres (36 to 60 cubic miles) of ice per year between 2002 and 2006, while Antarctica lost about 152 cubic kilometres (36 cubic miles) of ice

between 2002 and 2005. Both the extent and thickness of Arctic sea ice has declined rapidly over the last several decades (Polyak, *et al*., 2009).Global sea level rose about 17 centimetres (6.7 inches) in the last century. The rate in the last decade, however, is nearly double that of the last century (Church and. White, 2006). Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30 percent. This increase is the result of humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the oceans. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year (Sabine *et al*., 2004).

2.3 Causes of Climate Variability and Change

Climate variability describes short-term changes in climate that take place over months, seasons and years. This variability is the result of natural, large-scale features of the climate El Niño and La Niña, are the two phases of the El Niño-Southern Oscillation (sometimes shortened to ENSO) which is the most important driver of year-to-year variability in climate. The different phases of ENSO can cause droughts and floods. Each El Niño and La Niña event is different and so they have different impacts. El Niño and La Niña events drive changes in circulation, winds, rainfall and ocean surface temperatures.

The Earth's climate has changed over the centuries and millennia due to a number of different factors these include:

a) Natural changes in the sun which affect the amount of incoming solar radiation

b) Natural, large-scale volcanic eruptions which eject large amounts of ash into the atmosphere. The ash may remain in the atmosphere for several months or years reflecting sunlight back into space and resulting in a drop of mean global surface temperature

c) Changes in atmospheric chemistry (such as the quantity of greenhouse gases) – both natural and caused by human activities. It is almost certain that most of the changes seen in the past century have been caused by human activities such as burning fossil fuels.

d) Natural changes in the Earth's orbit which may occur over time scales of thousands of years (Guldberg *et al.*, 2007).

2.4 The Role of IPCC and UNFCCC

The Intergovernmental Panel on Climate Change (IPCC) is a scientific intergovernmental body under the auspices of the United Nations, (IPCC, 2010) set up at the request of member governments (Weart, 2013). It was first established in 1988 by two United Nations organizations, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), and later endorsed by the United Nations General Assembly through Resolution 43/53. Membership of the IPCC is open to all members of the WMO and UNEP (The Royal Society, 2013).

The IPCC produces reports that support the United Nations Framework Convention on Climate Change (UNFCCC), which is the main international treaty on climate change (UNFCCC, 2014). The ultimate objective of the UNFCCC is to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation (IPCC, 2006).Intergovernmental Panel on Climate Change reports indicate the largest contributor to global warming to be increase in atmospheric carbon dioxide (CO_2) since 1750, and it focuses its attention on emissions from fossil fuel combustion, cement production, and land use changes such as deforestation (Spencer, 2011). The IPPC's Fifth Assessment Report (AR5) states:

Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in *snow and ice*, in global mean sea level rise, and in changes in some climate extremes. This evidence for human influence has grown since AR4. It is extremely likely (95-100%) that human influence has been the dominant cause of the observed warming since the mid-20th century – IPCC AR5 WG1 Summary for Policymakers (IPCC, 2007). The IPCC (2007)

assessment report indicates scientific confidence and consensus that: (i) global temperatures are rising, (ii) this temperature increase and attendant impacts are attributable to anthropogenic greenhouse gas emissions, and (iii) previously accumulated and future emissions will contribute to further global climate impacts (Pachauri & Reisinger 2007).

2.5 Theories Informing and Forming the Basis of the Concepts on Climate Change and Variability

Several theories have been advanced informing and forming the basis of the concepts on climate change and variability. The first theory of climate change the "anthropogenic global warming" (AGW) contends that human emissions of greenhouse gases, principally carbon dioxide (CO2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The mechanism whereby this happens is called the enhanced greenhouse effect. During the past century, human activities such as burning wood and fossil fuels and cutting down or burning forests are thought to have increased the concentration of CO2 in the atmosphere by approximately 50 percent. Continued burning of fossil fuels and deforestation could double the amount of CO_2 in the atmosphere during the next 100 years, assuming natural "sinks" don't grow in pace with emissions. Those who support of the AGW theory contend the ~0.7°C warming of the past century-and-a-half and ~0.5°C of the past 30 years is mostly or entirely attributable to man-made greenhouse gases (IPCC, 2007).

The Biothermostat theory of climate change holds that negative feedbacks from biological and chemical processes entirely or almost entirely offset whatever positive feedbacks might be caused by rising CO_2. These processes act as a "global bio-thermostat" keeping temperatures in equilibrium. A third theory of climate change postulates that changes in the formation and albedo of clouds create negative feedbacks that cancel out all or nearly all of the warming effect of higher levels of CO2. This theory is based largely on observational data reported by a series of researchers, rather than computer models as in the case of the AGW theory. Research by (Sud *et al.*, 1999) found that changes in cloud coverage in the tropics acted as a natural thermostat to keep sea surface temperature (SST) between approximately

28°C and 30°C. Their analysis suggested that as SSTs rise, air at the base of the clouds is charged with the moist static energy needed for clouds to reach the upper troposphere, at which point the cloud cover reduces the amount of solar radiation received at the surface of the sea and cool and dry downdrafts promote ocean surface cooling. This "thermostat-like control," as Sud *et al.,* (1999) described it, tends "to ventilate the tropical ocean efficiently and help contain the SST between 28°- 30°C." The phenomenon also would be expected to prevent SSTs from rising any higher in response to enhanced CO2-induced radioactive forcing.

According to (Lindzen *et al.,* 2001), after examining upper level. cloudiness data and SST data they discovered a strong inverse relationship between upper-level cloud area and the mean SST of cloudy regions of the eastern part of the western Pacific. Further work carried out by (Spencer *et al*., 2008) used new satellite data to support Lindzen's "adaptive iris" thesis, finding "the net radioactive effect of clouds during the evolution of the composite ISO [tropical intra-seasonal oscillations] is to cool the ocean-atmosphere system during its tropospheric warm phase, and to warm it during its cool phase. Lindzen and Choi, 2009 found out that "for the entire tropics, the observed outgoing radiation fluxes increase with the increase in sea surface temperatures (SSTs). The observed behavior of radiation fluxes implies negative feedback processes associated with relatively low climate sensitivity. This is the opposite of the behavior of 11 atmospheric models forced by the same SSTs." In 2010, Lindzen and Choi responded to critics with a new study account for orbital drift by ERBE satellites and other data issues. They once again found negative feedback by clouds in the tropics, which "implies that the models are exaggerating climate sensitivity." If they are right, clouds act as a negative feedback to the warming that would otherwise be caused by man-made CO_2 emissions, eliminating any net warming.

A fourth theory Human Forcings Besides Greenhouse Gases of climate change holds that mankind's greatest influence on climate is not its greenhouse gas emissions, but its transformation of Earth's surface by clearing forests, irrigating deserts, and building cities. Pielke (2009) phrases the theory as follows: Although the natural causes of climate variations and changes are undoubtedly important, the human influences are significant and involve a diverse range of first-order climate forcings, including, but not limited to, the human input of carbon dioxide (CO_2).

The fifth theory of climate change contends that global temperature variations over the past century-and-a-half, and particularly the past 30 years, were due to the slow-down of the ocean's Thermohaline Circulation (THC) (Gray, 2009). The sixth theory of climate change contends that most or all of the warming of the latter part of the twentieth century can be explained by natural gravitational and magnetic oscillations of the solar system induced by the planet's movement through space. These oscillations modulate solar variations and/or other extra-terrestrial influences of Earth, which then drive climate change. Milankovitch (1941) suggested an extra-terrestrial influence on climate on a multi-millennial timescale associated with planetary motion More recent discoveries have enabled scientists to accurately measure these effects on climate.

The seventh theory of climate change is that solar variability accounts for most or all of the warming in the late twentieth century and will dominate climate in the twenty-first century regardless of man-made greenhouse gas emissions. According to the IPCC, "changes in solar irradiance since 1750 are estimated to cause a radioactive forcing of +0.12 [+0.06 to +0.30] W/m2," which is an order of magnitude smaller than the IPCC's estimated net anthropogenic forcing of +1.66 W/m2 from CO2 over the same time period. However, many scientists believe the IPCC got it backwards, that proxy data from ice cores, drift ice debris, and other sources reveal that the sun's influence was ten times as important as CO2 in influencing global temperatures in the past. In a research published by (Bond *et al.*, 2001) found changes in global temperatures occurred in cycles of roughly 1,500 years over the past 12,000 years, with virtually every cooling period coinciding with a solar minimum. (Soon, 2005) similarly documented close correlations using different temperature records and measures of solar radiation. Correlation, even repeatedly demonstrated, doesn't prove causation. Around 2000, several scientists working independently made discoveries that demonstrated plausible mechanisms linking variation in solar radiation to decadal changes in global temperature.

The shift in public discourse, and public mood, in response to the growing scientific consensus is difficult to characterize precisely. While a number of influential people have publicly relinquished their apparent denial of the reality or importance of global climate change (Brissenden, 2006; MacAskill, 2007), others continue resolutely with

their rejection of the scientific consensus. The Lavoisier Group is an Australian organisation formed by politicians and dominated by retired industrial business people and engineers does not accept the science of global warming and works to influence attitudes of policy makers and politicians. The organisation downplays the risk of the effects of global warming, rejects the scientific conclusion that human activity causes it, and opposes policies designed to curtail it. Some members regard climate change as a "scam. ("The global warming sceptics." Theage.com.au. Nov. 27, 2004. Retrieved Jan. 1, 2014.

Gray (2006) said that global warming became a political cause because of the lack of any other enemy following the end of the Cold War. He went on to say that its purpose was to exercise political influence, to try to introduce world government, and to control people. The TV documentary The Great Global Warming Swindle was made by Martin Durkin, who called global warming "a multibillion-dollar worldwide industry, created by fanatically anti-industrial environmentalists." In the Washington Times in 2007 he said that his film would change history, and predicted that "in five years the idea that the greenhouse effect is the main reason behind global warming will be seen as total bunk. "Global warming labeled a 'scam' - Washington Times" (washingtontimes.com. Retrieved 2010-03-15).

In defending that climate change is happening, (Connor, 2007) links the terms "hoax" and "conspiracy," saying, "Reading through the technical summary of this draft (IPCC) report, it is clear that no one could go away with the impression that climate change is some conspiratorial hoax by the science establishment, as some would have us believe.

The technique used by many deniers is what might be called ‘the manipulation of uncertainty into selective doubt’. This group of people take advantage of scientific uncertainty, for example uncertainty in predictions of global mean temperature, in order to bias assessment of climate predictions in an unscientific way. That is, it aims either to create the impression that some theories have no predictive power at all or to form the prejudice or unconscious assumption that only part of the existing range of scientific uncertainty needs to be considered seriously. This technique therefore seeks to encourage selective expectations, for example, of no significant change in climate,

generally on the basis of prevailing social mores or proposed economic imperatives (e.g. short-term personal gain).

2.6 Local Domestication of UN Policies

2.6.1 From Rio 1992 to the Present

During the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, Kenya endorsed and adopted Agenda 21 which provided the world with potential practical solutions to the ever-pressing problems of the environment and development. Kenya has ratified most of the international agreements, treaties, conventions, and protocols resulting from the first Rio conference, that are considered to be in harmony with the country's plans for sustainable development. The most significant outcome was that member countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC), to cooperatively consider actions to limit average global temperature increases and the resulting climate change, and to cope with whatever impacts were, by then, inevitable.

2.6.2 Building Climate Change Institutions in Kenya

Kenya has over the years been working to put in place various institutions to address climate change. For instance, following the adoption of Kenya's National Environment Action Plan (NEAP) in 1994, whose underlying objective is the integration of environmental concerns into the planning process, various sectoral action plans and strategies have since been adopted. The enactment of The Environmental Management and Co-ordination Act (1999) is one of such outcomes. The legal framework for environmental concerns within Kenya is the Environmental Management and Coordination Act No. 8 (EMCA) of 1999. However, the EMCA has minimal content relating explicitly to either adaptation or mitigation of climate change. There are provisions within EMCA 1999 for the Minister to issue regulations around coastal erosion or mangrove conservation – that may be of use in adaptation to climate change.

The Draft National Environmental Policy (NEP), 2008 treated climate change and disaster management as an emerging environmental issue and stated that the government will adopt two approaches in combating climate change – mitigation and adaptation. The policy recognized that many of the natural disasters in Kenya were climate related, e.g. floods, drought, occasional landslides, increased disease episodes, etc., and that the economic impact of these disasters cut across the key sectors of the economy. With agricultural production, industrial processing, manufacturing, tourism, infrastructure and public health being the most impacted. The policy anticipated that with climate change the frequency and intensity of extreme weather events such as floods and droughts would increase. In order to deal with Climate Change, NEP suggested the following staged measures:-

1. Develop and implement a National Climate Change Strategy,
2. Identify and raise awareness of opportunities for adaptation measures through promotion of appropriate technology transfer and capacity building,
3. Develop and implement under the Kyoto Protocol's Clean Development Mechanism (CDM) programmes and projects that encourage significant levels of investment and technology transfer for sustainable development,
4. Develop an integrated, improved early warning and response systems for climate and disaster risks with a clear strategy for dissemination of information to the grassroots,

In order to enhance investment that aims to reduce vulnerability and build resilience of the society, and in line with the provisions of the United Nations Framework Convention on Climate Change (UNFCCC) and its implementing instrument – the Kyoto Protocol, the Government of Kenya formulated and published a National Climate Change Response Strategy (NCCRS, 2010). To operationalize the NCCRS, the Government of Kenya, through the Ministry of Environment and Mineral Resources, has initiated a process to develop a National Climate Change Action Plan. The action plan put emphasis on three key messages as follows;

1. There is a close link between development and climate change adaptation and mitigation actions.

2. Both adaptation and mitigation response options need to be implemented by a variety of actors at local, national, regional and global levels.

3. The effective planning and implementation of climate change adaptation and mitigation actions require engagement and support of climate-related line ministries, private sector, civil society organizations and development partners.

2.6.3 Kenya Draft Climate Change Policy

The Government of Kenya has, through the UNFCCC process ratified UNFCCC in 1994 and the Kyoto Protocol in 2005. The draft Climate Change Policy 2012 reflects the Government's commitment to formulating a proactive, coherent and integrated climate change response that focuses on reducing vulnerability and building the resilience of the Kenyan people, property, environment and economy. The Policy positions Kenya to capture the economic, social and environmental benefits of the transition to a low carbon climate resilient economy. It further seeks to facilitate a coordinated, coherent and effective response to the local, national and global challenges and opportunities that climate change presents.

2.7 Climate Variability in Africa

The African climate is driven by several processes that are interrelated in complex and still not yet fully understood ways (O'Hare *et al.,* 2005). Two of these—tropical convection and the alternation of the monsoons—are processes that determine the regional and seasonal patterns of temperature and rainfall. A third—the El Niño is more remote and affects temperature patterns in Africa.

2.7.1 Tropical Convection

Intense solar heating near the equator leads to rising warm, moist air and heavy rainfall. As the air rises it creates an area of low pressure at the surface, also referred to as the ITCZ. The rising air moves north and south towards the tropics and eventually falls in the subtropics (between 20° and 30° N&S of the equator) as warm,

dry air. From there it is carried back towards the equator by the trade winds.

Each year, the ITCZ moves north and south following the seasonal tilting of the globe towards the sun, leading to four distinct climatic zones (O'Hare *et al.*, 2005):

i) Tropical moist climates with ~2000 mm of rain that support the equatorial rainforest.

ii) Tropical climates that alternate between wet summers (brought by the ITCZ) and short dry winters, giving a total rainfall of 1000-2000 mm.

iii) Tropical semi-arid climates, with long dry seasons, at the northernmost limits of the ITCZ and rainfall of 300-800 mm.

iv) Arid climates located 30°-40° north and south, with less than 250 mm year rainfall.

These are not distinct zones; their boundaries overlap and vary from year to year with the latitudinal and longitudinal movement of the ITCZ. For example, when it migrates further north than usual, it brings heavy rain and floods to the Sahel (as happened in 2007); when it lies quite far south over the SWIO it will be very dry over South Africa.

2.7.2 Monsoons

Another phenomenon linked to tropical convection is the marked seasonal change of direction of the monsoonal winds, which affect West and East Africa (O'Hare *et al.*, 2005). In simple terms, monsoon winds occur because land heats up and cools down more quickly than the sea. Their change in direction involves several processes including the movement of the ITCZ and relative surface temperatures, which interact in ways that are still not well understood (AMMA, 2005).

The Indian monsoon is the most extreme form of monsoon with a 180° reversal of the wind. The south-west monsoon arises in spring and summer. As the air over north-west India and Pakistan becomes much warmer than over the Indian Ocean, it creates a low pressure drawing in warm, moist air from over the Ocean. The air first moves northward, and then because of the effects of the Earth's rotation is diverted north-

eastward. It begins to rise and cool, shedding its moisture as rain. In winter the reverse occurs, with the land cooling more than the oceans do, creating the north-east monsoon. These changes affect lands far from south Asia, for example, along the eastern margins of Africa.

West Africa is affected by a south-west monsoon that arises in a similar fashion. In the summer, as the land becomes hotter than the ocean and the air starts to rise over the Sahara, cooler, more humid air from the Atlantic Ocean is drawn in, 1000 km to the south (Gu and Adler, 2004). It brings rainfall from May to September in two phases. The first phase (April - June) centres on the Gulf of Guinea (about 4°N), and appears to be influenced by sea surface temperatures. Then in a sudden event known as the monsoon jump, usually in early to mid-July, the rainfall maximum follows the ITCZ northwards into the southern Sahel (about 10°N) over a period of just a few days. The second phase is influenced by easterly atmospheric waves, which are also associated with the ITCZ.

2.7.3 El Niño-Southern Oscillation (ENSO)

The third driver of African climate, the ENSO, is far distant in the Pacific Ocean. Although ENSO is primarily a Pacific Ocean process, the effects are felt as far away as Africa and, indeed, in most regions of the world. ENSO events involve large exchanges of heat between the ocean and atmosphere and affect global mean temperatures.

Thus, six months after an El Niño phase the global mean surface air temperature increases. In the tropics and sub-tropics, this seems to be a consequence of the heat given up to the atmosphere as the water cools down during La Niña. After the severe El Niño of 1997-98 the global temperature went up by nearly 0.2°C (Trenberth, 2007). Relatively, simple statistical models predict that during an El Niño year, weather in December to February is usually wetter in eastern Africa but drier to the south, while La Niña produces the reverse. El Niño is also associated with a drier Sahel, while La Niña is correlated with a wetter Sahel and a cooler West Africa (Nicholson and Kim, 1997).

The 1997/98 El Niño was one of the strongest of the 20th century. It was associated with droughts in Indonesia and catastrophic floods in east Africa. Among its many other consequences was the extensive coral bleaching that occurred in the Indian Ocean and Red Sea and a massive outbreak of a *Paederus* rove beetle in Nairobi that caused severe dermatitis to a portion of the human population (Van Schayk, 2005). The following La Niña of 1998-2000 was associated with devastating floods further north in the Sudan and Sahel, and in the south in Mozambique. The floods in the south were then followed by two major cyclones (Obasi, 2005).

Therefore, Africa's climate is naturally both highly diverse and highly variable. It encompasses the extreme aridity of the Saharan deserts at one end of the range and the extreme humidity of the Congo rainforest at the other. Africa is already a continent under pressure from climate stresses and shocks on a regular basis. The IPCC report (2007) projected that by 2020, between 75 and 250 million people in Africa are will be to be exposed to increased water stress due to climate change. In some countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. It further projected that towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations and that by 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios. The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP) (IPCC, 2007). Many factors contribute and compound the impacts of climate variability in Africa. These include poverty, illiteracy and lack of skills, weak institutions, limited infrastructure, lack of technology and information, health care, poor access to resources, low management capabilities and armed conflicts. The overexploitation of land resources including forests, increases in population, desertification and land degradation pose additional threats (UNDP, 2006).

Africa has a low adaptive capacity to both climate variability and climate change exacerbated by existing developmental challenges including: low GDP per capita, widespread endemic poverty, weak institutions, low levels of education, low levels of primary health care, little consideration of women and gender balance in policy planning, limited access to capital, including markets, infrastructure and technology,

ecosystems degradation, complex disasters and conflicts (Boko *et al*., 2007; Christensen *et al*., 2007).

2.7.4 Climate Variability in East Africa

The interannual variability of East African rainfall is affected by ENSO (Hastenrath *et al.,* 1993; Mutai *et al.,* 1998). The ENSO exerts some control on equatorial and coastal East African rainfall, with warm events being associated with high rainfall and cold events with low rainfall. The association has however been weak and there has been considerable spatial variability with the most influence in the north where the rainy season is strongly connected to the southwest monsoon.

Research studies suggest that the climate of Indian Ocean basin as a whole, including East Africa, is mainly influenced by the Indian Ocean Dipole (IOD) mode or zonal mode (IOZM) (Saji *et al.,* 1999; Webster *et al.,* 1999). Saji *et al.,* (1999) identified an interannual mode of variability in Indian Ocean SSTs that has an east–west structure and is distinct from the basin wide warming attributed to the remote response to El Niño. The zonal mode was independent of El Niño because the years when the zonal mode was most active were not universally El Niño years. In particular, the year 1961 was not an El Niño year. Modelling studies have also found that although the SST in the Pacific exerted some control on East African rainfall, the Indian Ocean was the dominant factor, and the Pacific Ocean did not directly control rainfall in East Africa (Goddard and Graham 1999; Latif *et al.,* 1999).

The MJO is a major perturbation of tropical convection over the Indian Ocean moving and completing a global circuit every 30 to 60 days. It was a dominant cause of intraseasonal variability in tropical equatorial regions. When the MJO was active, many tropical cyclones were spawned. The seasonal cycle of rainfall in tropical East Africa is controlled by large-scale monsoon circulations, the migration of the ITCZ, and by regional orography (Nicholson *et al.,* 1988). Between October and March, the northeast monsoon brings dry continental air into East Africa, and consequently, the rainfall during these months is low. The southeast monsoon starts in April and persists until September, during which time the moisture influx from the Indian Ocean results

in high rainfall over northern East Africa. However, in the southern part of the continent the southwest monsoon season is dry because the monsoon flow is diverted by the high topography of Madagascar and the East African coast.

In equatorial and southern East Africa, which includes Kenyan coast there are two rainy seasons, which are driven by the migration of the ITCZ back and forth across the equator. The timing of maximum rainfall lags the position of the overhead sun by approximately 1 month. The first, between April and May, is known locally as the ‘‘long rains’’ and the second, in October and November, as the “short rains”. During the short rains, the ITCZ migrates rapidly southward and the heavy rainfall is of relatively short duration. In contrast, during the long rains, the ITCZ moves more slowly, and so there is heavy rainfall for several weeks. The Long Rains (March to May) contribute more than 70% to the annual rainfall and the Short Rains less than 20%. Much of the interannual variability comes from Short Rains (coefficient of variability = 74% compared with 35% for the Long Rains) (WWF, 2006). For example, in 1997, the OND East African rains were in many areas 5–10 times the normal, the highest in the century (WMO, 1998).

During recent decades, eastern Africa has been experiencing an intensifying dipole rainfall pattern on the decadal time-scale. The dipole is characterised by increase in rainfall over the northern sector and low rainfall over the southern sector (Schreck and Semazzi, 2004). East Africa has suffered both excessive and deficient rainfall in recent years (Webster *et al.*, 1999; Hastenrath *et al.*, 1993). In particular, the frequency of strong rainfall causing floods has increased. The data analysis from the International Disaster Database (EM-DAT) showed that there has been an increase in the number of reported hydro meteorological disasters in the region, from an average of less than 3 events per year in the 1980s to over 7 events per year in the 1990s and 10 events per year from 2000 to 2006, with a particular increase in floods (Shongwe *et al.*, 2009). In the period 2000-2006 these disasters affected on average almost two million people per year.

Research has suggested that warming sea surface temperatures, especially in the southwest Indian Ocean, in addition to inter-annual climate variability (i.e., ENSO) might play a key role and be linked to the change in rainfall across some parts of

equatorial-subtropical East Africa (Cane *et al.,* 1986; Plisnier *et al.,* 2000; Rowe, 2001). Warm sea surface temperatures are thought to be responsible for the recent droughts in equatorial and subtropical eastern Africa during the 1980s to the 2000s (Funk *et al.,* 2005). The number of African food crises per year has tripled from the 1980s to 2000s (FAO, 2004). Droughts have diminished water supplies, reduced crop productivity and have resulted in widespread famine in East Africa.

Since 1997, East Africa has suffered multiple severe climate fluctuations (temperature, floods, and droughts, with consequences such as coral bleaching and livestock disease outbreaks). These variations particularly affect the poor fisher communities, who lack the resources to prepare for and recover from changes (Van Schayk, 2005). The 1997/98 short rains experienced in Kenya resulted in economic, social and other losses running to millions of shillings [Republic of Kenya (2004), National Policy on Disaster Management (Revised Draft) p 4, Nairobi , Kenya].

Climate impacts– both direct and indirect– are already being felt across Kenya and potentially with increasing severity in the future if the world does not take unprecedented measures to reduce GHGs emissions. Natural disasters caused by climate variations could lead to reduction in GDP. For instance, in 1999 and 2000, droughts in Kenya caused damages equivalent to 16% of GDP (Stern, 2006).

2.8 The Role of Fisheries in Food Security

Fish is highly nutritious, so even small quantities can improve people's diets (FAO, 2007a). They can provide vital nutrients absent in typical starchy staples which dominate poor people's diets (FAO, 2005). Fish provides about 20 percent of animal protein intake in 127 developing countries and this can reach 90 percent in Small Island Developing States (SIDS) or coastal areas. Fisheries can also contribute indirectly to food security by providing revenue for food-deficient countries to purchase food. Fish exports from low-income, food deficient countries is equivalent to 50 percent of the cost of their food imports (FAO, 2005).

2.9 Global Trends in Fish Production

With global fish supply over 150 million tonnes, more than 85 percent of this supply is used directly for food; supplying 15 percent of the world's protein and essential nutrition for around 4.3 billion consumers (FAO, 2012). The sector generates first sale values of over US$ 218 billion annually, and about 38 percent of production is traded internationally (FAO, 2012). Aquatic systems are associated with rich biological diversity with at least 27 000 species of fish, shellfish and aquatic plants, in a wide variety of ecosystems, so far identified (FAO, 2010a). According to Asche and Smith (2010), the total value of world exports of fish and fish products in 2006 reached U.S. $86.4 billion, which is a 55% increase from 2000. This global value is considerably larger than any other single potentially renewable agricultural export commodity. Coffee, for example, which is the second-most traded agricultural product, had a total export value of $12.3 billion in 2006 – just one seventh that of fisheries (Asche and Smith, 2010).

Following rapid increases in production since the 1950s, the global fish yield has stagnated and may be declining. Many stocks have been, or are at risk of being, overexploited (Hilborn *et al*., 2003). The FAO statistics support this view, showing that marine fisheries production peaked in the 1980s and that over recent years, approximately half of fisheries had been exploited to their maximum capacity, one quarter overexploited, collapsed or in decline and only one quarter had potential for increased production (FAO, 2007a). According to FAO of the 600 marine fish stocks monitored by FAO: 3% are underexploited 20% are moderately exploited 52% are fully exploited 17% are overexploited 7% are depleted 1% are recovering from depletion.

Increasing demand for seafood, expansion of fishing effort, and the globalization of both fish catch and markets makes the global context of fisheries increasingly relevant to the management of local-scale fisheries (Pauly, 1998).Seafood contributed at least 15% of average animal protein consumption to 2.9 billion people worldwide in 2006.The international trade of seafood has grown rapidly over the last few decades, enabled by a corresponding increase in the global supply of seafood. The availability of seafood has more than doubled over the last 40 years as the total supply of seafood

increased from 65.3 million metric tons in 1970 to 148.9 million metric tons in 2011 (FAO, 2012).The majority of this growth in the seafood trade is coming from fisheries in developing countries, and Africa is becoming increasingly central in this growth trend (FAO, 2009). The important role of fisheries in the African agricultural sector is highlighted by the fact that approximately 10 million Africans derive their livelihood from the fishing industry and are employed in different entry points of the fishing value chain. Africa's contribution to global trade in fish and fish products generates local revenues of up to US$4.5 billion for African economies (World fish Centre, 2008).

2.10 Coastal and Marine Fishery in Kenya

Kenya has rich inland fisheries contributing 94 – 98% to overall national fisheries production; the marine fishery production contributes only 2 – 6% of the total (FAO, 2007a). Traditionally, the Kenyan coastal communities have depended on fisheries and exploitation of mangrove resources. The country is endowed with a rich inshore marine fishery with the most productive fishing areas being the North Kenya Banks (including Lamu, Kiunga, Kizingitini and Faza), Malindi-Ungwana Bay that covers the Sabaki estuary and Tana River delta, and the Funzi-Vanga complex (Ruwa *et al*., 2003). Much fishing activity takes place along the reef, with mainly reef and sea grass associated fish species being exploited, while a few prawn trawlers fish for shrimp in the shallow waters of Ungwana Bay (UNEP, 2006a).

Approximately 80% of the total marine products come from shallow coastal waters and reefs, while only 20% are from off-shore fishing. Off-shore fishing in Kenyan waters is done by Kenyans and foreign vessels, the latter under licence. The main marine products consist of: demersal species 42%; pelagic species 18%; crustaceans 11%; sharks, rays and similar species 18%; molluscs and echinoderms 4%; deep sea and game fish 6% (Wakwabi *et al*., 2003).

Artisanal fishers, using simple fishing vessels and gears such as gillnets, shark nets, hook and line, beach seines, spear gun and traditional traps (especially basket traps), exploit the inshore fishing grounds (Ochiewo, 2004a; McClanahan *et al*., 2005).

Artisanal fishing in the inshore waters is labour intensive, providing employment and livelihood to thousands of households. Currently it is estimated that over 10,000 fishermen are directly engaged in artisanal fishing at the Kenyan coast line (Ochiewo, 2004 a&b). In 2008, the Kenyan marine fishery had 2,368 fishing boats, of which only 194 were motorized (IOTC, 2008).The artisanal fisheries of Kenya are multi species in nature (WIO Fish, 2008), landing over 95% of the marine catch and estimated to generate over US $ 3.2 million per year (UNEP, 2006b).

Kenya's marine fishery includes the coastal near-shore waters and the 200 nautical miles exclusive economic zone. The fishery environment is impacted by climate through rise in temperatures, sea level rises, floods and droughts. Impacts of deforestation and land degradation through heavy siltation and loss of critical habitats directly affects fish production. Pollution from land-based agricultural activities and petrochemicals disposed off in water systems also affect production and quality of fish (MoFD, 2008).

2.11 Potential Effects of Global Climate on Marine Environments

The marine ecosystems change on a variety of time scales, from seasonal to centennial and longer (Lehodey *et al.,* 2006). Many of these time scales are forced by atmospheric and climate-related processes, and therefore climate variability is a strong driver of changes in fish populations and in fisheries (Lehodey *et al.,* 2006). A very large part of the observations describing climate-related changes in the marine ecosystems come from the fisheries that are directly affected by fluctuations in the abundance of the exploited stocks (Lehodey *et al.*, 2006).

The most obvious driver of interannual variability is that characterized as the ENSO. The term "El Niño" is used to describe the warm phase of the large-scale ENSO, which may or may not be associated with the coastal El Niño off Peru. The converse applies to "La Niña" conditions (Lehodey *et al.,* 2006). Hence, ENSO is an irregular oscillation of (3 – 7) year involving a warm (El Niño) and cold (La Niña) state that evolves under the influence of the dynamic interaction between atmosphere and ocean (Philander 1990). Although ENSO effects are felt globally, the major signal occurs in

the equatorial Pacific with an intensity that can vary considerably from one event to another. The warm waters in the surface layer of the western equatorial Pacific (the warm pool) have a temperature above 28°C year-round, inducing an atmospheric convection connected to the colder eastern Pacific Ocean through the atmospheric zonal Walker circulation. During El Niño events, the warm pool extends far to the east in the central Pacific and reaches the coast of Peru during the most powerful events. Conversely, during La Niña the warm pool is confined to the extreme west of the equatorial Pacific. These east–west displacements of the warm pool are accompanied by changes in the walker circulation that are reflected by the
SOI, calculated from the difference in sea level pressure between Tahiti and Darwin. A strong negative index indicates an El Niño while a positive index reveals a La Niña event.

Contiguous to the warm pool, the equatorial upwelling in the central and eastern Pacific is generated by the trade winds that result in a vertical circulation bringing relatively cold and nutrient-enriched deep water toward the surface. This equatorial divergence occurs within a mean westward zonal flow, the SEC. The biological consequence of the equatorial upwelling is a large zonal band with high primary production frequently called the cold tongue that prolongs the highly productive coastal upwelling system along Peru and Chile. However, the primary productivity in the tropical Pacific is strongly affected by ENSO variability. During the development of El Niño events, the cold tongue retreats east of the International Date Line accompanying the warm waters extension into the central Pacific and the displacement of the atmospheric convective zone. The decreasing intensity in equatorial upwelling and primary production in the equatorial upwelling system is associated with this displacement. During the same period, stronger wind stresses occur in the western Pacific and increase primary production in this region (Lehodey, 2001).

The effects of El Niño events on the anchovies (*Engraulis ringens*) and sardines (*Sardinops sagax*) along the coasts of Peru and Chile have long been observed. An El Niño event has three major impacts in the coastal upwelling system off Peru: (i) it increases coastal temperatures by up to 8°C; (ii) it reduces plankton production by lowering the thermocline, which inhibits upwelling of nutrients; and (iii) by changing

trophodynamic relationships, it creates a more tropical predator and prey environment. Sardines seem to do well or even thrive under these conditions, and El Niño events usually do not harm the sardine stocks in the Humboldt Current. In contrast, anchovies suffer severely, particularly under strong events (Lehodey *et al.,* 2006).Between1997and 1998 alone 16% of the world's coral reefs were severely impacted by a combination of a strong El Niño and the warmest year on record (Obura, 2005). Each year, climate related disasters trigger devastating losses in human lives and economic assets, with the poor in developing countries being most at risk (UNISDR, 2002; Wisner *et al.,* 2004).

Interdecadal variability of climate has also been documented in the global climate cycles like those associated with the PDO index (Gedalof and Smith, 2001) and NAO index, (Parsons and Lear 2001; Hurrell *et al.,* 2003). Multidecadal to centennial variability has also been documented in the climate variability literature associated with the above mentioned climate indices, but due to the short period of records used in this study, we will restrict the study to the time scales of interannual variability**.**

2.12 Understanding Vulnerability, Resilience and Adaptation in Fisheries

According to IPCC (2007a) "vulnerability of fishery-based livelihoods to climate variability and change can be defined as the degree to which a fishery-based livelihood system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes". Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a fishery-based livelihood system is exposed, its sensitivity and its adaptive capacity (IPCC, 2007a).

2.12.1 Indicators of Vulnerability

i) Exposure

Exposure in this study is taken to mean the nature and degree to which a fishery-based livelihood system is exposed to significant climatic variations (modified from IPCC,

2001a). In assessing the vulnerability of coastal communities to key impacts of climate change on coral reef fisheries, Cinner *et al.* (2012) focussed on a specific impact pathway (coral bleaching) to study the exposure of fisheries systems to climate change. Allison *et al.* (2009) used a more general exposure indicator of predicted mean surface temperature. Pratchett *et al.* (2008) and Wilson *et al.,* (2006), however, found that a generalised indicator of 'climate change' based on mean surface temperature change could not account for the main impact pathways by which fisheries were likely to be affected by climate change, both in terms of time-lagged ecological impacts on target species or impacts on the social, economic or cultural context in which coastal communities conducted fishing (Daw *et al.,* 2009). For example extreme events were likely to have the greatest impacts but were not reflected by mean temperature changes.

ii) Sensitivity

Sensitivity is the degree to which a fishery-based livelihood system is affected by or responds to, climate stimuli (note that sensitivity includes responsiveness to both problematic stimuli and beneficial stimuli) (IPCC, 2007a). This could be measured, for example, by a proportional change in ecosystem productivity (or household income and/or expenditure) as a result of perturbations in temperature or precipitation. Sensitivity indicators include livelihood characteristics such as dependence of livelihoods on climate-sensitive activities and patterns of resource use (Smit and Wandel 2006; Eakin and Bojo´rquez-Tapia 2008).

Sensitivity indicators characterise the first-order effects of stresses (IPCC, 2001a; Polsky et al., 2007). At the local level, exposure and sensitivity are almost inseparable, and it is challenging to characterise them (Smit and Wandel, 2006). But many indicators of sensitivity are similar to those that influence a system's adaptive capacity (Smit and Wandel, 2006).). Only indicators of the dependence of livelihoods on climate-sensitive activities in the fisheries sector, for employment, income, and nutrition could be used as sensitivity indicators (Macfadyen and Allison, 2009; Allison *et al.,* 2009). This assumes that households and communities with higher dependence on fisheries for employment, income, and nutrition are more likely to be impacted by climate variability and change (Allison *et al.,* 2009).

While there are growing case studies on the observed effects of climate variability on the distribution and production of individual fisheries (Lehodey *et al*., 2006; Drinkwater, 2005), little attention has been given to the consequences of changing fisheries ecosystems on people, particularly so for the millions of small-scale fisherfolk (fishers, fish processors, traders and ancillary workers) in the developing world who are among the most vulnerable to climate change (McClanahan *et al*., 2008).

When referring to the concept of vulnerability, experience suggests that the exposure and sensitivity of fisher folk to risks are relatively high in comparison with other socio-economic groups, and that their adaptive capacity is generally low. As indicated by McGoodwin (2001), few land-based occupations confront their participants with the risks of losing all of their productive capital, as well as their lives, every time they go to work. Yet these possibilities are common place among many small-scale fishers. He further asserted that both large- and small-scale approaches to fishing comprise some of the most hazardous and economically risky occupations in the world. Indeed, fisherfolk appear to be highly exposed to physical risks [drowning, accidents while hauling nets, etc. (ILO, 2000), climate-induced risks (natural disasters like tsunami, tropical storms, floods or variability of fish stocks. (Allison *et al.,* 2009), health risks (water-borne diseases, HIV/AIDS, (Kissling *et al.,* 2005), or political and security risks (theft, inter-ethnic or inter-country conflict), among many others. Market volatility (currency devaluations, increases in fuel prices) also made small-scale fisherfolk, along with smallholder farmers, landless households and ethnic indigenous people, among groups identified by IFAD as 'functionally vulnerable groups' who were 'economically insecure and thus particularly sensitive to the slightest change in external factors' (Jazairy *et al.,* 1992)

iii) Adaptive Capacity

In this study adaptive capacity is taken to mean the ability or capacity of the fishery-based livelihood systems to adjust to climate change (including variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007a). Within the literature, adaptive capacity has been primarily examined through the concepts of thresholds and coping ranges

(Smit *et al.,* 2000). Smit and Wandel (2006) frame these terms as "conditions that a system can deal with, accommodate, adapt to and recover from" Smit *et al.,* (2000). Adaptive capacity focuses on: ecological capital (environmental stock and services), economic/physical capital (financial, infrastructure etc.), human capital (skills, education, experience etc.), social capital (relationships among families; the demography, community and the power structure (Mendis *et al.,* 2003).

While climate impacts can never be reduced to zero, the heavy and rising toll of weather-related disasters and the burden of less severe variations indicate that we are not as well adapted as we might or should be. There is, at present, an adaptation deficit (Burton, 2004). Since the earth summit in 1992, a number of strategies to support adaptation to climate change have been implemented with mixed degree of success. The strategies range from the more policy reforms, technological options (including use of improved crop varieties) to research and information exchange and institutional as well as human resource development. In addition to these, communities have over time learnt to cope with extreme weather. The urgent challenge in capacity building for the developing countries concerns strengthening the social, economic and technical resilience of the poorest and most vulnerable against extreme climate events (Najam *et al.,* 2003).

Africa's major economic sectors are vulnerable to current climate sensitivity, with huge economic impacts, and this vulnerability is exacerbated by existing developmental challenges such as endemic poverty, complex governance and institutional dimensions; limited access to capital, including markets, infrastructure and technology; ecosystem degradation; and complex disasters and conflicts. These in turn have contributed to Africa's weak adaptive capacity, increasing the continent's vulnerability to projected climate change (Boko *et al.,* 2007). Although several studies have documented how rural communities successfully cope with climatic variability (Mortimore and Adams, 2001; Thomas and Twyman, 2005), a few have considered the levels of adaptive capacity that will be required to deal with future climate change (Pahl-Wostl, 2009), there is still insufficient attention to the necessity of building adaptation on current coping strategies of vulnerable communities (World Bank, 2002).

Marine and freshwater fisheries are susceptible to a wide range of climate impacts. The ecological systems which support fisheries are already known to be sensitive to climate variability. For example, the IPCC (2007a), highlighted various risks to aquatic systems from climate change, including loss of coastal wetlands, coral bleaching and changes in the distribution and timing of freshwater flows, and acknowledged the uncertain effect of acidification of oceanic waters which was predicted to have profound impacts on marine ecosystems (Orr *et al.,* 2005). Meanwhile, the human side of fisheries: fisherfolk, fishing communities and related industries concentrated in coastal or low lying zones were increasingly at risk from sea level rise, extreme weather events and a wide range of human pressures (Nicholls *et al.,* 2007). The vulnerability of an individual, community or larger social group depends on its capacity to respond to external stresses that may come from environmental variability or from change imposed by economic or social forces outside the local domain. Vulnerability is complex and depends on a combination of natural and socio-political attributes and geography. Non-climate factors such as poverty, inequality, food insecurity, conflict, disease and globalization, could increase vulnerability by affecting the exposure, sensitivity and adaptive capacity of systems, communities and individuals (Adger *et al.,* 2007).

Graham *et al.* (2007) pointed out the disadvantage of a specific vulnerability focus which captured one, of potentially many, impact pathways. He noted that there was no guarantee that one impact would be significant compared to other, more complex, unpredictable or poorly understood impacts. For example, time lags between coral mortality from a bleaching event, structural complexity collapse, and demographic changes further up the food web mean that the impacts on fisheries production took over a decade to be realized. The effects of coral bleaching on fisheries yields and the livelihoods of fisherfolk was difficult to tease out given this time lag and the confounding effects of overfishing and other stressors (Darling *et al.,* 2010; McClanahan *et al.,* 2002). Thus, unlike some other potential climate change impacts, a coral bleaching event is unlikely to be an ‘extreme event’ from a fisher’s perspective. Single scale and single stressor studies were important in understanding specific aspects of vulnerability, while a multi-scale and multi-stressor approach helped to provide a more holistic understanding of vulnerability to climate change (Bunce *et al.,* 2010).

Cinner *et al.* (2012), in their measure of sensitivity assumed that fisheries are mostly supported by reef-related species and that were negatively affected by coral bleaching. However, some key fisheries species were not found exclusively on carbonate reefs. Fisheries landing statistics and surveys of the biomass of targeted species could not demonstrate the impact of the bleaching (Grandcourt and Cesar 2003; Graham *et al.*, 2007). They recommended that future studies could potentially improve the sensitivity index by including the degree to which the local fishery targets fishes dependent on the live coral and reef matrix (Cinner *et al.*, 2009b; Pratchett *et al.*, 2008) and institutional capacities to reduce vulnerability of coastal small scale-fishers by using social safety nets and agency as indicators of vulnerability. Some part of this study attempted to address this recommendation.

Vulnerability can also be analysed based on statistics at the sub-national level. McClanahan *et al.* (2008) derived an index of adaptive capacity with respect to a loss of fishing livelihoods of 29 coastal communities in five nations in the western Indian Ocean (Kenya, Madagascar, Mauritius, Seychelles and Tanzania). However, Daw *et al.* (2009) pointed out that a range of factors indicate adaptive capacity and wealth may not be a complete indicator of vulnerability. Badjeck (2008), in carrying out her research on the vulnerability of coastal fishing communities to climate variability and change, mainly concentrated on the effect of El Niño phenomenon on the scallop fishery. The study did not look at the various coping capacities employed by fishers to deal with climate variability and the socio-economic factors that influenced coping capacities of small-scale fishers.

As McCarthy *et al.* (2001) pointed out, vulnerability to climate variability and change varies by region, sector, and social group, and adaptive capacity is unevenly distributed across space and time. Climatic variations might create new economic and societal opportunities, as well as challenges, for fishermen (Vilhjálmsson *et al.*, 2005). However, the potential economic and societal gains will depend on the species of fish, their seasonal distribution, and whether fishermen could both recognize and exploit new fishing opportunities and manage the new risks associated with more extreme and variable weather or the need to travel farther out to sea or to different locations to fish (Hovelsrud and West, 2008).

2.12.2 Perception and Vulnerability

Perception is an abstract term that cannot be observed directly by the investigator. What is observed is the response received from respondents on the specific questions raised. The assumption is that the reply to the question reflects the perception the individual respondent possesses on the research topic (Wei *et al.,* 2009; Bekele, 2006). Local knowledge and perceptions were increasingly considered to be essential inputs to studies of human-environment interactions (Gearheard *et al.,* 2006; Hovelsrud and Winsnes, 2006). The complexity and uncertainty characterizing coupled social and ecological change is one argument for pursuing interdisciplinary research that incorporates both scientific and lay expertise (Berkes, 2007; Tyler *et al.,* 2007; Smit *et al.,* 2008). The integration of scientific and local knowledge was necessary in understanding the societal implications of climate variability and change (Berkes *et al.,* 2002; Tyler *et al.,* 2007; Crate, 2008).

Analyzing past impacts and responses to climate variability is important in understanding the role of institutions in future adaptation to climate change. The success of historically developed adaptation practices among the rural poor depends crucially on the nature of prevailing formal and informal rural institutions. Chambers (1989) argued that past coping strategies of any group to a particular hazard vary not only by place and social group, but also by time in history. Hilhorst and Bankoff (2004) have argued that there is need for more historically grounded vulnerability studies in order to fully understand the interaction between nature and society and thereby fully appreciate the construction of vulnerability. Only by increasing the integration of these various historical perspectives to vulnerability would it be possible to fully understand the processes which shape a particular system's vulnerability. While a growing body of research and literature documented and assessed local observations and perceptions of climate and environmental change (Strauss and Orlove, 2003; Ford and Smit, 2004; Gearheard *et al.,* 2006; Crate, 2008), comparatively little research has been conducted with communities and resource users at the Kenyan coast on socio-economic factors that influence fishers' perceptions on climate variability.

2.12.3 Resilience

Resilience is a concept borrowed from ecology, which refers to an ecosystem's ability to absorb a perturbation and return to a stable state (Holling, 1995). Most definitions of resilience discuss some type of system (ecological, social, socio-ecological, among others) being exposed to a stress, disturbance, change undergone, perturbation, or other type of outside influence. Resilience can be defined as the capacity of a complex system to absorb shocks while still maintaining function and to reorganize following disturbance (Walker *et al.,* 2004). 'Complex system' in this context refers to a linked socio-ecological system, which is defined as "a system that includes societal (human) and ecological (biophysical) subsystems in mutual interaction" (Gallopin *et al.*, 1989). Cutter *et al.* (2008) define resilience as the capacity of a population, system, or place, to buffer or adapt to changing hazard exposures. In human systems, the term is used to describe populations that are able to cope and adapt in the face of external shocks, including climate extremes (Davies, 1996). Within the climate change community, resilience is used along with adaptation to gauge how society responds to this threat.

2.12.4 Adaptation of Fishing Communities to Climate Variability and Change

Within the literature on climate change, the concepts of coping and adapting share similarities within both vulnerability and resilience approaches but the terms have different origins (Cutter *et al.*, 2008). Climate hazards such as floods and droughts have traditionally been addressed through disaster risk management and coping, whereas adjusting to climatic changes such as increased mean temperatures has been the domain of adaptation (Agrawal, 2008a). There has been a need to differentiate between the two concepts because of the mainstreaming of climate change adaptation into disaster risk reduction efforts (Pelling, 2011; Schipper, 2009). Coping capacity is the ability of actors to draw on available skills, resources and experiences as an immediate response to manage adverse stress or shocks brought about by climate variability (ISDR, Terminology on Disaster Risk Reduction, 2009).

Adaptation can take place at many different levels–global, national, regional, and local. Community-based adaptation (CBA) is an innovative approach enabling communities to enhance their own adaptive capacity, empowering them to increase

their resilience to climate change impacts (Huq and Reid, 2007). The IPCC identifies three standard strategies of coastal adaptation to sea level rise: i) managed retreat (moving landward to higher ground), ii) accommodate (staying in the same location but make adjustments, e.g., elevate buildings on piles), and iii) protect (employing various hard structures such as seawalls, bulkheads, groins, and breakwaters or use soft measures such as beach nourishment, mangrove replanting, and preservation of coral reefs) (McCLean *et al.*, 2001).

From an analysis of the National Communications of Asian countries, adaptation options differ from tropical to semi-arid and arid regions. Tropical coasts tend to protect wetlands and marine resources, improve preparedness for weather extremes, and implement CZM and contingency plans for migration in response to sea level rise (Alam *et al.*, 2007). In Southeast Asia, several adaptation options and practices are now widely used, including upgrading existing coastal protection systems, conserving mangrove forests and planting new stands, relocating aquaculture farms and coastal infrastructure, improving the design of housing and infrastructure, monitoring sea level rise and mapping hazard and vulnerability risks, and providing information to stakeholders and the public (ADB, 2009). In the Indian Ocean islands, coral conservation is particularly important. Successful adaptation, however, is expected to go beyond these technologies.

Adaptation technologies for coastal zones are normally classified as “hard” or “soft,” with the former relying on permanent concrete and rock constructions, and the latter on natural elements such as sand dunes, and vegetation. These technologies can be further classified as traditional-, modern-, high-, and future- technology (UNFCCC, 2009). *Traditional/indigenous technologies* are those that were first developed in traditional societies to respond to specific local problems. *Modern technologies* are those created since the Industrial Revolution. *High technologies* are those created from recent scientific advances, including information and communication technologies and computer monitoring and modelling. *Future technologies* do not yet exist in a commercially viable form. Some traditional, modern, and high technologies used in the coastal zones are listed in Table 2.1.

Table: 2.1: Traditional, modern, and high adaptation technologies in the coastal zones

Technology	Traditional	Modern	High
Restoration of coastal forests and coral reefs	√		
Sand dune restoration	√		
Community based conservation and aquaculture	√		
Sea walls revetments and head lands	√		
Beach nourishment and dune restoration	√		
Protection and reconstruction of wet lands	√		
Littoral drift replenishment	√		
Afforestation	√		
Creation of drainage areas	√		
Dikes, Dams, levees, nets and dredging	√	√	
Dikes and groins	√	√	
Salt intrusion barriers	√	√	
Tidal barriers	√	√	
Reef protection	√	√	√
Detached break waters	√	√	√
Coastal and coral erosion monitoring		√	√
Impact assessment studies			√
Light detection and ranging			√

(Adapted from UNFCCC, 2009)

2.12.5 Adaptation of Fishing Communities to Reduced Fish Resources

Many of the world's fisheries are being overfished, which has led to declines in productivity and catch (Pauly *et al.*, 1998). Fishers have developed a range of strategies and responses to deal with fluctuations in catch (Allison and Ellis, 2001). Key climate impacts to fisheries, likely adaptation measures and actors are summarized in Table 2.2. The general response options to fishers faced with a decline in yield are to suffer losses in catch; temporarily switch to alternative occupations in hopes that catches will improve later; leave the fishery; or attempt to mask declining stocks with increases in effort, changing fishing grounds, or changing to alternate and usually more efficient or destructive gear (Pauly, 1998; McClanahan *et al.*, 2005). A range of factors may influence whether or how fishers reallocate their effort, including investments in the fishery, ownership or tenure, market factors (e.g., price and distance to market), and conditions of the wider economy (Allison and Ellis, 2001).

Table: 2. 2: Potential adaptation measures to variations in fish catch

Impact on Fisheries	Potential adaptation measures	Responsibility	Reactive/ Anticipatory
Reduced fisheries productivity (indirect ecology)	Access higher value markets with same product	Public/ private	Either
	Increase effort / fishing power	Private	Either
	Diversify livelihoods portfolio	Private	Either
Increased variability of yield (indirect ecology)	Insurance schemes	Public	Anticipatory
	Precautionary management for resilient ecosystems	Public	Anticipatory
Change in distribution of fisheries	Private research and development and investments in technologies to predict migration routes and availability of commercial fish stocks*	Private	Anticipatory
	Migration	Private	Either
Reduced profitability (indirect ecological and socio-economic)	Reduce costs to increase efficiency	Private	Either
	Diversify livelihoods	Private	Either
	Exit the fishery for other livelihood/ investment	Private	Reactive
Increased vulnerability of coastal, riparian and flood plain communities and infrastructure to flooding, sea level and surges (direct)	Hard defences	Public	Anticipatory
	Managed retreat/ accommodation	Public	Anticipatory
	Rehabilitation and disaster response	Public	Reactive
	Integrated coastal management	Public	Anticipatory
	Infrastructure provision e.g. protecting harbors and landing sites	Public	Anticipatory
	Early warning systems and education	Public	Anticipatory
	Post disaster recovery	Public	Reactive
	Assisted migration	Public	Reactive
Increased risks associated with fishing (direct)	Private insurance of capital equipment	Private	Anticipatory
	Adjustment in insurance markets	Public	Reactive
	Insurance underwriting	Public	Reactive
	Weather warning systems	Public	Anticipatory
	Investment in improved vessel stability/ safety	Private	Anticipatory
	Compensation for impacts	Public	Reactive
Displacement of population leading to influx of new fishers (indirect socio-economic)	Support for existing local management institutions	Public	Either

Sources: Categories adapted from Tompkins and Adger, (2004) and Smit *et al*., (2000).

2.13 Factors that Influence Fishers' Capacity to Cope with Climate Variability

A key question that can be asked is what are the key factors that influence people's capacity to cope with and adapt to increasing climatic stresses? Income is often considered as one of the key factor(s) (Cutter *et al.,* 2003; Lindell and Perry, 2004; Wisner *et al.,* 2004; Kahn, 2005; Toya and Skidmore, 2005; Blankespoor *et al.*, 2010). It is argued that people who have resources (e.g., wealth, assets, insurance) are more likely to succeed in safeguarding their lives, property, and livelihoods as well as to

make a swifter recovery after disasters, although their economic losses in disasters are often of greater magnitude in absolute numbers (Wisner *et al.*, 2004).

In recent studies, however, the question is raised as to whether formal education might in fact play a more central role in determining people's adaptive capacity. Formal education is generally not considered to be a key factor to people's level of risk or their capacity to cope with and adapt to disasters-it is rather only linked to a higher socio-economic status and more lifetime earnings (Cutter *et al.*, 2003) or mentioned as one of many resources that people draw on to obtain a livelihood (see models such as the Pressure and Release (PAR) Model and the ("Sustainable Livelihoods (SL) approach") (Wisner *et al.*, 2004). In other words, it is argued that it is only through its correlation with income (and livelihood) that education is related to risk. It is important to understanding the factors that influence fishers' capacity to cope with and adapt to increasing climate stresses and the effectiveness of these coping strategies.

2.14 The Role of Institutions in Adaptation

Institutions are formal and informal mechanisms that shape social and individual expectations, interactions, and behaviour. They can be classified as falling into public (administrative units, and elected local governments), civic (membership and cooperative organizations), and private sectors (service and business organizations) (Uphoff and Buck, 2006). Cooperatives, savings and loans associations, and producer organisations are examples of civic institutional solutions that support their members during times of stress (Agrawal *et al.*, 2008b). For the purpose of this study, institutions are defined as structured, formal or informal organizations that are the means through which local households cooperate with each other or through which central governments and donors channel resources for local development (Agrawal and Perrin, 2009). The focus is on groups of people, who are organized formally or informally and who can be approached as a group. The New Institutional Economics literature (see e.g. North, 1990; Williamson, 2000) defines institutions to also cover norms and rules which govern behaviour of households and organisations. In particular, the role of kinship (clan, ethnic group), factors affecting commitment

among community members and factors affecting market functioning are important in this respect. Organizations, on the other hand, can then be defined as social systems that have been actively established to pursue specific aims and objectives (Hill, 1989). Organizations comprise of players that are guided by, and shape, these rules. Organizations are thus the manifestation of both formal and informal institutions. For example; an organization's internal rules deal with personnel, budgets, procurement, and reporting procedures, thereby constraining the behaviour of their members (Burki and Perry, 1998).

Capacity building in climate literature includes, (among other things): strengthening disaster warning systems, strengthening coastal zone management, identifying, assessing, and evaluating coastal technologies, providing specialized capacity building packages on adaptation and strengthening socio-economic analysis of adaptation options (UNFCCC, 2003). The urgent challenge in capacity building for the developing countries concerns strengthening the social, economic and technical resilience of the poorest and most vulnerable against extreme climate events (Najam *et al.,* 2003).Institutions are important for coping: informal social and cultural norms and formal policies and institutions all affect how an individual, a household or a community is able to respond in the short term to climatic and other stressors (Young, 2002). Agrawal (2008a) pointed out that institutions influence livelihoods and adaptation of rural households. Institutions are therefore important for fostering adaptive capacity (Adger and Vincent, 2005; Brooks *et al.,* 2005; Leach *et al.,* 2010). They influence the ways in which societies can respond to hazards and environmental stress (Brondizio *et al.,* 2009) and are key in the functioning of markets, local governance of common-pool resources and land tenure and access (Ellis, 2000), all of which are important for daily coping strategies of rural communities. Public, civic, and private institutions are all relevant to local adaptation (Agrawal *et al.,* 2008). They are often interlinked and shape not only how households and communities are impacted by climatic variability and change, but also how they are able to respond. Institutions link local systems to larger spatial systems (Agrawal, 2008a): it is important to understand how all types of institutions at all levels influence the ability of a community to respond through short term coping, as well as to adapt over the longer term. Institutions are thus treated as a system with its actors, boundaries and dynamic interactions. Institutions are relevant to the study of fisherfolk responses

because they regulate human-environment interactions, co-evolve with environmental change, and mediate social responses (Bakker *et al.*, 1999). There is limited research on how institutions influence adaptive capacity of individuals or communities (Anderies *et al.,* 2004) especially in the fisheries sector in Kenya.

2.15 The Sustainable Livelihoods Approach

i) Fisheries and Livelihoods

The concept of livelihood is about individuals, households, or groups making a living, attempting to meet their various consumption and economic necessities, coping with uncertainties, and responding to new opportunities (de Haan and Zoomers, 2003). A livelihood can be defined as the capabilities, assets and activities required for means of living (Chambers and Conway, 1992). The concept of sustainable livelihood seeks to bring together the critical factors, assets and activities that affect the vulnerability or strength of household strategies (Allison and Ellis, 2001; Ellis, 2000). People can access, build and draw upon five types of capital assets: human, natural, financial, social and physical. Access to assets is mediated by policies, institutions or processes (PIPs) such as market or organizations (see Figure 2.1). Livelihoods are also affected by a vulnerability context which includes, for instance, seasonality and changes in fuel prices (Allison and Horemans, 2006).

The concepts and methods of livelihoods analysis have recently been applied to understand the role that fisheries play in the rural economy in coastal, lakeshore and floodplain areas in developing countries (Allison and Ellis, 2001; Béné and Neiland, 2003; Nettleton and Baran, 2003; Whittingham *et al.,* 2003; Allison, 2004). The livelihoods approach is set out in the form of a framework that brings together the principal components that are thought to comply with the livelihoods definition, as well as demonstrating the interactions between them. The ability of a community to cope with and respond to change depends heavily on the access to and control over key assets (Daze *et al.,* 2009). Assets include both tangible capital (natural, physical and financial) as well as intangible ones (human and social) (Prowse and Scott, 2008). The capital assets that can be accessed by fishermen are grouped into five categories, and can be described as the "livelihood platform" (Bond *et al.,* 2007). Ellis (2000)

defines capital assets as the basic building blocks upon which individuals are able to undertake production, engage in labour markets, and participate in reciprocal exchanges with other individuals or households. The asset base-human, physical, natural, financial, and social capital-forms the building blocks of livelihoods and helps reduce vulnerability. Understanding fishermen livelihood platforms, will therefore give a perspective of how fishermen livelihoods respond to climate variability.

NB: Assets are indicated by letters: H: human, N: natural, F: financial, P: physical and S: social.

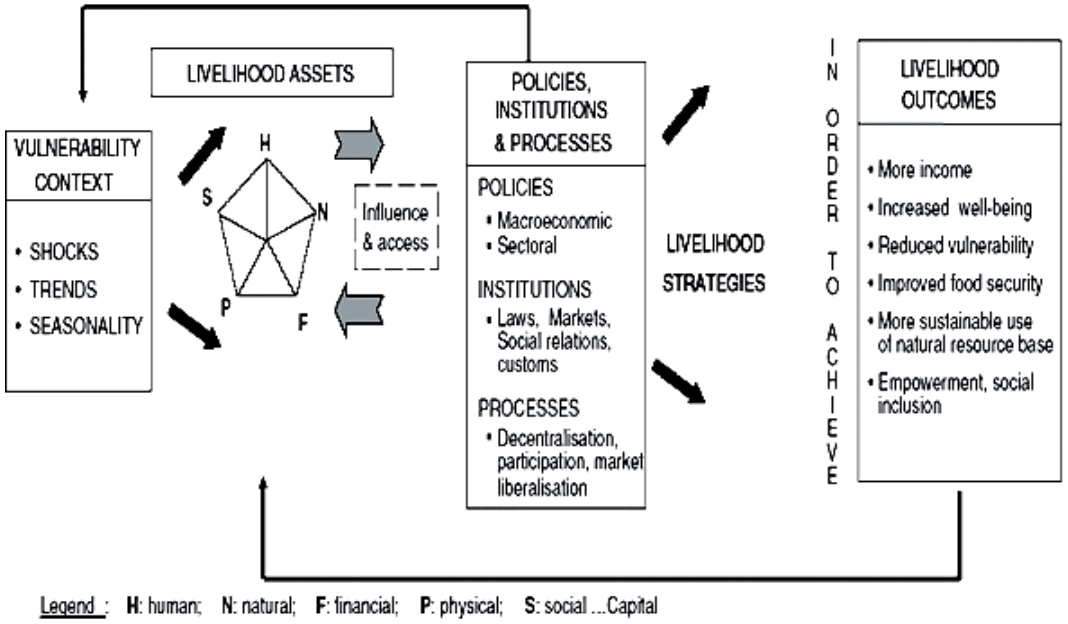

Figure 2.2: The Sustainable Livelihood Framework (Source: Allison and Horemans, 2006)

Various studies have worked from a vulnerability and social security perspective; several have focused on disturbances and local vulnerabilities (Blaikie, 1995; Adger *et al.*, 2001). Investigations into change processes and adaptation have included short-term (Davies, 1996) and long-term responses (Singh and Gilman, 1999). However, few livelihood studies have pursued the agenda of how livelihoods "can cope with and recover from stresses and shocks," and the resilience analysis that this would entail (Berkes *et al.*, 2003). Stresses and shocks that impinge upon livelihoods are the result of interactions between global forces and local contexts (de Haan and Zoomers, 2003; Armitage and Johnson, 2006). Fluctuations in resource abundance, seasonal cycles of resource use and changes in access, create conditions that bring challenges

for rural households.

According to Turner *et al.* (2003), a stress is a continuous or slowly increasing pressure, commonly within the range of normal variability, whereas a perturbation (shock) is a major spike in pressure beyond the normal range of variability in which the system operates. Stresses tend to be ongoing as in the case of resource declines; seasonality issues, such as lean times; and perturbations and fluctuations within the social–ecological system. The onset of shocks tends to be intense and dramatic, such as the December 2004 tsunami that hit Asian coastal communities or economic devaluation (Thailand economic crash of 1997).

2.16 Influence of Climate Variability on Livelihood Capital Assets

2.16.1 Climate Variability and Natural Capital

Production of fish in many aquatic ecosystems varies considerably as a result of interannual and decadal variability in their environment, for which the term ‘‘climate variability’’ is used. Lehodey *et al.* (2003) showed that recruitment of the two tropical species of tuna skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*) and the subtropical albacore (*Thunnusalalunga*) in the Pacific is related to regimes in the major climate indices, ENSO, and the Pacific Decadal Oscillation. Large scale distribution of skipjack tuna in the western equatorial Pacific warm pool can also be predicted from a model linked to changes in ENSO (Lehodey, 2001). These tuna models are notable because they simulate NPP, driven by ocean biogeochemistry, and the pelagic fish ecosystem in two trophic levels, thus explicitly relating fish production to primary production. An inland example of the consequences of a change in NPP comes from Lake Tanganyika, where the decline in pelagic fish catches since the late 1970s has been ascribed to a climate-induced increase in the vertical stability of the water column, resulting in reduced availability of nutrients (O’Reilly *et al.*, 2004).

Balston (2009) showed that significant relationships between long-term climate indices such as the Inter-decadal Pacific Oscillation and fisheries catch have been shown for a number of oceanic species such as herring, cod, sardine and anchovy that are dependent on oceanic upwelling for food chain nutrients. The results indicated that

long-term climate cycles may affect the early life cycle stages of the species by influencing climate variables such as rainfall, stream flow and temperature and hence nutrient availability and nursery habitat suitability.

A study carried out by Lea (2000) indicated that Squid landings in California have been increasing since the 1960s; this increase, however, has been interrupted several times by major El Niño events that raise ocean surface temperatures along the California coast. Landings, for example, dropped markedly during the 1958, 1983-84, 1992, and 1998 El Niño episodes or events. Squid are short lived, reproducing and then dying within one year. During El Niño events they are not found on their normal spawning grounds or farther north. They may be spawning in deeper colder water during these years. So far, the population has always recovered after the El Niño event has passed.

Coral bleaching is a biological phenomenon in which stony corals and related organisms, lose the symbiotic algae normally found in their tissues as a result of stress (including unusually high water temperatures). As a result, the corals appear white; they may recover but can die if bleaching is severe or prolonged. Coral reefs in the western Indian Ocean region experienced very severe bleaching and mortality because of the El Niño of 1998 to 1999 and were bleached again in 2005. Inner reefs of the Seychelles showed severe ecological consequences. Live coral cover dropped from 27 percent to three percent, and coral-feeding fish species disappeared (Graham *et al.,* 2006). Coral bleaching and the loss of reef complexity may be critical factors that lead to reduction of abundances and biodiversity of invertebrates and fishes. Corals interact with fishes in a variety of ways. Some species of fish forage on the gametes or larvae of corals (Prachett *et al.,* 2001). Other species of fish use coral as a means of refuge and protection, others forage on non-structural invertebrates, while others eat algae that are overgrowing on corals. Many fishes also provide nutrients to coral (Mora and Ospína, 2001; Prachett *et al.,* 2001). In coral reef communities where intense bleaching has occurred, significant changes in the abundance of some fishes are observed. Species intimately tied to live coral for shelter and sustenance have shown little recovery from severe bleaching events (Williams, 1986; Spalding and Jarvis, 2002).

2.16.2 Climate Variability and Physical Capital

Climate variability and change through sea-level rise and storm and flood frequency can impact on the physical capital of households or of entire communities, leading not only to decreased harvesting capacity but also to the disruption of public infrastructure and services that support livelihoods. More specifically, storm and severe weather events can destroy or severely damage productive assets and infrastructure such as landing sites, boats and gear (Jallow *et al.,* 1999). For instance, during Hurricane Gilbert in 1998, Jamaican fisherfolk lost 90% of their traps resulting in a loss of revenue and high cost of repairs, as well as the ability to resume fishing activities promptly (Aiken *et al.,* 1992). In Belize, the loss of fishing tackle and associated infrastructure as a consequence of Hurricane Mitch (1998) was estimated to have cost US$1.2million (Gillet *et al.,* 2003). The impacts of climatic events outside the normal range (from El Niño to natural disasters) on post- harvesting infrastructure as well as damages to transportation and marketing systems have also been well documented (Iwasaki, *et al.,* 2009). Damage to fisherfolks' non-productive physical assets such as housing and community infrastructure (hospitals, schools, sewage system, etc.) are also important consequences of extreme climatic events (Westland *et al.,* 2007). In Northern Peru, damage to or loss of houses was perceived by fisherfolk as one of the most important impacts of El Niño (Badjeck *et al.,* 2010). Poor housing conditions, loss of dwellings and community infrastructure can result in resettlement and displacement, and more broadly disruption of livelihoods.

2.16.3 Climate Variability and Financial Capital

Many fisheries are known to be profoundly controlled by climate variability through ecological impacts. Long-term climate-related changes have been observed in marine ecosystems (IPCC, 2007a), including in targeted fish populations. Fisheries can be affected by direct climate impacts on processing and trade. For example, following hurricane Katrina, fishers in the Mississippi area of the United States were unable to sell and catch fish or buy fuel or ice (Buck, 2005), while heavy rain in Peru in 1998 disrupted road networks and prevented rural fishing communities from accessing their usual markets (Broad *et al.,* 1999). Increasing frequency of algal blooms, shellfish poisoning and ciguatera poisoning because of warming seas, ecological shifts and the

occurrence of water-borne human pathogens, like Vibrio in areas affected by flooding may lead to fears over fish contamination. These factors may adversely affect fish markets (Patz, 2000; Hales *et al.,* 1999) although this impact is still uncertain. Nagy *et al.* (2006), reported that fishermen remain vulnerable and have not appropriated social and financial capital to cope with climate extremes. In the Kenyan Coast context, heavy unseasonal rains in January and February could reduce the tourist numbers, hence reducing the market opportunities for fish sales.

In inland waters, fisheries created by increases in flooded areas may partially offset the loss of land for agriculture or other economic activities. In Peru, an increased sea surface temperature negatively affect pelagic fisheries for small-scale artisanal fishers, but also bring a variety of (sub) tropical immigrants and expands the distribution zone of some species, illustrating very well how climate change could bring new opportunities to fisherfolk and their communities. During the El Niño of 1982 to 1983 and 1997 to 1998, penaeid shrimps and rock lobsters from the Panamic Province appeared in Peru (Arntz, 1986). These species, along with dolphin fish (mahi-mahi), tuna and diamond shark created a new economic opportunity for the artisanal fishing sector (CAF, 2000).

2.16.4 Climate Variability and Human Capital

The livelihoods of small-scale fishers are already vulnerable to a range of non-climate risks, including fluctuating resources, loss of access, HIV/AIDS, market fluctuations, conflict, political marginalization and poor governance (Allison *et al.*, 2008). The different dimensions of human capital, ranging from safety at sea to food security, are also affected by climate variability and change. The loss of lives can be the most dramatic impact of extreme climatic events on human capital, affecting not only surviving household members but also potentially disrupting economic and social activities and systems outside the immediate family (Westland *et al.*, 2007).

Extreme events increase the risks associated with working at sea, and changes in weather patterns may disrupt fishing practices that are based on traditional knowledge of local weather and current systems. Disruption of other sectors (e.g., agriculture,

tourism, and manufacturing) by extreme events could lead to indirect socio-economic effects. Mahon (2002), pointed out that the displacement of labour into fishing can lead to conflicts over labour opportunities and increased fishing pressure. This was observed as a result of hurricanes in the Caribbean. Droughts and resultant agricultural failure forecast in some areas of sub-Saharan Africa (Conway *et al.,* 2005) may lead to so-called "environmental refugees" moving to coastal areas and creating an influx of surplus fishing labour. Studies have shown that the risk of malaria in South America, Central Asia, and Africa (areas where the majority of small-scale fishermen are located) has been shown to be sensitive to variability in climate driven by El Niño (Patz and Kovats, 2002). Marine phytoplankton blooms caused by increased SSTs can result in red tides that could cause diarrhoea and paralytic diseases linked to shellfish poisoning (Hales *et al.,* 1999; Patz, 2000).

2.16.5 Climate Variability and Social Capital

"Social capital" is a concept that describes the extent and nature of relationships people have with others, the relationships people have with their communities, and relationships between people and various services, institutions and systems. It is also a concept that can be used to understand the linkages between communities or institutions (Stone, 2003). Social capital is a productive asset that enables individuals to better fulfill their aspirations through access to goods and services via their social network and through collective action (Castle, 1998). Social capital, unlike other forms of capital, is not depleted with use but actually increases in value with use (Ostrom, 1999). In social capital theory, norms and rule-ordered relationships are viewed as resources which individuals can use to reduce risk, access services, obtain information, and coordinate collective action (Grootaert, 1998). He points out that social capital is hypothesized to have several long-term benefits, such as better access to credit and a resulting better ability to smoothen out income fluctuations by borrowing and/or accumulating assets. According to Sobel (2002), social capital describes circumstances in which individuals can use membership in groups and networks to secure benefits. Dercon (2001), based on his knowledge and experience on the concept of social capital and its applications, says that leveraging social capital is an important risk management strategy during times of economic distress and the

idea is further supported by the view that divided societies will experience greater difficulty managing economic shocks.

i) Bonding, bridging and linking social capital

Harper and Kelly (2003) perceive the concept, bonding social capital, as the closer connections between people and is characterized by strong bonds, e.g., among family members or close friends; it is good for "getting by" in life. According to these co-authors, bridging social capital refers more distant connections between people and is characterized by weaker, but more cross-cutting ties, e.g., with business associates, acquaintances, friends of friends; it is good for "getting ahead" in life. Harper and Kelly (2003) express their views that linking social capital describes connections with people in positions of power and is characterized by relations between those within a hierarchy where there are differing levels of power; it is good for accessing support from formal institutions. And they further explain that linking social capital is different from bonding and bridging in the sense of the relationship between people who are not on an equal footing. Stone (2001) says that linking social capital involves social relations with those in authority, which might be used to garner resources or power.

The “bonding”, “bridging” and “linking” social capital framework provides a useful way for thinking about the various different types of relationships that people have at any point in their life. It also highlights the fact that different families and communities will have different “mixes” of these types of relationships. That is, some people have strong family and friendship relationships (bonding social capital), whereas other people may be more engaged in community groups (a form of bridging social capital) or know many people in various organizations and institutions (linking social capital). Strengthening bonding, bridging or linking relationships may be critical for building family and community capacity, linking families to services and supports, improving safety nets for prevention and early intervention, and for empowering family and community members (Stone, 2003).

Social networks are defined as links or relationships between households, communities and institutions of governance that facilitate the flow of material and non-material resources (Gouden and Naess, 2009; Adger *et al.,* 2009). Only limited research has been conducted on the role of social networks in the enhancement of adaptive capacity to climate change.

2.17 Knowledge Gaps in the Literature

From the reviewed literature, various knowledge gaps for the study were identified. First, knowledge on the effects of climate variations on the livelihoods of small-scale coastal fishing communities in Kenya is still missing. Second, although considerable research has been conducted on many aspects related to the geological and biological impacts of climate change, little is known about the specific impacts on the future well-being of the world's population and how they are related to the ability to adapt to changing climate conditions. In fact, knowledge about future societies' adaptive capacities is one of the most important missing links in making predictions about the effects of climate variability (Lutz, 2008). Against this background, one of the objectives of this research is to help fill this gap by providing new knowledge on the aspects that shape people's capacities to adapt to changing climate conditions. More specifically, it aims to examine how adaptive capacities of the respondents in the study areas are influenced by their level of education, age, experience in fishing and number of dependants. No documentation has been done on key factors that determine fishers' capacity to cope with and adapt to climatic stress and the effectiveness of this coping strategies in Kenya. Further, institutional capacities to reduce vulnerability of fishing communities to future climate variations in the study areas were missing. Third, knowledge on influence of education, number of dependants, age and experience in fishing as factors that influence fishers' perception on climate variability being a key factor that may influence fish abundance was missing. This research aimed at generating information that would fill these gaps.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents a detailed description of the research methods applied in this study. The chapter is divided into three sections; description of the study area, research design, and data analysis. Each of the sections is further divided into sub-sections giving details of the different approaches used. The description of the study sites gives details in terms of location, environmental characteristics, land use, population size, climate, hydrology, soils, and vegetation. The research design entails sampling techniques used and data collection. Finally, data analysis provides methods used in the analysis.

3.2 Study Area

Kenya's coastline, extending from the border with Somalia in the north to the border with Tanzania in the south, is about 600 km long (SOC, 2009). There are five counties in the Kenyan coast with access to the sea. These include: Lamu, Tana River, Kilifi, Mombasa, and Kwale. Figure 3.1 shows the study sites in Mombasa County and Malindi in Kilifi County. Geographically, Mombasa County is bordered by Kilifi County to the north, Kwale to the south and west and the Indian Ocean to the east. It comprises of 7 Divisions, 18 Locations and 30 sub-Locations (Mombasa County MTEF Budget Report, 2012/2013-2014/2015). On the other hand, Malindi is situated in Kilifi County. It comprises of 3 administrative Divisions, 16 Locations and 56 Sub-Locations (GoK, 2008a)

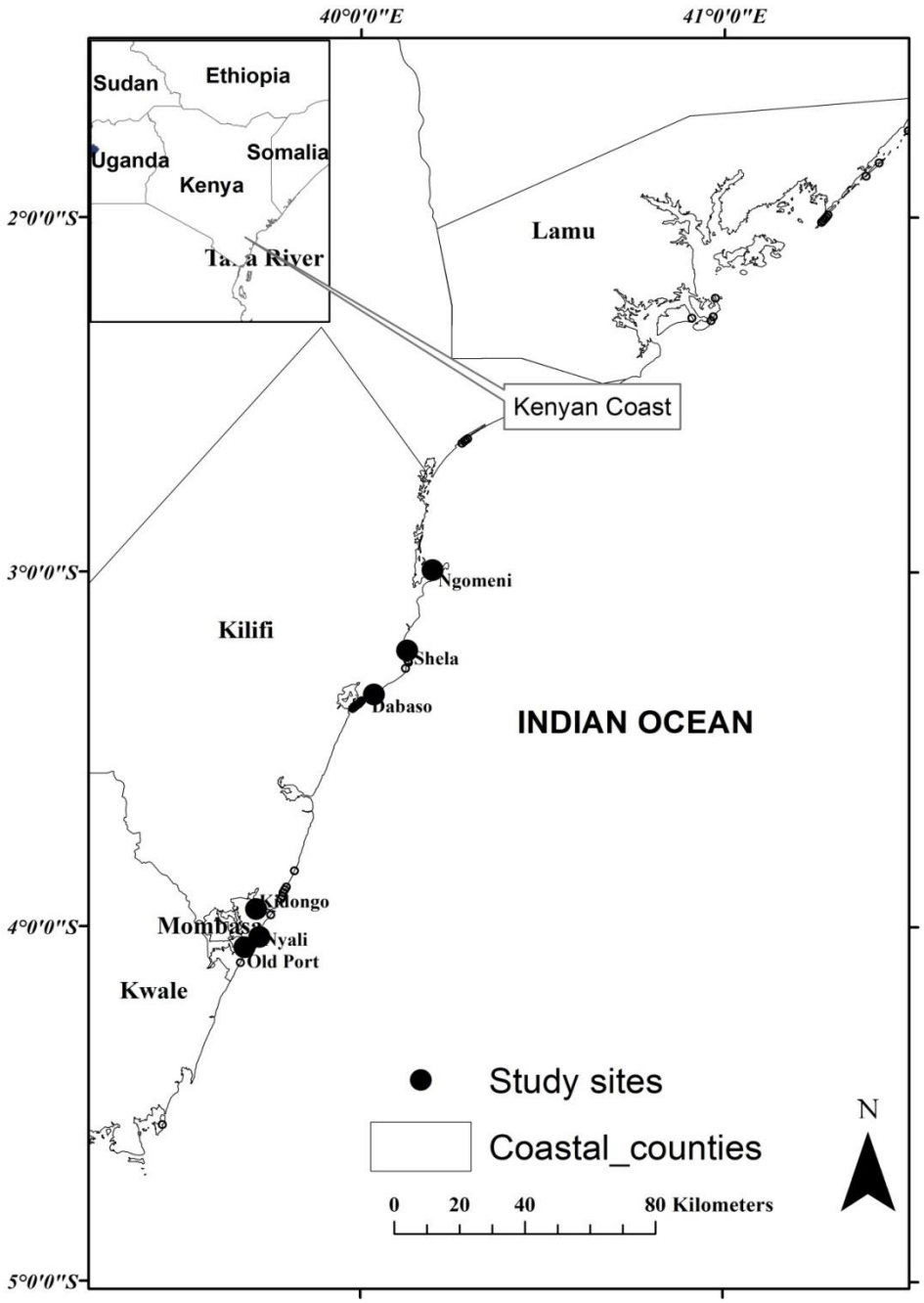

Figure 3.1: Locations of study sites in Mombasa County and Malindi in Kilifi County (*Source: B. Akunga 2012*)

3.2.1 Malindi in Kilifi County

Malindi lies between latitude 2˚ 20´and 4 ˚south and longitude 39˚ and 40˚ 14´ east. It covers an area of 7,605 Km^2 (GoK, 2008a).

a) Topography

Malindi has four major topographic features: coastal plains, foot plateau, coastal range, and Nyika Plateau. The Nyika Plateau is sparsely populated and is covered by thin vegetation, shallow depression and gently undulating terrain. The soils are poor causing the area to have low potential for rainfed crop farming. The main economic activities in this area are livestock keeping and growing of drought resistant crop varieties, e.g., maize and cassava. Vegetables are grown along river Sabaki through small-holder irrigation. The coastal range zone is characterised by low range sand stone hills of altitude 130m-420m. The zone has the largest forests in the area. The foot plateau zone is characterised by slightly undulating terrain. The zone is traversed by a number of dry water courses. It has an altitude ranging from 60m to 136m above sea level and slopes towards the sea. The area has grassland and stunted vegetation and is densely populated. The coastal plains are along the district's coastline. Across the coastal plains are several creeks with mangroves and estuaries of river Sabaki. River Sabaki flows across the district and it influences human settlement. The Indian Ocean is a major feature in the district. The district coastline is 155 km long, running from Mida to Ungwana and has good beaches for tourism and fishing activities (GoK, 2008a).

b) Climate

Malindi has a monsoon type of climate with hot humid conditions throughout the year. The mean daily temperatures range from a minimum of 22˚C to a maximum of 29.5˚C. The district has two rain seasons each year. The long rains fall between April and June while the short rains fall between October and December. The coastal belt receives an average of between 900mm and 1110mm due to the effect of monsoon winds and topography. The Nyika Plateau and Coastal range receive 700mm and 1200mm of rainfall annually. On the other hand, the foot plateau receives an average rainfall of 900mm-1110mm annually (GoK, 2008a).

c) Population

Figure 3.2 shows population totals as enumerated in the censuses of the years 1969, 1979, 1989, 1999 and 2009 (GoK, 1969, 1979, 1989, 1999, 2009). The figure shows an increasing trend in population for both Mombasa and Malindi over the years. Similarly, Figure 3.3 shows percentage changes of the population in both Mombasa and Malindi in Kilifi Counties .The percentage changes show both increasing and decreasing trends over the years. The highest percentage population increase in Malindi was recorded in the years 1979-1989. The years 1989 -1999 and 1999-2009 recorded slight percentage decreases in population. In Mombasa, the years 1979-1989 recorded slight percentage decreases in population while the years 1989-1999, and 1999-2009 recorded slight percentage increase and decrease, respectively. According to the 2009 Population and Housing Census, Malindi in Kilifi County had a total population of 400,514 in 2009 with 196,681 being male and 203,833 being female. The total numbers of households were 73,330 (GoK, 2009a).

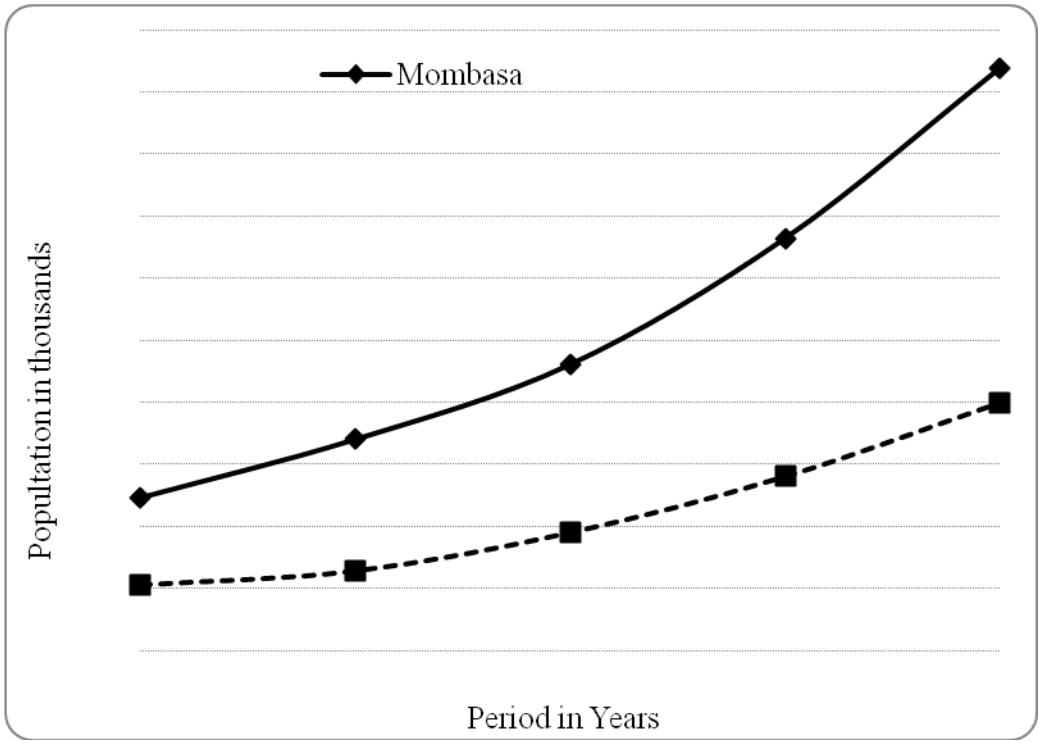

Figure 3.2: Enumerated total population for Mombasa and Malindi for the years 1969, 1979, 1989, 1999, and 2009

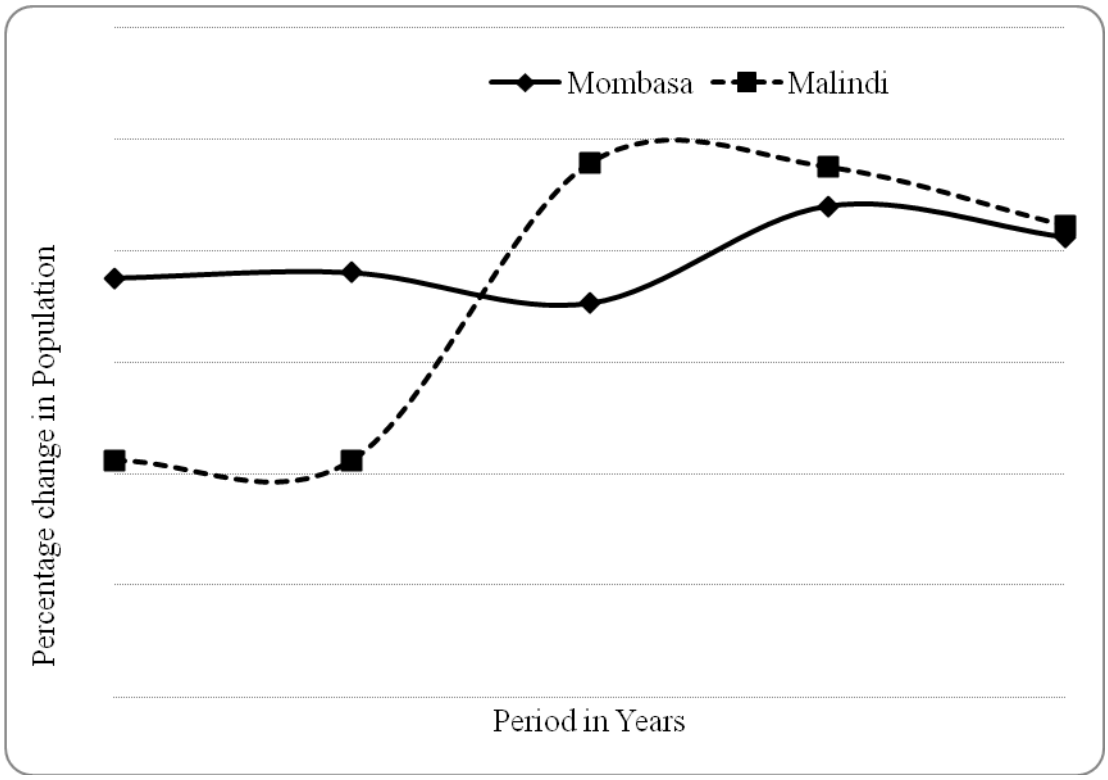

Figure 3.3: Percentage changes of population in both Mombasa and Malindi in Kilifi Counties

3.2.2 Mombasa County

Mombasa county covers an area of 229.7 km^2 excluding 65 km^2 of water mass.
The County lies between latitudes 3˚55′ and 4˚08′south of Equator and between longitudes 39˚ 35′and 39 ˚46′east of Greenwich Meridian. The County is divided into seven Divisions, eighteen Locations and thirty Sub-Locations (Mombasa County MTEF Budget Report 2012/2013-2014/2015).

a) Topography

Mombasa County lies within the coastal lowland which rises gradually from the sea level in the east to slightly over 76.2 m above sea level in the main land west.

The County has three distinct physical graphic units. The coastal plain is found close to the sea covering parts of south coast, the island, parts of Changamwe and parts of North Coast areas of the County. It consists of extensive flat terrain dominated by a series of raised beach terraces underlain mainly by coral limestone and back reef sand

deposits. The hilly, dissected and eroded terrain is found within the western part of the County. It rises generally from about 45m to 122 m above sea level. It has mainly clay soils and agriculture is the main activity. Finally, is the Indian Ocean and the shoreline. Geologically, sedimentary rocks of Jurassic to recent age underlie the County (GoK, 2008b).

Other physiographic features include: the sea, the fringing coral reef and cliffs, the island, harbours, creeks, tidal flats, sandy beaches, the coastal plain and a hilly dissected and eroded terrain. These features are as a result of interaction between the existing geological conditions and natural processes such as sea level changes, erosion and deposition. These features have greatly affected the development of the County in a number of ways, for instance, the fringing coral reef, the creeks and tidal flats with extensive mangrove forests are breeding grounds for fish.

b) Climate

The total annual rainfall is between 1025-1270 mm. The rainfall pattern is characterised by two distinct long and short rainy seasons, corresponding to changes in monsoon winds. The long rains occur in April –June and average 1,100 mm with a peak of 330 mm in May and correspond to South-Easterly Monsoon winds. The short rains start towards the end of October lasting until December, and correspond to North-Easterly Monsoon winds, which are comparatively dry. The short rains average a peak of 240 mm with about 100 mm in November.

The annual mean temperature is 27.9˚C with a minimum of 22.7˚C and a maximum of 33.1˚C while the lowest temperature is in July with a minimum average of 22.7˚C. The average humidity at noon is about 65% (GoK, 2008b).

c) Population

Kenya is experiencing rapid urbanization growth just like many other developing countries in Africa (UN Habitat, 2008). According to the 2009 Population and Housing Census, the population of Mombasa County was 939,370 (GoK, 2009a). According to the UN-Habitat urban information data base the population trends of

Mombasa has been increasing over the years. Table 3.1 below shows the population trends for Mombasa from 1979 -2009.

Table 3.1: Population distribution in the Mombasa District by division (Source: GOK (1979, 1989 & 1999, 2009); World Resources Institute

Division Name	**Population (thousands)**			
	1979	**1989**	**1999**	**2009**
Changamwe	81.3	113.5	171.5	282.3
Kisauni-1	1.7	3.3	5.4	405.9
Kisauni-2	78.3	150.0	242.2	
Likoni	39.7	67.2	93.3	176.4
Mombasa1sland	136.1	127.7	141.4	74.7
Mombasa-County	**341.143**	**461.7**	**653.018**	**939.4**

3.3 Research Design

The study adopted a descriptive survey design. The survey aimed at getting the frequency or the number of answers to the same questions by different people (Orodho, 2005). Sproull (1988) observed that descriptive survey explores the relationship between variables in the natural setting. This type of design yields a sizeable volume of data that can be classified by type and frequency indicated. Miller (1991), Gay (1976) and Mutai (2001) noted that descriptive study involved finding out what people are doing, thinking and gathering information from them by use of questionnaire and interview schedule. Bless and Achola (1990) indicated that the purpose of a descriptive study is to give an accurate account of a particular phenomenon, situation, community or person. It also includes the estimate of how frequent some events occur or the proportion of people within a certain area sharing certain views. Quantitative research techniques were used to quantify the size, distribution, and association of certain variables in the study population (Mugenda & Mugenda, 2003).

Out of the five Counties along the coast, Mombasa and Malindi in Kilifi County were purposely selected. Mombasa County was selected due to the low fish catches over the years in comparison to the other fishing Counties at the Coast. Malindi is one of the leading fishing districts along the Kenyan coast. Malindi was selected because the Athi-Galana-Sabaki River the second longest river in Kenya enters the Indian Ocean in 30˚ 12' S just north of Malindi town. The state and size of the estuary varies seasonally depending on river flows. Climate variability is likely to affect the dynamics in river flows which is likely to affect the livelihoods of the local people fishing, being one of them.

3.4 Sample Size and Sampling Procedure

Kombo and Tromp (2006) described a sample as a set of respondents selected from a larger population, and sampling as the technique of selecting a suitable sample for the purpose of determining characteristics of the whole population. Gay (1992) added that a sample size of 10% of the population is considered minimum while for small populations 20% of the population may be required. On the other hand, Nwana (1979) recommended 5% to 20% sample size for populations that run in thousands. However, he asserts that there is no hard and fast rule on sample size. Kerlinger (1979) argued that the main factor in determining the sample size is the need to keep it manageable enough. The study collected data from three categories of respondents; fishers, key informants and focus groups. Collecting data from different sources provided information that could be used to compare and or complement each other. In this study, a proportion of 10% of the total population was considered as an appropriate sample size.

3.4.1 Fishers Sample

The primary step taken was to define the population that was to be sampled or the target population. At the time of the survey design, statistics of the fishermen population and fish landing sites for both Mombasa and Malindi were obtained from the Fisheries Department offices in Mombasa and Malindi. About 1,050 and 1,350 fishermen have been registered in Mombasa County and Malindi, in Kilifi County,

respectively. The numbers of fishermen depend on the type of season with some seasons registering high numbers and some months recording low numbers.

A list of all fish landing sites in Mombasa County and Malindi in Kilifi County was obtained from Fisheries Department. Mombasa County and Malindi in Kilifi County have 31 and 23 landing sites, respectively. Stratified random sampling was used to categorize fishermen according to the different fishing zones or fishing grounds they operated. This technique was preferred because it ensured the presence of the key subgroup within the sample. The sample size of each stratum in this technique was proportionate to the population size of the stratum when viewed against the entire population. This means that each stratum had the same sampling fraction.

Fish landing sites were classified into three sub-groups. This included landing sites that were found within the creeks, reef and open sea. In each stratum, simple random sampling was used to come up with landing sites that were to be studied within each stratum. The landing sites that were randomly selected in Mombasa County comprised of Kidongo, Nyali and Old Port. The landing sites in Malindi comprised of Dabaso, Shela and Ngomeni. The landing sites were purposely selected to represent landing sites within the urban and peri-urban areas. It was assumed that fishers in the urban areas would have alternative livelihoods as coping mechanisms to climate variability compared to those in peri-urban areas. They also represented the different fishing zones the fishers operated.

The sampling unit was comprised of fishers from the selected landing sites. The sample size was based on the approaches by Gay (1992) and Bunce *et al.* (2000) who proposed a minimum sample size to be 10% of the total population. A sample size of 105 was set for Mombasa and 135 for Malindi. The sample respondents were randomly selected from among the captains or owners of fishing units in the fish landing sites. Table 3.2 shows the distribution of fisher questionnaire in the selected landing sites in Mombasa and Malindi.

Table 3.2: Distribution of fisher questionnaire in the selected landing sites in Mombasa and Malindi

Study site	Fishers' population	Sample size
Mombasa (Total population)	**1050**	**105**
Old port	320	32
Kidongo	250	25
Nyali	350	35
Rejected questionaires		13
Total sample population		**92**
Malindi (Total population)	**1350**	**135**
Ngomeni	400	40
Shela	500	50
Dabaso	360	36
Rejected questionnaires		9
Total sample population		**126**
Total (Both Study Sites)	**2400**	**240**

3.5 Data Collection Instruments

The main instruments used in this study were questionnaires, interview schedules, and Focus Group Discussions. The questionnaire and interview schedules were first pre-tested with a small sample of fishers to detect ambiguities, poorly worded and unclear questions, choices and instructions (Mugenda & Mugenda ,2003; Fraenkel & Wallen, 2000).

3.5.1 Questionnaires

A questionnaire is an instrument that is used to collect data, which allows measurement for or against a particular view point (Orodho, 2005). Closed-ended questions are easy to analyze. The open-ended questions permit the respondents to respond freely (Orodho, 2005; Mugenda & Mugenda, 2003). . The questionnaire had two main sections; the first section consisted of closed-ended questions on socio-economic profile of respondents and details on fishing activity. Questions regarding age, number of dependants, educational background, capacity building courses received, number of crew in the vessel, type of propulsion of vessel, main gears used,

number of hours and days dedicated to fishing activity, potential radius of operation, estimated monthly income, estimated monthly expenses, the main economic activities and whether women participated in any economic activities were asked. The second section addressed questions on the kind of climate vulnerability and trends experienced in the study areas and its effect on livelihoods, the various coping strategies employed by the fishers to deal with climate vulnerability, the attitude and local perceptions small-scale fishers have on climate variability in relation to it being a key factor that may have direct effect on the abundance of fish and institutional capacities that are in place to cope with current climate variability and future climate extremes. The detailed questionnaire is attached as Appendix 1.

3.5.2 Interview Schedules

An interview schedule is a set of questions that the interviewer asks when interviewing respondents. Orodho (2005) stipulated that the interviews elicit in depth information which is not possible with questionnaires. An interview schedule makes it possible to obtain data required to meet specific objectives of the study. Interviews involved face-to-face contact with the respondents. This ensured that questions were clarified and unclear answers followed up. The main task of the interviewer was to pose questions, evaluating answers and probing for evaluation in the event of incomplete responses, noting down answers, and leading the discussion. Interview schedules complemented information from the questionnaires (Appendix 2 and Appendix 3).

3.6 Data Collection

3.6.1 Direct Observation

Direct observation described by Bunce *et al.* (2000) provided first-hand information about the fishery in the study areas. During observation, questions relevant to the variables (e.g. type of fish catches, gear and coping strategies) under investigation were asked. Key observations made included fish catches at landing sites, type of gear used and various coping strategies that the fishers have employed to deal with climate

variability, e.g., planting of mangroves and alternative livelihoods. A detailed observation sheet is attached as Appendix 4.

3.6.2 Interviews

Interviews were conducted with various key informants to gather in-depth information on the topic under study. Mikkelsen (1995) defined key informants as individuals anticipated to have a particular insight or opinions about the topic under study. Interviews were done face-to-face through the use of semi-structured questionnaires which worked as guide for the interviewer, allowing for both focus and flexibility in data collection (Creswell, 1994; Czaja and Blair, 1996). The key informants interviewed included Beach Management Unit leaders and relevant institutional stakeholders in fisheries (government agencies e.g. Fisheries Department, Kenya Metrological Department, research institutions, academic experts and NGOs). The snowball technique (Goodman, 1961) (in which information is gathered by asking an initial informant to suggest other prospective key informants in the same stakeholder group) and purposive methods were used to identify respondents. The information from key informants was important for validation of information collected using other research methods. A total of thirteen key informants were interviewed.

3.6.3 Focused Group Discussions

The research process further included feedback and verification of the reliability of information given by respondents through focus group interviews. Agar and MacDonald (1995) define focus groups as somewhere between “a meeting and a conversation” where participants relate their experiences and reactions among presumed peers. This technique was applied following the approach proposed by Bunce *et al.* (2000). A set of open-ended questions was used to prompt participants into free discussions focusing on the issues under study. The focus group consisted of 8-10 people per landing site. This method encouraged interactions between the interviewers and the interviewees (Photo 3.1). It allowed the facilitator to probe for answers, follow up on original questions and new lines of questions during the interview. Focus group discussions were selected to represent both urban and peri-urban landing sites. A total of six focus groups were conducted in the study areas.

Photo 3.1: Focused Group Discussions *(Photo by B. Akunga)*

3.6.4 Questionnaire Administration

In order to obtain information on the influence of climate variability on coastal small-scale fishing communities in Kenya, fisherman survey was designed and conducted. The questionnaires were administered to respondents who were randomly selected from among the captains or owners of fishing units in selected landing sites. Open-ended questions were included to solicit data on opinions of respondents on certain issues of effects of climate variability. Responses for open-ended questions were categorised and coded for ease in data analysis. A questionnaire has advantages that include; standardized responses, encouraging responses to sensitive issues and avoidance of embarrassment.

3.7 Ethical Considerations

Ethical guidelines such as consent and confidentiality were followed during data collection. Ethical considerations were done by first ensuring that before the commencement of the interviews, consent was sought from local leaders. Secondly, the respondents were assured of confidentiality of the information they gave. They were made to feel free to avoid revealing their identity by not giving their names in

data collecting instruments (Corlien *et al.,* 1991)

3.7.1 Data Collection Limitations

The data collection faced limitations that included: first, respondent fatigue. This was a common occurrence as most respondents felt that they had been interviewed by many researchers many times without getting feedback or benefiting from the researches done. The consequence was lack of cooperation by a section of respondents. It took plenty of time persuading them to cooperate and participate in the exercise. The use of variation of data collection methods was meant to minimise information bias that could have threatened the validity and reliability of data. The second limitation in this study was lack of adequate data, as well as missing data from secondary sources. Available data were used to the extent possible.

3.8 Types of Data Collected

3.8.1 Primary Data

Both primary and secondary data were collected during the study. Primary data were collected using a combination of various techniques namely observation, questionnaires, key informant interviews and focus group discussions, as proposed by Bunce *et al.,* (2000).

3.8.2 Fisheries Data

Past and current data on fish catches for both Malindi and Mombasa were obtained from official documents from the Fisheries Department of Kenya. The Department sends fish catch data to FAO every year therefore, to a great extent, these data are reliable.

3.8.3 NCEP Re-analysis Data

Monthly data sets of sea surface temperature and precipitation; (1948-2012) were obtained from the National Centre for Environmental Prediction/ National Centre for

Atmospheric Research (NCEP/NCAR) website. NCEP (National Centre for Environmental Prediction) has developed monthly re-analyzed data sets using all recovered data (land surface, ship, radiosonde station, aircraft, satellite) from 1948 to the present using a highly advanced numerical analysis and data assimilation system. The re-analysis project is a joint effort between NCEP and NCAR (Kalnay *et al.,* 1996). The NCEP data has been used by researchers such as Webster *et al.* (1999) and Rakotondrafara, (2001).

3.9 Data Management and Analysis

All received questionnaires, interview schedules and discussion reports were sorted out. Attention was given to missing data and consistency of information. Data cleaning was then done to check for errors that needed correction. A code book was then created and data were coded to assign numbers to various categories of variables. The data were then entered into Statistical Package for Social science (SPSS) master sheets. Frequency distribution of variables was conducted in the preliminary analysis. This was done to facilitate description of variables, check for differences between groups and determine associations between variables. Statistical analysis was then undertaken to determine whether differences and associations found were significant or not. Qualitative data from in-depth interviews and focus group discussions were organized and coded so that statistical analysis could be undertaken.

3.9.1 Objective 1: Climate Variability Experienced in the Study Area and its Influence on Fish Catches and the Livelihoods of Fishing Communities

A statistical method – SPSS version 18.0 (Statistical Package for Social Science) was used to analyse the data, producing descriptive statistics. Cross-tabulations were conducted to identify potential relationships or associations between different attributes in the five livelihood capitals and their significance was tested using χ^2 (Chi-square) tests. Spearman correlation was used to measure the association between variables (ordinal or continuous) such as codified type of gear and income. The Mann-Whitney *U* test and T-test were used to compare mean rank differences of variables between the study sites.

i) Empirical Modelling using Historical Environmental and Fish Catch Data

In this approach, data on various fish species, sea surface temperature and rainfall received for both Mombasa and Malindi were subjected to Pearson moment correlation coefficient at 95% CI. This was tested for relationships between fish catch and SST and fish catch and rainfall. The trend of sea surface temperature and rainfall over the years was analyzed using moving averages. The principle was to identify a sufficiently accurate quantitative relationship between yield /abundance and a climatological parameter (rainfall/ temperature).

3.9.2 Objective 2: Coping Mechanisms of Fishers' to Climate Variability, Factors Influencing their Coping Strategies and Institutional Capacities in Place to Deal with Current and Future Climate Extremes

i) Extent to which Education Level, Age and Period in Fishing Influence Gear as a Coping to Climate Variability

To determine the extent to which education level, age and period in fishing of small-scale fishers influence migration and gear as coping strategies to climate variability, data to determine the relationship between gear and the above variables were analyzed using Statistical Package for Social Sciences (SPSS) version 18.0 and reported using cross-tabulations tables (Elifson *et al.*, 1990). Their significance was tested using χ^2 (Chi-square) tests. To determine the institutional capacities that are in place to cope with current climate variability and future climate extremes, fishers were asked whether they had received any external help during times of climatic related stresses and whether the help was effective. Access to weather information was used as an indicator of climate vulnerability. The data were analyzed using Statistical Package for social science (SPSS) version 18.0 and reported using cross-tabulations tables. Their significance was tested using χ^2 (Chi-square) tests. Cross-tabulations were also conducted to identify potential relationships between gear type and access to climate information. Their significance was tested using χ^2 *(*Chi-square) tests.

ii) Modelling Determinants that Influence the Perception of Fishers on Climate Variables over the last 20 or so Years and Migration as a Coping Strategy to Climate Variability

A logistic regression model establishes a relationship between a binary outcome variable and a group of predictor variables. The model was adopted and used to

analyze the determinants of migration as a coping strategy to climate variability and the perception of fishers on climate variables over the years. The logistic model identifies *ceteris paribus* (i.e., all other variables being constant) the strength of the effect of each explanatory variables on the binary dependent variable (Tabachnick and Fidell, 1996). It models the logit-transformed probability as a linear relationship with the predictor variables. In the equation below, let **y** be the binary outcome variable indicating increase /decrease with 0/1 and p be the probability of y to be 1, p = prob(**y**=1). Let $\mathbf{X1}$, $\mathbf{X2}$ ……, $\mathbf{Xk}$ be a set of predictor variables. Then the logistic regression of **y** on $\mathbf{X1}$, $\mathbf{X2}$, ……, $\mathbf{Xk}$ estimates parameter values for $\beta_0, \beta_1, \ldots, \beta_k$ via maximum likelihood method of the following equation:

$$\text{logit}(p) = \log(p/(1-p)) = \beta_0 + \beta_1 * \mathbf{X1} + \ldots + \beta_k * \mathbf{Xk}$$

$$logit(p) = \log\left(\frac{p}{1-p}\right) = \beta_0 + \mathbf{ß1\ X1} + \ldots\ldots + \mathbf{ßk\ Xk}$$

In terms of probabilities, the equation above is translated into

$$p = \exp(\beta_0 + \mathbf{ß1} + \ldots + \mathbf{ßk} * \mathbf{Xk}) / (1+\exp(\beta_0 + \mathbf{ß1} * \mathbf{X1} + \ldots + \mathbf{ßk} * \mathbf{Xk}).$$

$$p = \frac{\exp(\beta_0 + \mathbf{ß1\ X1} + \mathbf{ß2X2} + \ldots\ldots + \mathbf{ßk\ Xk})}{[\mathbf{1} + \exp(\beta_0 + \beta_1 \mathbf{X1} + \mathbf{ß2X2} + \ldots\ldots + \beta_k\ \mathbf{Xk})]}$$

$\mathbf{ß1}$ +…..+ $\mathbf{ßk}$ = set of k regression coefficients

$\mathbf{X1}$ +…. $\mathbf{Xk}$ = set of k (k= 9) predictors and exp = base of the natural logarithm

The dependent variable is a dichotomous variable. It takes for example the value 1 if fishers perceived increased temperature over the years (i.e., they agreed with the statement), and zero otherwise (i.e., if they disagreed or expressed a neutral opinion about the statement). The logit model was also used to measure the parameters of the conditional probability (chance) of being a migrant fisherman. The explanatory variables used in the Logit Models and hypothesized as determinants of respondents perception of climate variability over the years and migration as a coping strategy are: education (x_1), age (x_2), period in fishing (x_3), fishing distance (x_4), ownership (x_5), member of organisation (x_6), access to credit (x_7) and monthly income (x_8). The details and definitions of variables were as in Table 3.3. The choice of the explanatory variables in the model was based on literature review (Ghazouani and Goaied 2001;

Rodriquez and Smiths, 1994; Mendelsohn and Nordhaus, 1994). To explore the relationship or association of these explanatory variables chi-square was used.

Table 3.3: Definition and description of modelling variables

Variables	Description	Dummy description
Dependent variable		
a) Increased temperatures	Fishers' view on climate variable e.g. temperature, rainfall, SLR, winds over the years	1 = increased temperature, 0 = otherwise
b) Coping strategy (migration)	Fishers' using migration as a coping strategy to wind variability	1 = fishers migrated, 0 = otherwise
Explanatory variable		
a) Education (x_1)	Education level of household head	1 = schooled primary to tertiary, 0 = otherwise
b) Age (x_2)	Age of the household head	1 = below 35 yrs, 0 = otherwise
c) Period in fishing (x_3)	Number of years spent in fishing	1 = more than 20 yrs fishing experience, 0 = otherwise
d) Fishing distance (x_4)	Average distance of fishing	1 = fishing distance more than 3Km, 0 = otherwise
e) Vessel ownership (x_5)	Ownership of vessel	1 =owner of vessel, 0 = otherwise
f) Access to credit (x_6)	Access to credit	1 = access to credit 0 = otherwise
g) Member of organisation (x_7)	Member of a local organisation	1 = member of organisation, 0 = otherwise
h) Number of dependants (x_8)	Number of members in the house hold	1 = dependants, 0 = otherwise
i) Income (x_9)	Income of house hold head in Ksh	1 = less than Ksh 10,000, 0 = otherwise

3.9.3 Objective 3: Perceptions of Local Small-scale Fishers on Fish Abundance and Influencing Factors

In ascertaining perceived influence of climate variability on fish abundance, a five-point Likert-type scale with options of strongly agree, agree, neutral, disagree and strongly disagree with nominal values of 5,4,3,2 and 1 respectively was used to obtain responses from fishers. Data were analyzed using frequencies and mean scores. The perception of small-scale fishers towards climate variability and its influence on fish abundance in the study sites would be influenced by a number of explanatory factors. Perception determinants: level of education, age of respondents and experience in

fishing were analyzed using ordinal logistic regression. The ordinal logistic model identifies the strength of the effect of each explanatory variable on the dependent variable. To explore the relationship or association of these explanatory variables, chi-square was used.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The main purpose of this study was to determine the nature of climate variability experienced in the study area and the extent to which fishing communities are vulnerable to these climate related threats in terms of livelihoods. The study also sought to investigate mechanisms developed by small-scale fishing communities to cope with their vulnerabilities, factors influencing their coping strategies and institutional capacities in place to deal with current and future climate extremes. The study further sought to determine the perceptions of local small-scale fishers on fish abundance and influencing factors.

This chapter, therefore, presents the results of the above laid out objectives. Data collected for each item are presented in the following paragraphs together with their mode of analysis and interpretation. The chapter begins by discussing the socio-economic characteristics of the respondents in the study areas. The socio-economic characteristics investigated include; age, education level, marital status, number of dependants, experience in fishing, income levels and fishing activity. Detailed information on the five different assets fishermen draw upon in building their livelihoods is also discussed.

4.1.1 Age Categories of the Respondents

As indicated in Table 4.1(a) respondents in this study were grouped into four categories notably, below 18 years, 18-35 years, and 36-60 years and above 60 years. Majority (77.1%) of the respondents' age ranged between 36 - 60 years followed by those aged 18 to 35 years (22.9%). None of the respondents were aged above 60 years or below 18 years. Results indicate that, there was a significant association between age and fishing experience (χ^2=8.291, df = 3, P<0.05 (Table 4.1(b). Most of the fishermen are young and middle-aged with potential and drive to sustain fish production. The different age categories aided in understanding the kind of climate

vulnerability experienced in the study areas over the years and the different coping strategies that have been employed. An Independent t-test was conducted to compare categories in age of respondents in Mombasa and Malindi. Results indicate that there was no significant difference in scores in categories of age in Malindi and Mombasa (M=2.78, S.D 0.419), (t=0.217, df=216, P=0.826). (Table 4.1 (c).

Table 4.1(a): Category of ages of the respondents

Respondent's age	**Frequency**	**%**
Below 18 years	0	0
18-35 years	50	22.9
36-60 years	168	77.1
Above 60 years	0	0
Total	**218**	**100**

Table 4.1(b): Relationship between age and period in fishing

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	8.291[a]	3	.040
Likelihood Ratio	7.739	3	.052
Linear-by-Linear Association	.572	1	.449
Number of Valid Cases	218		

a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 4.59.

Table 4.1 (c): Comparison of Age categories of Respondents in Mombasa and Malindi

	District	Number of respondents	Mean	Std. Deviation	Std. Error Mean
Age of respondents	Malindi	125	2.78	.419	.037
	Mombasa	93	2.76	.427	.044

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Age of respondents	Equal variances assumed	.187	.666	.217	216	.828	.013	.058	-.101	.127
	Equal variances not assumed			.217	196.112	.829	.013	.058	-.102	.127

4.1.2 Education Levels of the Respondents

Tables 4.2 (a) shows the education levels of the respondents in the study areas. In this study population, most (61.5%) (n=134) of the respondents in both study sites had attained primary education, 9.6% (n=21) had secondary education, a few 1.8% (n=4) had tertiary education. About twenty seven percent (n=59) of the respondents had no formal education. These findings are similar with results from Greece, where fishers' education was found to be low when compared to non-fishers (Tzanatos *et al.*, 2006). Results indicate that, there was no significant association between gear type and education level, and gear type and number of courses attended (χ^2=36.27, df = 36, P>0.05 and χ^2=11.83, df = 13, P>0.05). Further, results from an independent t-test conducted indicate that there no significant difference in scores for level of education in Mombasa and Malindi (M=1.41, SD= 0.695), (t=1.117, df=216, p=0.265) (Table 4.2 (b).

Table 4.2 (a): Respondents' education level

Education level	Frequency	%
Primary	134	61.5
Secondary	21	9.6
Tertiary	4	1.8
No formal education	59	27.1
Total	**218**	**100**

Table 4.2 (b): Comparison of Education levels in Mombasa and Malindi

	District	Number of respondents	Mean	Std. Deviation	Std. Error Mean
Education	Mombasa	93	1.41	.695	.072
	Malindi	125	1.30	.675	.060

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Education	Equal variances assumed	2.018	.157	1.117	216	.265	.105	.094	-.080	.289
	Equal variances not assumed			1.113	195.042	.267	.105	.094	-.081	.290

4.1.3 Marital Status of Respondents

Table 4.3 indicates that, majority (88%) (n=191) of the respondents were married, 11% (n=25) were single and 1% (n=2) were divorced. Marital status is of great importance because of its potential source of labour that can be made available for fishing. There was no significant difference in marital status of respondents in

Mombasa and Malindi (M=1.04, S.D=0.204, (t=0.426, df=216, P=0.671)(Table 4.3 (b).

Table 4.3 (a): Marital status of respondents

Marital status	**Frequency**	**%**
Married	191	88.0
Single	25	11.0
Divorced	2	1.0
Total	**218**	**100**

Table 4.3 (b): Comparison of Marital Status of Respondents in Mombasa and Malindi

	District	Number of respondents	Mean	Std. Deviation	Std. Error Mean
Marital status	Mombasa	93	1.04	.204	.021
	Malindi	125	1.03	.177	.016

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Marital status	Equal variances assumed	.725	.395	.426	216	.671	.011	.026	-.040	.062
	Equal variances not assumed			.417	181.449	.677	.011	.026	-.041	.063

4.1.4 Number of Dependants

Table 4.4 shows that, majority (56.4%) (n=123) of the respondents had 3-5 dependants, 17.6% (n=39) had more than 5 dependants, 5.9% (n=13) had less than 3 dependants while 19.9% (n=43) had no dependants.

Table 4.4: Household size of respondents

No of dependants	Frequency	%
None	43	19.9
Less than 3	13	5.9
3 to 5	123	56.4
More than 5	39	17.6
Total	**218**	**100**

4.1.5 Experience in Fishing

Table 4.5 (a) shows that, majority (62.4%) (n = 136) of the respondents have been fishing for 20 – 30 years, 11.2% (n = 24) for more than 30 years, 17.3% (n = 38) for 10 – 20 years while 9.1% (n = 20) have experience of less than 10 years. Majority of the fishermen who were in the category of having the experience of 20 –30 years and those who had experience of more than 30 years were useful in giving information on the changes experienced in climate variables over the years. Results indicate that, there was no significant association between period in fishing and fishing income (χ^2=0.901, df = 6, P>0.05) (Table 4.5 (b). Further, results from an independent t-test indicate that there was no significant difference in the scores for the number of years respondents spent in fishing in Mombasa and Malindi (M= 2.70, SD= 0.749, t=0.882, df=216, p=0.379) (Table 4.5 (c).

Table 4.5(a): Years spent in fishing by respondents

Years in fishing	Frequency	%
Less than 10 years	20	9.1
10 to 20 years	38	17.3
21 to 30 years	136	62.4
More than 30 years	24	11.2
Total	**218**	**100**

Table 4.5(b): Relationship between period in fishing and fishing income

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.901[a]	6	.989
Likelihood Ratio	.893	6	.989
Linear-by-Linear Association	.112	1	.737
N of Valid Cases	174		

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is 3.68.

Table 4.5 (c): Comparison of the number of Years Spent Fishing by Respondents in Mombasa and Malindi

	District	No. of respondents	Mean	Std. Deviation	Std. Error Mean
Years spent Fishing	Mombasa	93	2.70	.749	.078
	Malindi	125	2.79	.786	.070

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Years spent fishing	Equal variances assumed	.091	.763	-.882	216	.379	-.093	.105	-.301	.115
	Equal variances not assumed			-.889	203.303	.375	-.093	.105	-.300	.113

4.1.6 Respondents' Income Levels per Month

Figure 4.1 shows that, respondents' incomes ranged from below Ksh 5,000 (11%); Ksh 5,001 - 10,000 (26%); Ksh 10,001-15,000 (28%); Ksh 15,001-20,000 (23%); and above Ksh 20,000 (12%) per month.

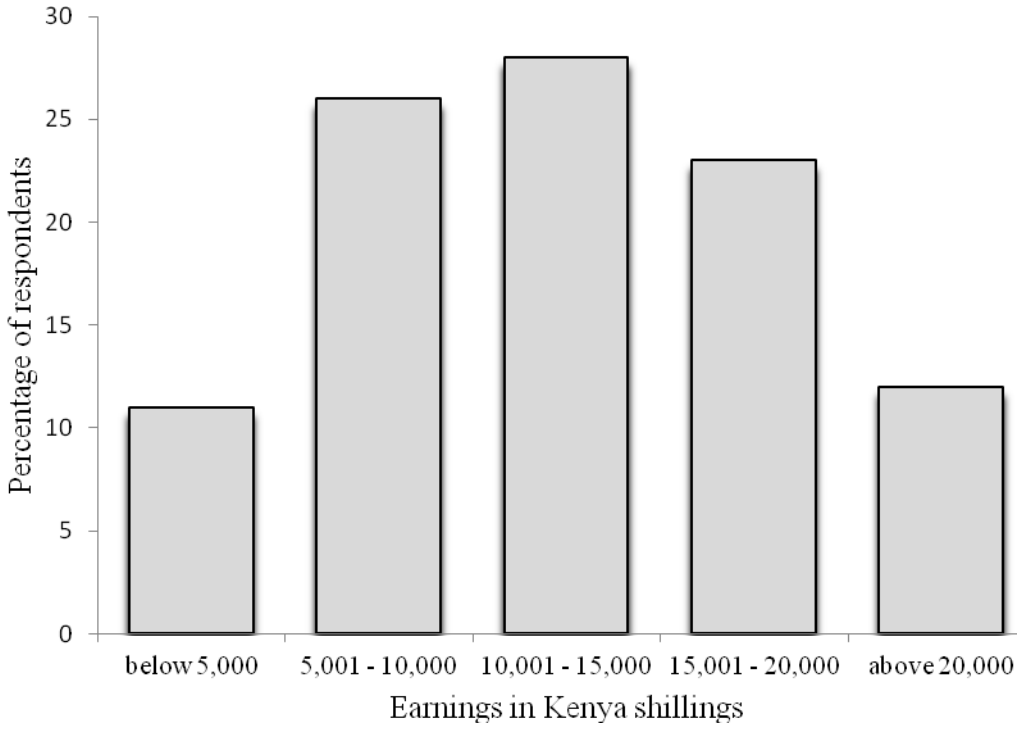

Figure 4.1: Monthly family incomes of respondents in the study areas

Figure 4.2 shows that, respondents', monthly fishing incomes ranged from below Ksh 5000 (8.7%); Ksh 5001-10,000 (23.9%); Ksh 10,001-15,000 (19.3%); Ksh 15,001-20,000 (14.2%) and above Ksh 20,000 (33%). (USD1= Ksh 86 in 2013). According to World Fish Center (2005), fishing households involved in capture fisheries are found to be poorer and less educated than their counterparts in the aquaculture sector with earnings as low as USD$1 per day.

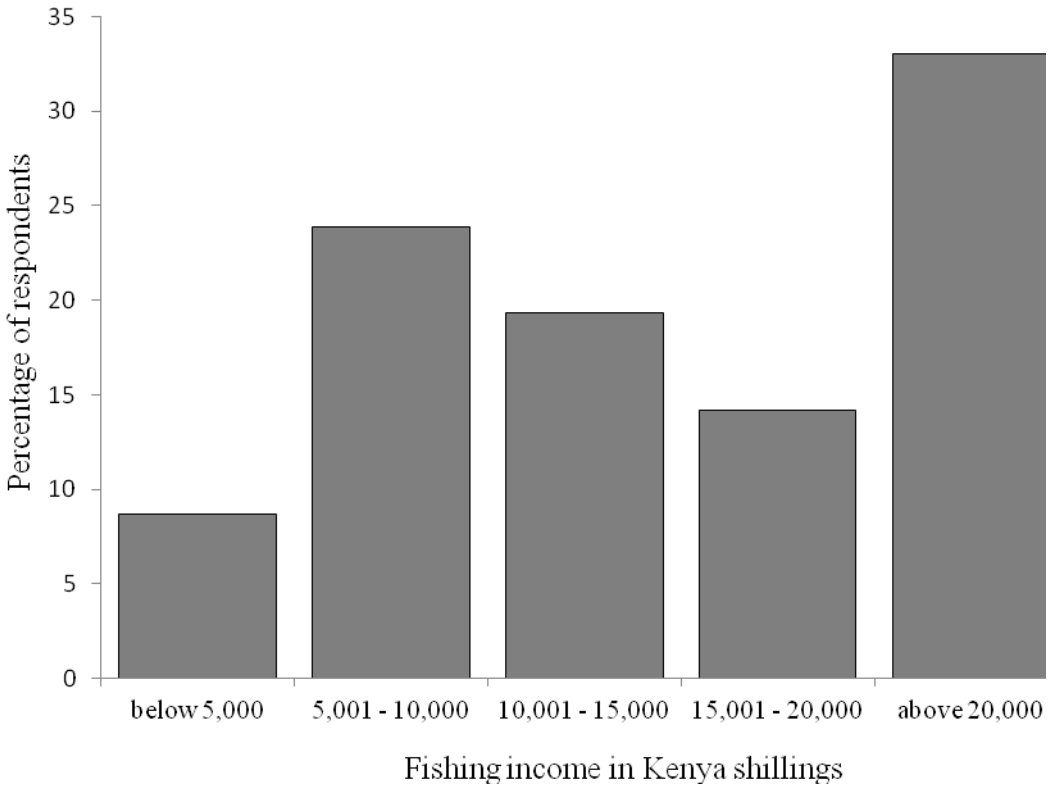

Figure 4.2: Monthly incomes of respondents from fishing activity in the study areas

4.1.7 Economic Activities Undertaken by Respondents

Results show that, whereas, 91.7% (n = 200) of the respondents considered fishing as their main source of income, 3.6% (n = 8) reported farming as their most important economic activity, while 2.7% (n = 5) indicated formal employment to be their most important source of income. A few (2%) of the respondents reported to be involved in other activities, e.g., small business (Figure 4.3). This assumes that households with higher dependence on fisheries for employment and sources of income are more likely to be affected by climate variability (Allison *et al.,* 2009). Whittingham *et al.* (2003) noted that fishing may be the only source of cash income, especially for poorer households.

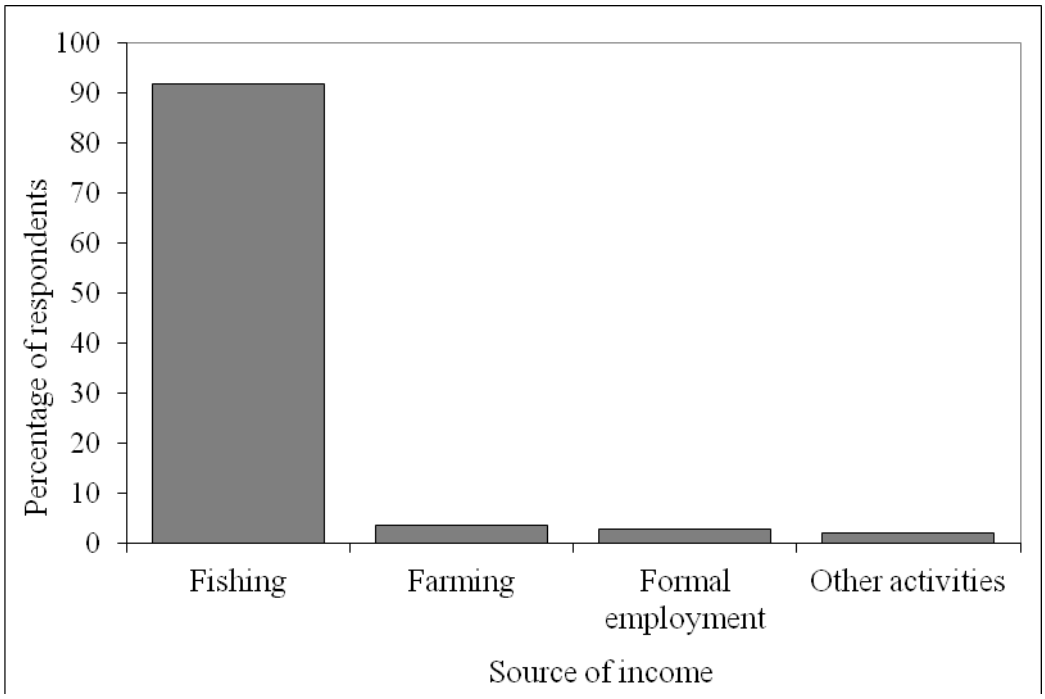

Figure 4.3: Economic activity undertaken by respondents

4.2 Fishing Activity

In order to understand the fishing activities of the respondents' information on the main fishing gear, vessels used, number of crew in the vessels, number of days dedicated to fishing, fishing distance and fishing grounds were determined.

4.2.1 Fishing Gear and Vessels

In this study a fishing gear refers to any device used to capture fish from the water. It may be a net, a hook, any type of trap, be it traditional or modern, plus all the accessories that go with it. Fishermen were categorized according to the main gear type they used. Table 4.6(a) shows that trammel and gill nets were the most important gears (23.4% and 18.8%), respectively. This was followed by hand lines (14.2%), beach seine (11.5%), cast nets (10.1%), hook and line (9.2%), traps or basket (5%), spear gun (3.7%), mosquito nets (1.8%), trawl nets (0.9%), scoop nets (0.5%), prawn seine (0.5%) and pointed sticks (0.5%). Results of an independent t-test indicate that there was a significant difference in the scores for type of fishing gear of respondents in Mombasa and Malindi (M=6.14, SD= 4.717, t=2.082, df 185.951, P=0.039) (Table 4.6 (b).

Table 4.6 (a): Fishing gear of respodents'

Fishing Gear Used by Respondents	Frequency	Percentage (%)
Gillnet	41	18.8
Hook and line	20	9.2
Hand line	31	14.2
Trammel nets	51	23.4
Trawl net	2	0.9
Traps/Basket	11	5.0
Scoop net	1	0.5
Pointed sticks	1	0.5
Prawn seine	1	0.5
Beach seine	25	11.5
Cast net	22	10.1
Spear gun	8	3.7
Mosquito net	4	1.8
Total	218	100

Table 4.6 (b): Comparison of fishing gear of respondents in Mombasa and Malindi

	District	No. of respondents	Mean	Std. Deviation	Std. Error Mean
Gear types	Mombasa	93	7.57	5.249	.544
	Malindi	125	6.14	4.717	.422

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Gear types	Equal variances assumed	6.615	.011	2.115	216	.036	1.434	.678	.098	2.770
	Equal variances not assumed			2.082	185.951	.039	1.434	.689	.075	2.792

4.2.2 Fishing Vessels

Fishing vessels used by small-scale fishers in the study areas are mainly paddled (63%). This was followed by foot fishers (20%), outboard engines (10%), sails (4%) and inboard engines (3%) (Figure 4.4). Previous studies (e.g. Ochiewo, 2004) have shown that the type of fishing vessel determines catch because it influences how fast one can reach the fishing ground and the amount of time available for actual fishing. Results in this study show that fishers who use motorized boats are very few. These findings imply that, in case of increased climate variability only few fishermen will go off shore and this may affect their livelihoods. Results of an independent t-test show that there was no significant difference in the scores for mode of propulsion in Mombasa and Malindi (M= 3.62, SD= 1.141, t= -0.002, df 216, P=0.998) (Table 4.7).

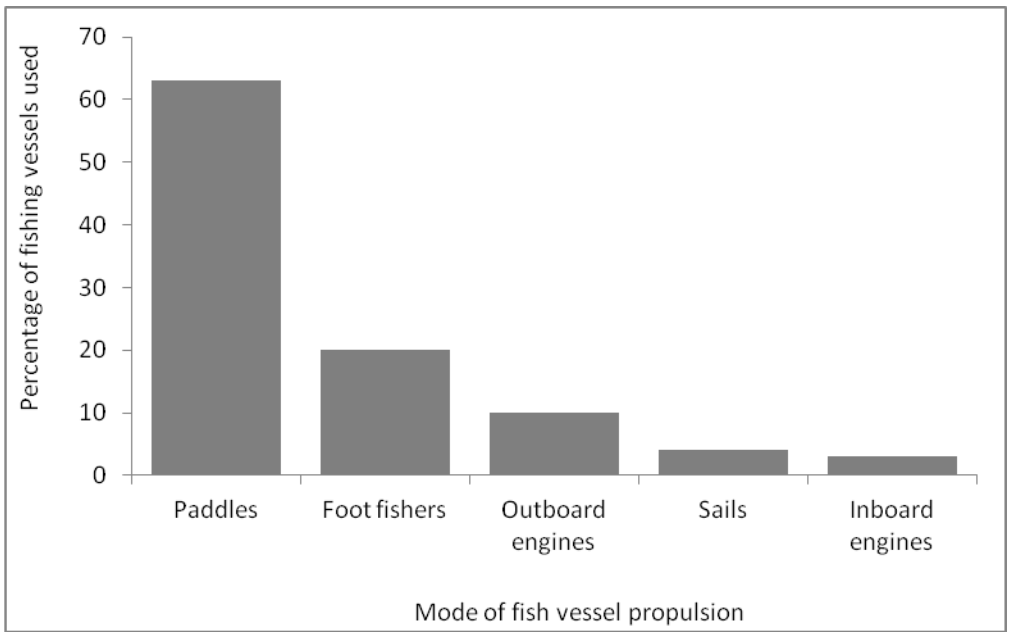

Figure 4.4: Mode of propulsion of respondents

Table 4.7: Comparison of mode of propulsion of respondents in Mombasa and Malindi

	District	No. of respondents	Mean	Std. Deviation	Std. Error Mean
Propulsion	Mombasa	93	3.62	1.141	.118
	Malindi	125	3.62	1.182	.106

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Propulsion	Equal variances assumed	.232	.631	-.002	216	.998	.000	.160	-.315	.314
	Equal variances not assumed			-.002	202.014	.998	.000	.159	-.313	.313

4.2.3 Number of Crew Members in Each Vessel

In this study, crew refers to the persons who actually go to the waters to fish. Figure 4.5 indicates that, majority (53%) of the vessels had 2 crew members. This was followed by vessels with 3 crew members (19%), 4 crew members (10%), 1 crew member (10%), 5 crew members (3%), 6 crew members (3%) and 7 crew members (2%).

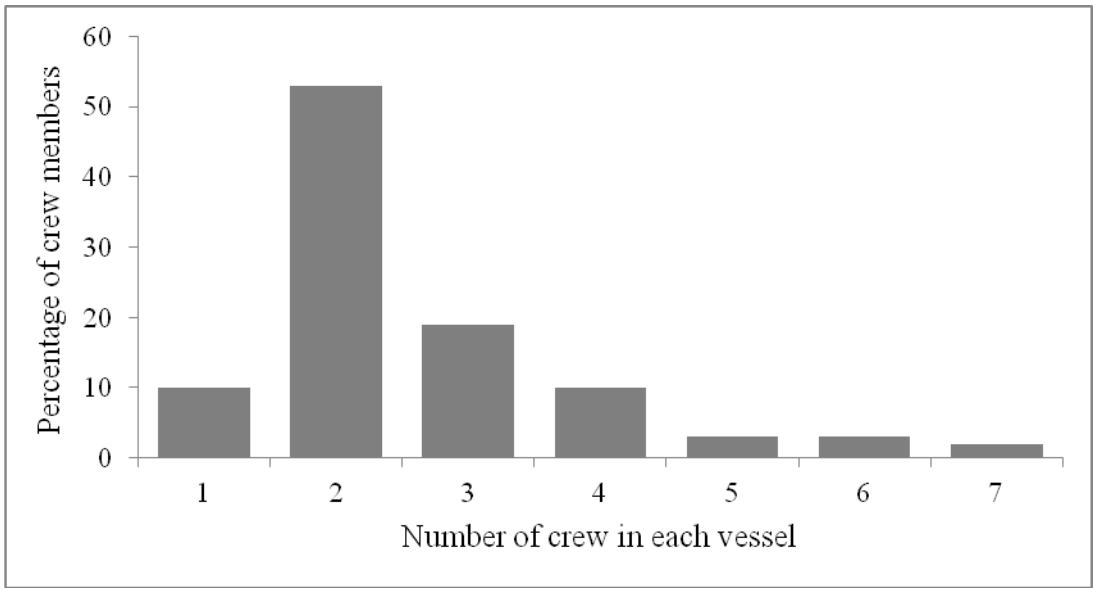

Figure 4.5: Number of crew in each vessel

4.2.4 Number of Days Dedicated to Fishing

Figure 4.6 and Figure 4.7 show the average number of days and hours respondents dedicated for fishing activities. Whereas 57.5% of the respondents dedicated an average of 3-5 days per week for fishing activities, 22.4% dedicated 2 days while 19.6% dedicated more than 5 days of the week to fishing activities. These study findings concur with results by Neiland *et al.* (2000) who indicated that in the north-eastern area of Nigeria most of the fishers are part timers and less than 5% of the families have fishing as the only source of income, fishing for less than six months a year. Fishing is usually a part-time activity in marine or freshwater small-scale fisheries (60%) and this is due to the seasonal variation of the fishing resources and fishing regulations (FAO, 2004).

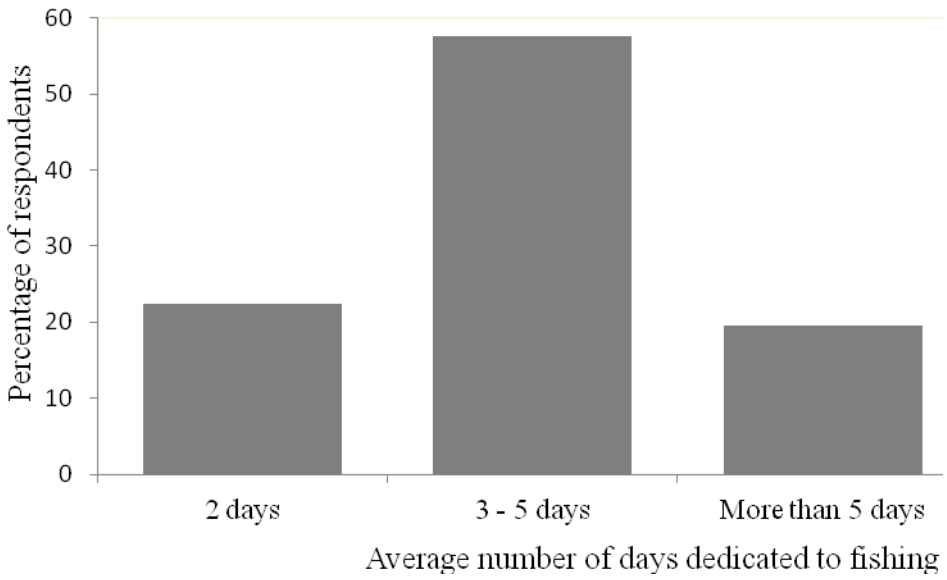

Figure 4.6: Average number of days dedicated to fishing

Figure 4.7 shows that most (68%) of the sampled fishermen spent less than 5 hours per day in fishing activities. Whereas 30% spent 5-10 hours, only 2% of the sampled fishermen were engaged in fishing activities more than 10 hours per day. The results are almost similar to findings in Cachoeira de Emas in Brazil where fishers usually work for about 6 hours (Carvalho, 2002).

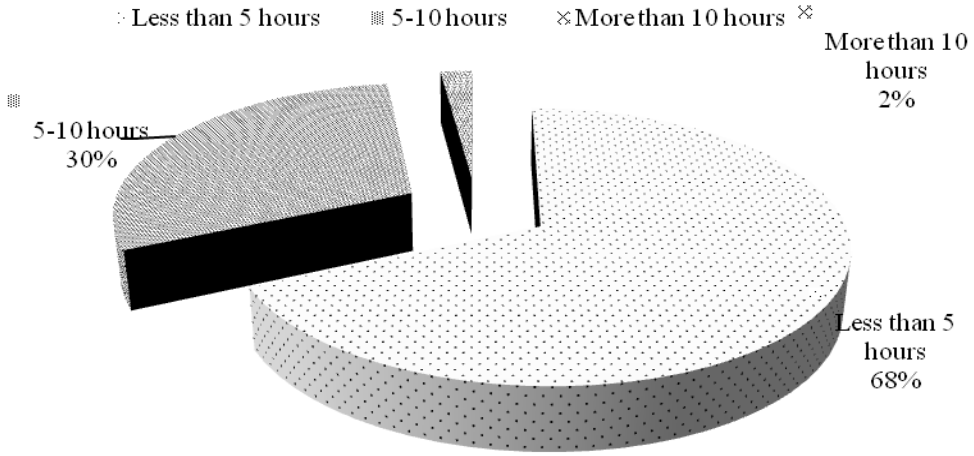

Figure 4.7: Number of hours spent fishing per day

Results of the study indicate that there is no significance association beween age, period in fishing, level of education, fishing gear and average number of days and

hours respondents dedicated to fishing (χ^2 =1.14, df 2, P>0.05; χ^2 =5.952, df 6, P>0.05; χ^2=2.157, df 6,P>0.05; χ^2=25.523, df 26, P>0.05) (Tables 4.8-4.11) respectively.

Table 4.8: Relationship between age of respondents and average number of days and hours dedicated to fishing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.140[a]	2	.565
Likelihood Ratio	1.100	2	.577
Linear-by-Linear Association	.805	1	.370
Number of Valid Cases	218		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.86.

Table 4.9: Relationship between level of education of respondents and average number of days and hours dedicated to fishing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.952[a]	6	.429
Likelihood Ratio	7.253	6	.298
Linear-by-Linear Association	1.171	1	.279
Number of Valid Cases	218		

a. 5 cells (41.7%) have expected count less than 5. The minimum expected count is .59.

Table 4.10: Relationship between Period Spent in Fishing by Respondents and Average Number of Days and Hours Dedicated to Fishing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.157[a]	6	.905
Likelihood Ratio	2.328	6	.887
Linear-by-Linear Association	.559	1	.455
Number of Valid Cases	218		

a. 3 cells (25.0%) have expected count less than 5. The minimum expected count is 3.94.

Table 4.11: Relationship between gear type of respondents and average number of days and hours dedicated to fishing

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	25.523[a]	26	.490
Likelihood Ratio	26.111	26	.457
Linear-by-Linear Association	.717	1	.397
Number of Valid Cases	218		

a. 28 cells (66.7%) have expected count less than 5. The minimum expected count is .20.

4.2.5 Fishing Distance

Results show that, about (40.3%) (n=87) of the respondents fished within a distance of 0-3 Km, followed by 24.5% (n=53) who operated within 4-6 Km, few 24.1% (n =52) operated more than 10 Km while very few 11.1% (n=24) operated within a distance of 7-10 Km. The results show that, majority of the fishers (64.8%) operated within 0-6 Km. This can be attributed to the type of vessels they used. This further confirms the vulnerability of fishers to increased climate variability (Figure 4.8). Results from an independent t-test show that there was a significant difference in the scores for distance of fishing in Mombasa to that of Malindi (M =2.00, SD =0.000, t=9.489, df=92, P=0.000) (Table 4.12).The study found out that during the South East monsoon when the sea is characterized by rough sea and long rains, activities are restricted to shallow inshore waters within the reef and mangrove areas. During the long rains the respondents reduced the number of fishing days and hours. During the North East monsoon the fishers travelled further into the sea because of the calm sea.

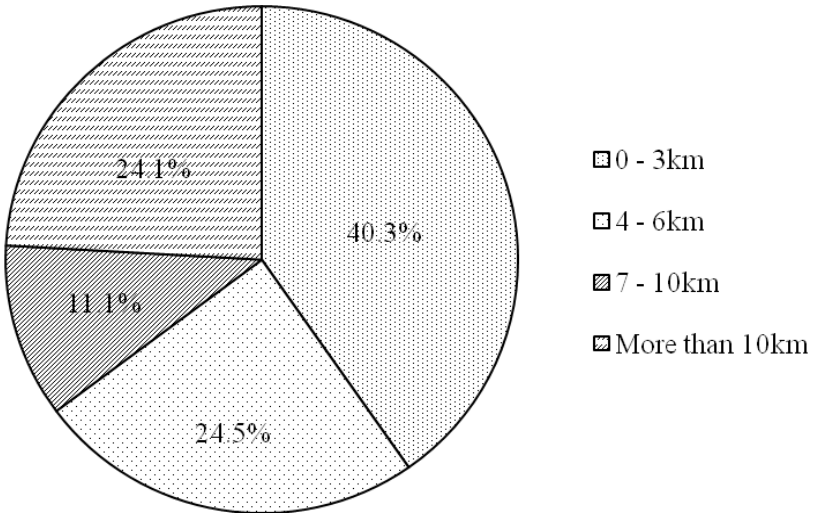

Figure 4.8: Potential radius of operation

Table 4.12: Comparison of fishing distance of respondents in Mombasa and Malindi

	District	N	Mean	Std. Deviation	Std. Error Mean
Potential radius of operation	Mombasa	47	2.00	.000	.000
	Malindi	93	1.51	.503	.052

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Potential radius of operation	Equal variances assumed	400649.486	.000	6.734	138	.000	.495	.073	.349	.640
	Equal variances not assumed			9.489	92.000	.000	.495	.052	.391	.598

4.3 Climate Variability and its Influence on Fish Catches and Livelihoods of Fishing Communities

Section 4.3 presents climatic data and trends of the study area from 1948 to 2012. It also reports on the nature of climate variability experienced in the study area as reported by the respondents. The five categories of capital assets that can be accessed by fishermen, described also as the "livelihood platform" (Bond *et al.*, 2007). Understanding fishermen livelihood platforms, will therefore, give a perspective of how fishermen livelihoods respond to climate variability.

i) Sea Surface Temperature Trends in Malindi for the Period 1948-2012

Figure 4.9 shows the annual and 5-year moving averages of SST off Malindi coast from the year 1948-2012. The Sea surface temperature observations show an increasing trend from 1948 to 2012. The highest (26.45ºC) SST was recorded in the year 2010 while the lowest (24.1ºC) was recorded in the year 1976. However, the graph showed a tendency towards stable or reduced SSTs during the period 1948 to 1976. The increasing SST trend is clearly evident from the year 1976 onwards.

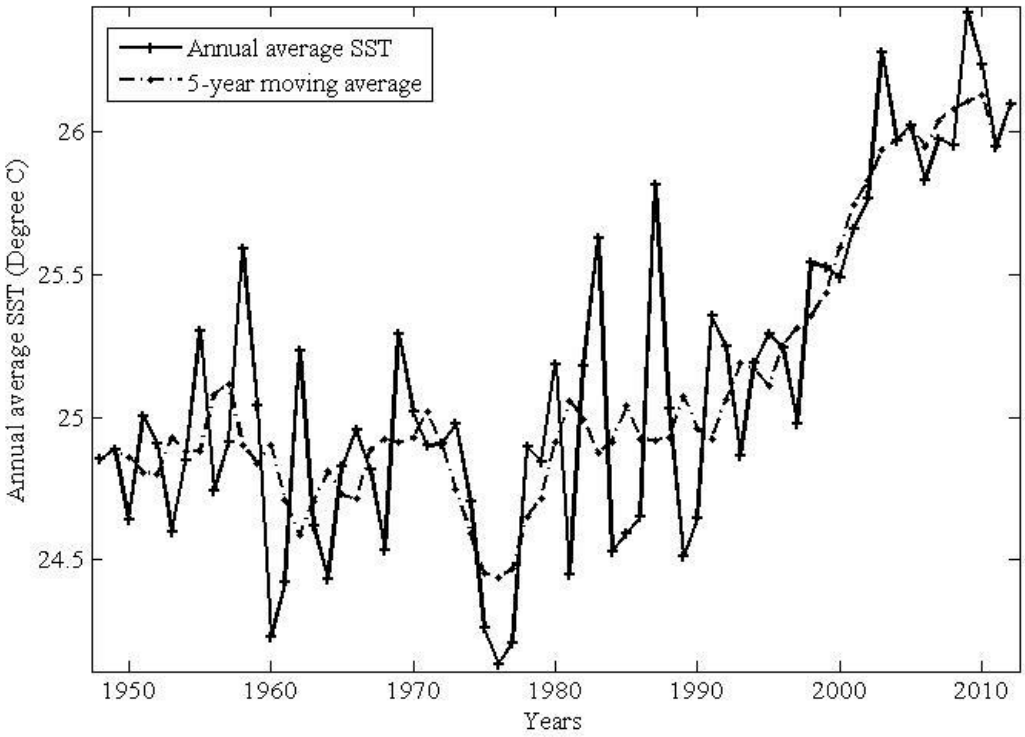

Figure 4.9: Annual and 5-year moving averages of mean SST off Malindi coast from the year 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America

ii) Annual Rainfall Trends in Malindi in the Period 1948-2012

Figure 4.10 shows the annual and 5-year moving average of total rainfall variations off Malindi coast during 1948-2012. The observations show both positive and negative fluctuations in the amount of rainfall during the period 1948 to 2012 with the overall trend showing a reducing trend. An increasing trend in the amount of rainfall is observed from 1948 to around 1980 with a reducing trend starting from the year 1980 onwards. The highest amount of rainfall was recorded in the year 1980 (1750 mm) while the lowest amount was recorded in the year 2012.

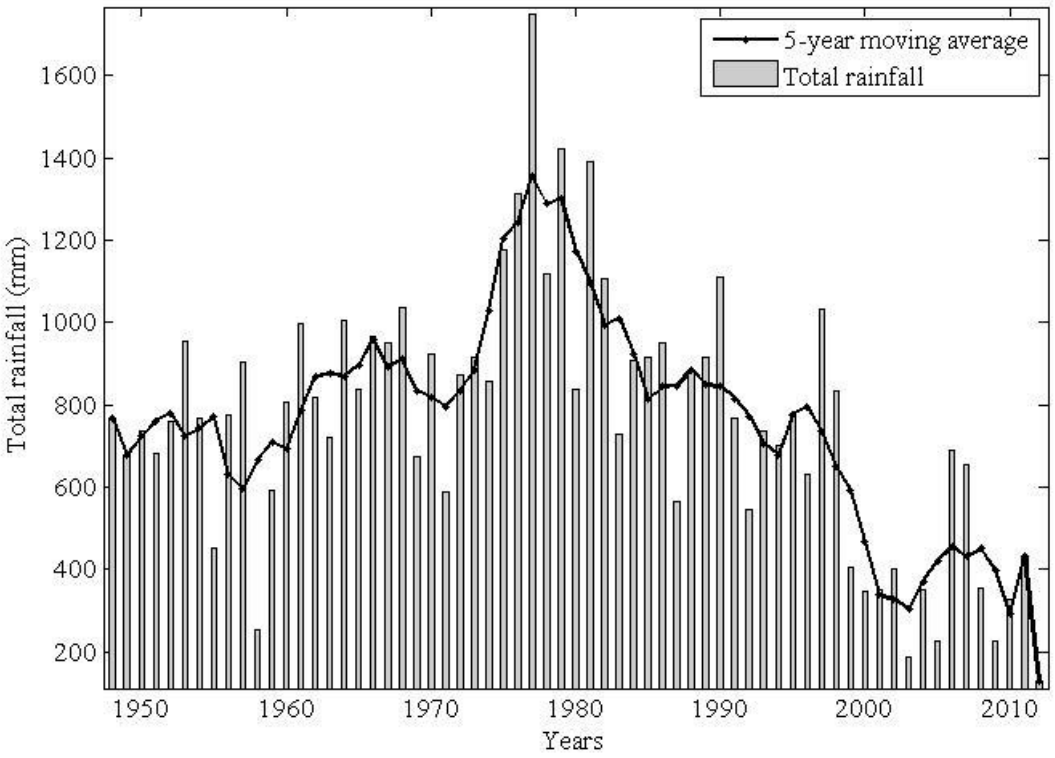

Figure 4.10: Annual and 5-year moving average of total rainfall variations off Malindi coast during 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America

i) Comparison between Annual and 5-year Moving Average Total Rainfall and Sea Surface Temperature of Malindi in the Period 1948-2012

Figure 4.11 shows the comparison between annual and 5-year moving average total rainfall and sea surface temperature variations of Malindi in the period 1948-2012. From the correlation between standardized values of temperature and rainfall, it is observed that there is a significant negative correlation between SST and rainfall in Malindi (-0.8). This means that as temperature increases rainfall decreases. The relationship between the two variables explains about 64% of the variation between rainfall and sea temperature at Malindi.

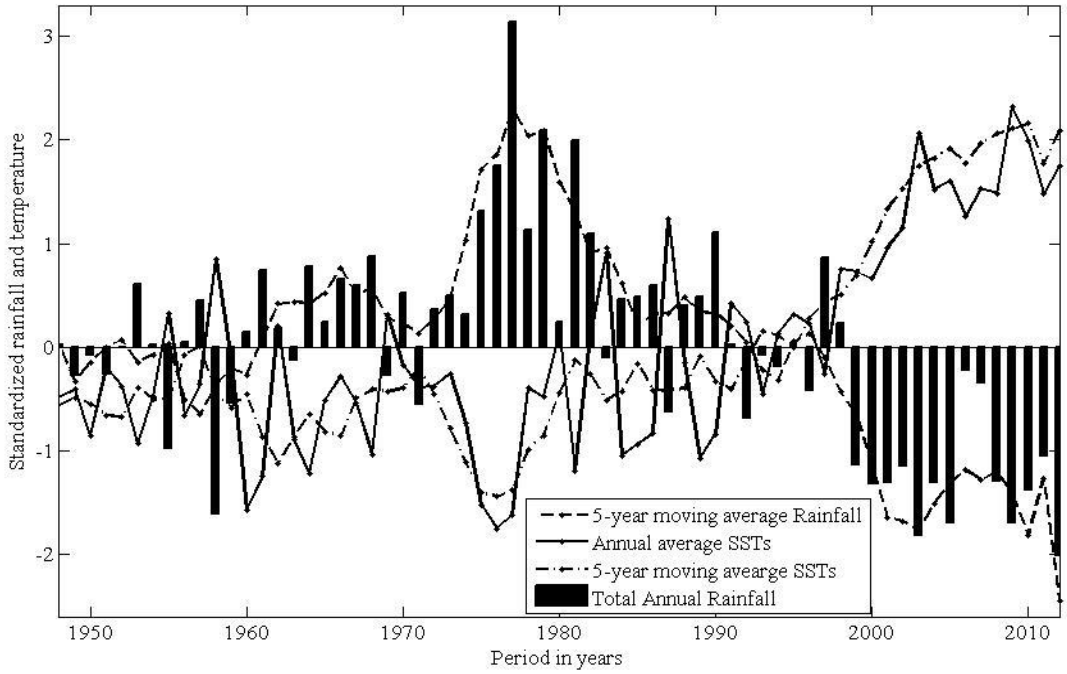

Figure 4.11: Comparison of annual and 5-year moving average total rainfall and sea surface temperature variations of Malindi in the period 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America

i) Rainfall Trends in Mombasa for the Period 1948-2012

Figure 4.12 shows the annual and 5-year moving average of total rainfall in Mombasa for the period 1948-2012. The results of annual and moving averages show a general downward trend in the amount of rainfall in Mombasa over the years. However, an increasing trend of rainfall is observed from 1948 to around 1980 with a reducing trend starting from the year 1980 onwards. The highest amount of rainfall was recorded in 1962 (approximately 1380 mm) and the lowest was in 2012 (200 mm).

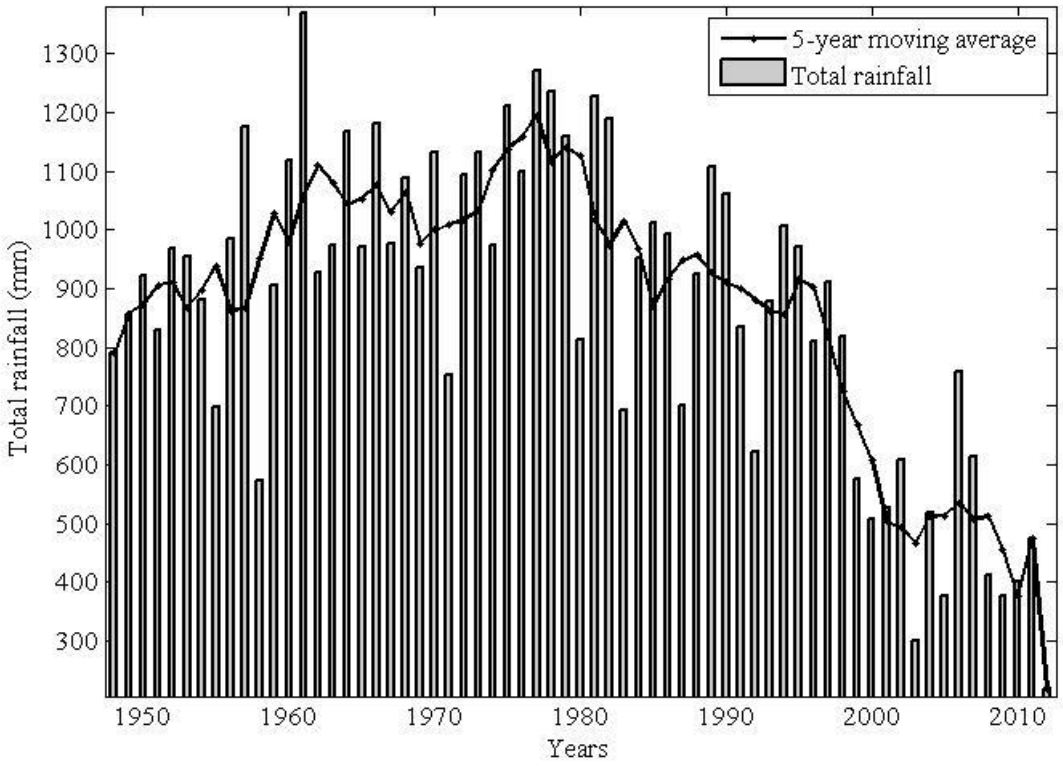

Figure 4.12: Annual and 5-year moving average of total rainfall in Mombasa for the years 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America

ii) Sea Surface Temperatures Trends in Mombasa for the Period 1948-2012

Figure 4.13 shows the annual and 5-year moving average of SST trends in Mombasa for the period between 1948-2012.. The SSTs show an increasing trend from 1948 to the recent years with the highest SST (27.1ºC) being recorded in the year 1998 and the lowest (25.41ºC) in 1954. An increasing SST trend is clearly evident from the year 1972 to 1996.

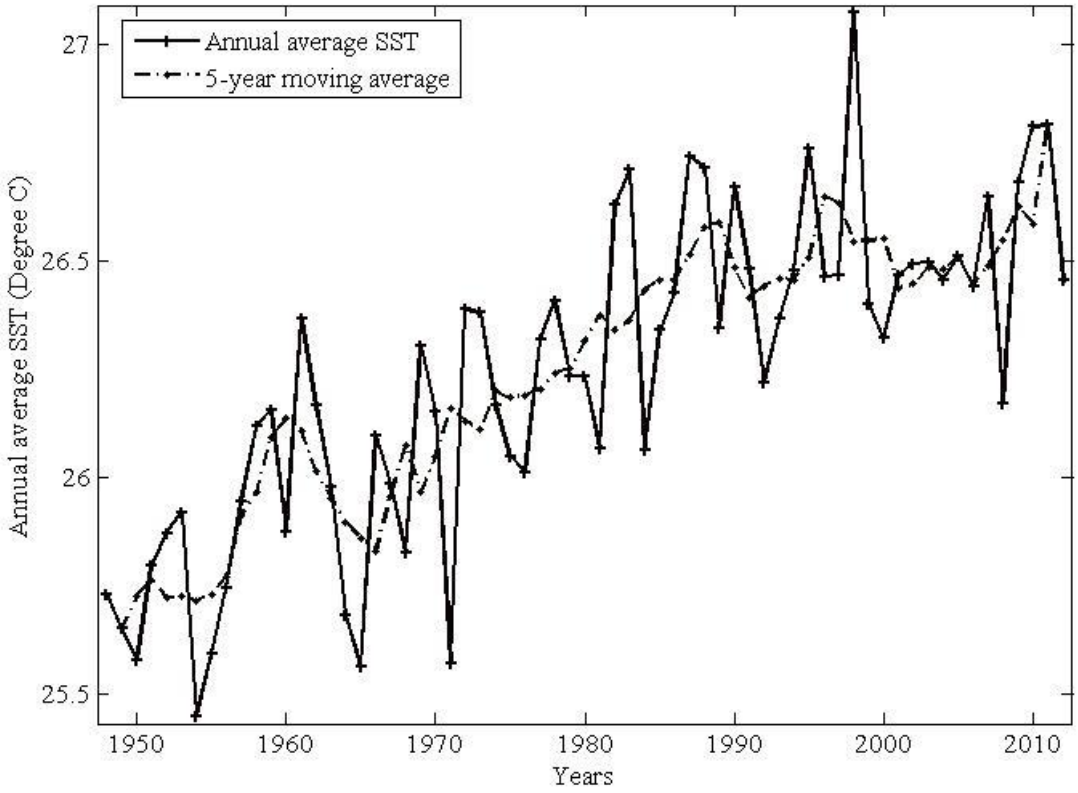

Figure 4.13: Annual and 5-year moving average of SST trends in Mombasa in the years 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America

i) Comparison of Rainfall and SST Trends for Mombasa for the Period 1948-2012

Figure 4.14 gives a comparison of total annual rainfall and 5 year moving average of total rainfall and SST trends for Mombasa for the period between 1948 and 2012. Observations show a decreasing rainfall trend and an increasing SST trend over the said period. From the correlation between standardized values of temperature and rainfall, it is observed that there is a negative correlation between temperature and rainfall (-0.294). This means that as temperature increases rainfall decreases. However, the correlation is not very significant as it explains only 8.6 % of the variation between rainfall and sea temperature. Therefore, there might be other factors other than sea temperature that affects rainfall.

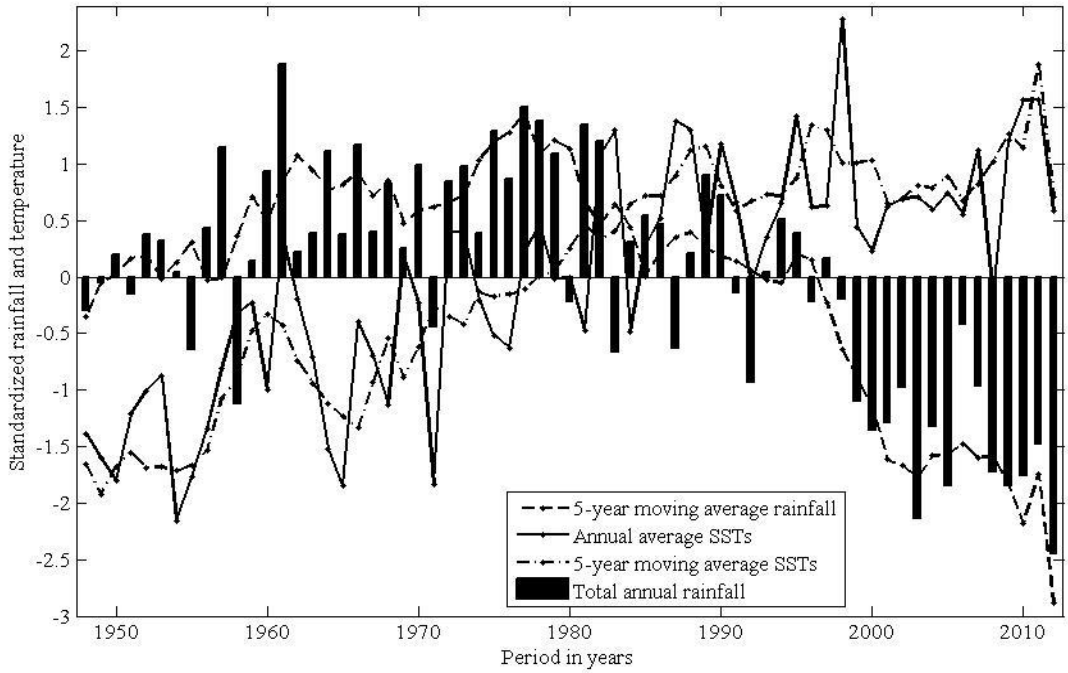

Figure 4.14: Comparison of Total Annual rainfall and 5-year moving averages of total rainfall and SST trends over Mombasa in the years 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America

4.3.1 Climate Risks and Vulnerabilities Affecting Fishing Communities in the Study Area

Fishermen's responses with regard to the general perception of climate variability experienced in the study areas and the effects associated with those variations on their livelihoods are discussed in this section. Figure 4.15 shows changes in the environment observed by respondents in the study sites over the last 20 or so years. About 77.6% of respondents reported to have experienced increased temperatures, 73.5% experienced delayed and reduced rainfall, 12.8% experienced decreased temperatures, 22.3% experienced increased sea level rise, 38.9% experienced violent rainfall, 42.9% experienced increased strength of winds, 31.1% experienced changed timings of winds and 7.8% experienced changed timings of rainfall. Secondary climatic data were analyzed from 1948-2012. It was expected that by analyzing this climatic data it would give historical data on the trends of temperatures, rainfall and wind over the years. Comparing secondary historical climatic data and primary data on perceptions of respondents on climate over the years gave information that confirmed the perceptions of respondents. However, the period of time 1948-2012

that was used may have had negative implications on the respondents because very few respondents were 60 years and above. In this study climatic data from the respondents were only analyzed for the last 20 years or so years. In addition, most (88.6%) of the respondents reported these climatic hazards to have had negative effects on their households. Most (61.7%) of the respondents indicated that extreme rainfall had negative effects on their households. They indicated the effects of these changes to include increased risks at sea, loss of fishing time, reduced efficiency, negative effects on their health, i.e., increased incidences of malaria cases and increased damage and disruption of their homes. According to Jallow *et al.,* (1999) storm and severe weather events can destroy productive assets and infrastructure such as landing sites, boats and gear, as well as impacting negatively on the health of the fisher folk. A study by Johnson (2012) observed that increased frequency and severity of storms or weather may be unsuitable for fishing. Song, Semazzi, Xie and Ogolla (2004) also observed that wind speed and intensity in Bukoba (Tanzania) influences the fish catch per vessel either positively or negatively. These findings are similar to the findings of this study.

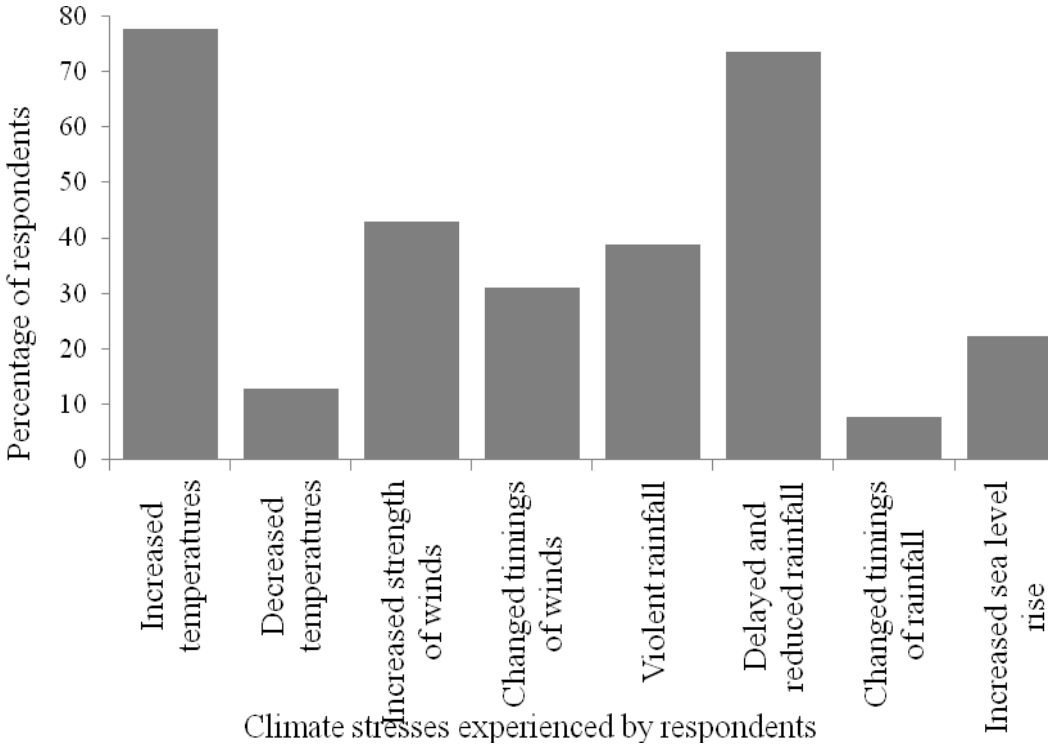

Figure 4.15: Climate stresses experienced by respondents over the years 20 or so years

Most of the respondents agreed that they have been affected by increased temperature and delayed and reduced rainfall events. Rainfall and temperature might have played the main role in the negative impacts, as witnessed by the various fisheries households. Climatic data of annual and 5-year moving averages of SST and total rainfall in both Malindi and Mombasa for the period 1948 to 2012 overly, show an increasing and reducing trend respectively. An analysis of the rainfall data in Mombasa and Malindi revealed that in the past 60 years, except in the year 1958, some of the lowest rainfall totals were recorded in the last thirteen years from 1999. The lowest annual rainfall totals were recorded in Mombasa and Malindi in the year 2012 with the totals of 217.0 and 127.3mm.

A further analysis of the temperature data in Mombasa and Malindi revealed that since 1978, eleven of the warmest mean average sea surface temperatures have been experienced during the period 1948 – 2012. The year 1998 was the warmest year on record at Mombasa with an average mean SST of 27.1° C. The temperatures started to increase from November 1997 during the El Niño, peaking in April 1998 at 29.7° C, and reduced thereafter.

The climatic data analysed in the study areas agrees with the respondents' perception of increasing temperatures and decreasing rainfall in the study area over the years. The results are similar with reports from IPCC which indicate that the global average temperature has increased since 1861. Over the 20th century the increase has been 0.6°C. (TAR; IPCC, 2001). IPCC further reports that eleven of the last 12 years (1995-2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1860) (AR4; IPCC, 2007). The findings are also is in line with that of George (2010) that farmers perceived climate change effects from sustained changes over time in environmental temperatures, rainfall intensity and pattern and also wind variability. Zoellick (2009) stated that, as the planet warms, rain fall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent. This results in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa (UNFCCC, 2007). Tologbonse *et al.*, *(*2010).further said that the risk from climate in Africa, and the rest of the world, includes, rising temperatures and heat waves, shortfalls in water supply/increasing floods arising from shortage/excessive rainfalls, sea level rise, increasing likelihood of

conflict and induced environmental and vector borne diseases. These conditions emanating from climate change are bound to compromise agricultural productions (crop, livestock, forest and fishery resources) among others.

4.3.2 Perception Determinants

i) Modelling of Increased Temperature Determinants using Binary logistic Model

In this logistic regression model of selected variables, level of education, age, vessel ownership and fishing distance were found not to be significant (P>0.05) determinants influencing the perception small-scale fishers have on temperatures having increased over the years. However, the logistic regression model shows that, period in fishing and monthly incomes are significant (P<0.05) determinants that influence the perception fishers have on temperatures having increased over the years (Table 4.13). Results indicate that, respondents who earned incomes of less than Ksh 10,000 were 1.51 times more likely to perceive temperatures to have increased over the years compared to those who had earned over Ksh 10,000. Similarly, respondents who had more than 20 years fishing experience were 0.483 times more likely to perceive temperatures to have increased over the years compared to those who had less than 20 years fishing experience.

Table 4.13: Determinants influencing fisher perception on increase in temperature over the years

Explanatory variables	B	S.E.	Wald	df	p-value	Odds ratio
a) Education	0.039	0.197	0.039	1	0.843	1.04
b) Age	-0.224	0.596	0.141	1	0.707	0.799
c) Period in fishing	-0.728	0.363	4.028	1	0.045*	0.483
d) Owner of vessel	0.677	0.513	1.746	1	0.186	1.969
e) Fishing distance	0.781	0.508	2.362	1	0.124	2.184
f) Monthly income	0.437	0.223	3.857	1	0.05*	1.549
Constant	0.931	2.295	0.165	1	0.685	2.537

*Significantly different (P<0.05)

Similarly, binary logistic regression model shows that, level of education, age of respondents, vessel ownership, period in fishing and fishing distance were found not

to be significant (P>0.05) factors influencing fishers' perceptions on delayed and reduced rainfall over the years. However, monthly income was found to be a significant (P<0.05) factor that influenced the perception fishers have on reduced and delayed rainfall over the years (Table 4.14). Respondents who earned monthly incomes of less than Ksh 10,000 were 1.7 times more likely to perceive delayed rainfall over the years compared to those who had earned more than Ksh 10,000 per month.

Table 4.14: Fishers' perception determinants on delayed and reduced rainfall over the years

Explanatory variables	B	S.E.	Wald	df	p-value	Odds ratio
a) Education	0.078	0.232	0.114	1	0.736	1.082
b) Age of respondents	0.486	0.624	0.606	1	0.436	1.625
c) Period in fishing	-0.688	0.405	2.888	1	0.089	0.502
d) Vessel owner	1.072	0.577	3.448	1	0.063	2.922
e) Fishing distance	0.502	0.583	0.743	1	0.389	1.652
f) Monthly income	0.528	0.262	4.065	1	0.044*	1.695
Constant	-0.127	2.406	0.003	1	0.958	0.881

On the other hand, education, age, period in fishing, vessel ownership and monthly income determinants were found not to significantly (P>0.05) influence fishers' perception on violent rains over the years (Table 4.15).

Table 4.15: Fishers' perceptions determinants on violent rain over the years

Explanatory variables	B	S.E.	Wald	df	p-value	Odds ratio
a) Education	-0.049	0.115	0.178	1	0.673	0.953
b) Age of respondents	-0.242	0.349	0.482	1	0.488	0.785
c) Period in fishing	-0.287	0.188	2.329	1	0.127	0.75
d) Vessel owner)	0.236	0.32	0.542	1	0.462	1.266
e) Monthly income	0.235	0.129	3.291	1	0.07	1.265
Constant	-0.058	1.235	0.002	1	0.963	0.944

Tables 4.16 and 4.17 show that, education, age, period in fishing, vessel ownership and monthly income are not significant (P>0.05) determinants that influence fishers perception on increased strength of winds and sea level rise over the years.

Table 4.16: Fishers' perceptions determinants on increased strength of winds over the years

Explanatory variables	B	S.E.	Wald	df	Sig.	Exp(B)
a) Education	-0.068	0.114	0.363	1	0.547	0.934
b) Age of respondents	0.045	0.348	0.017	1	0.897	1.046
c) Period in fishing	-0.122	0.185	0.433	1	0.511	0.885
d) Vessel owner	0.496	0.316	2.47	1	0.116	1.642
e) Monthly income	0.238	0.127	3.512	1	0.061	1.269
Constant	-1.333	1.232	1.17	1	0.279	0.264

Table 4.17: Fishers' perceptions determinants on increased sea level rise over the years

Explanatory variables	B	S.E.	Wald	df	Sig.	Exp(B)
a) Education	0.014	0.134	0.011	1	0.917	1.014
b) Age of respondents	0.199	0.425	0.219	1	0.64	1.22
c) Period in fishing	-0.174	0.218	0.636	1	0.425	0.84
d) Vessel owner	0.361	0.384	0.881	1	0.348	1.434
e) Monthly income	0.067	0.149	0.202	1	0.653	1.069
Constant	-2.512	1.485	2.862	1	0.091	0.081

However, Table 4.18 shows that, whereas, education, age and vessel ownership are not significant (P>0.05) factors that influence perception of fishers on changed timings of winds over the years, period in fishing and monthly incomes significantly (P< 0.05) influence respondents perception on changed timings of winds over the years. The results indicated that, respondents who earned monthly incomes of less than Ksh 10,000 were 1.37 times more likely to perceive changed timings of winds over the years compared to those who had earned more than Ksh 10,000 per month. Additionally, respondents who had more than 20 years' experience in fishing were 0.61 times more likely to perceive changed timings of winds over the years compared to those who had less than 20 years' experience in fishing. The above results imply that incomes and period in fishing were significant factors influencing the perception of fishers' on the climate variability over the years in the study areas.

Table 4.18: Fishers' perceptions determinants on changed timings of winds over the years

Explanatory variables	B	S.E.	Wald	df	p-value	Odds ratio
a) Education	0.06	0.119	0.257	1	0.612	1.062
b) Age of respondents	-0.131	0.368	0.128	1	0.721	0.877
c) Period in fishing	-0.49	0.198	6.085	1	0.014*	0.613
d) Vessel ownership)	0.066	0.337	0.039	1	0.844	1.068
e) Monthly income	0.315	0.138	5.216	1	0.022*	1.37
Constant	-0.273	1.288	0.045	1	0.832	0.761

*Significantly different (P<0.05)

The above results imply that incomes and period in fishing were significant factors influencing the perception of fishers' on climate variability (increased temperatures, delayed rainfall and changed timings of wind) over the years On the basis of the study findings we posit that the perceptions of respondents' may have been greatly influenced by reduced incomes. Most respondents indicated climate variability as having contributed to their reduced incomes. Salas *et al.* (2011) points out sea fishing to have shown substantial variability in catch and consequent uncertainty in financial return. Adeoti *et al.,* (2010) found similar results which posited that majority of fishers reported loss of income from fishing during times of flooding.

Period in fishing was also a significant factor influencing the respondents' perception on climate variability over the years. This results could perhaps, be explained by the fact that most (89.1%) respondents had been involved in fishing activities for more than 10 years and were therefore very useful in expressing their views of the climatic changes happening since they had more experience. Experience in fishing was useful in determining their opinions.

The other independent variables (education, age, vessel ownership and fishing distance) were not significantly in influencing their perception. Previous studies have shown education to be significant in farmers' observation of changes in climate parameters such as temperature, rainfall and wind variability (Adebayo *et al.*, 2011). In this study those with higher educational level had better knowledge and understanding of the concept. The results in the study are contrary to other similar studies. This may perhaps be explained by the fact most fishers' who had secondary and tertiary education were very few and hence their views were not significant. On

the other hand age was not significant in influencing their perception. Previous studies by Adebayo *et al.*, (2011) showed that older farmers have observed lower volumes of rainfall which is supported by several literature findings but the younger ones observed an increase in rainfall. Enete *et al.,* (2011) argued that it is likely that age may endow the farmers with requisite experience that empower them to make better assessments of the prevailing risks.

4.3.3 Seasonality and Seasonal Patterns

Fishers are dependent on monsoon winds for their fishing activities. The North East Monsoon (NEM) occurs between December and March of every year. During NEM the sea is calm and the water is clear thus it is easy to carry out fishing activities. The South East Monsoon (SEM) occurs between May and August. During this period the sea is very rough and the water gets turbid limiting fishers' ability to carry out normal activities. Majority (90.6%) of the respondents indicated that seasonal wind patterns have changed over the years; they indicated that winds that should arrive at particular periods of the year do not appear on time, which leads to an overall disturbance in fishing conditions. Table 4.19 shows respondents opinion on the shifts of monsoon winds over the years. Out of the respondents who had indicated that they had observed changes in the monsoon seasons 73.2% indicated that SEM seasons had changed to be longer over the years, 10.6% indicated that the SEM seasons had not changed while 16.2% indicated the seasons to be shorter. Majority, (67.6%) of the respondents said that the NEM seasons had become shorter over the years, 20.2% indicated the seasons to have been longer while few, (12.2%) said that indicated to have been no change in the seasons.

Table 4.19: Respondents' Opinions on the SEM and NEM winds over the years

	SEM	**NEM**
Observed Changes	**Percentage of Respondents**	**Percentage of Respondents**
Seasons are longer	73.2%	20.2%
Seasons are the same	10.6%	12.2%
Seasons are shorter	16.2%	67.6%

The analysis of Mombasa and Malindi zonal and meridional wind speeds data

revealed some of the perceptions as indicated by the respondents. The meridional winds (south to north flows) are stronger and dominate the wind flows at the locations in comparison to the weaker zonal winds (west to east flows). Figure 4.16 shows the annual average march of the zonal winds at the two locations for the period 1948-2012. Negative values in the graph indicate easterlies, while positive values indicate westerlies. The zonal winds are dominated by the easterly flow (west to east flows) at the two locations for most of the year round, except during April to June in Malindi, where the flow changes direction to weak westerly flow. This in essence, indicates a convergence zone, because the winds are shifting from easterly flow to westerly flow, at Mombasa and Malindi, respectively. The April to June period is also a transition period from NEM to SEM.

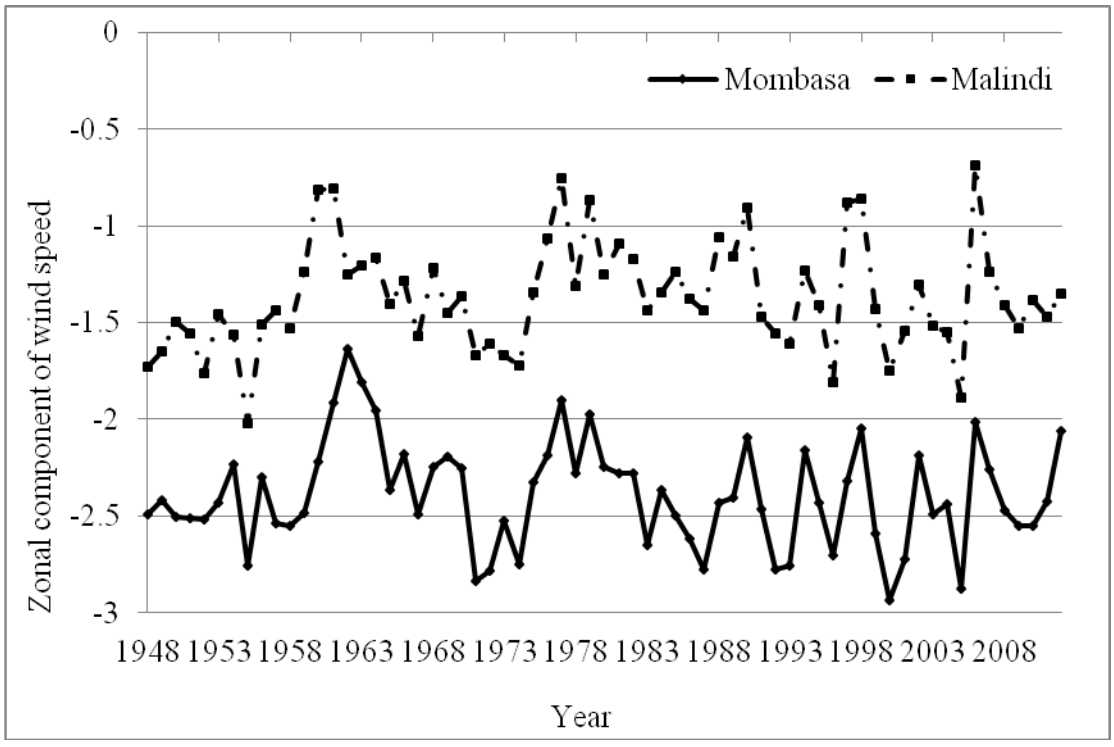

Figure 4.16: Annual average zonal wind speeds for the period 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America

Figure 4.17 shows the annual average march of the meridional winds at the two locations for the period 1948-2012. Negative values in the graph indicate southerlies, while positive values indicate northerlies. The mean monthly march of the meridional winds shows that the southerly flow dominates for longer period of the year in

comparison to the northerly flow. The southerlies are observed for eight months, starting to appear in the month of March, peaks during the months of June and July and persists up to the end of the month of October. The northerlies are observed for four months, starting to appear in the month of November, peaks in the month of January and persists up to the end of the month of February.

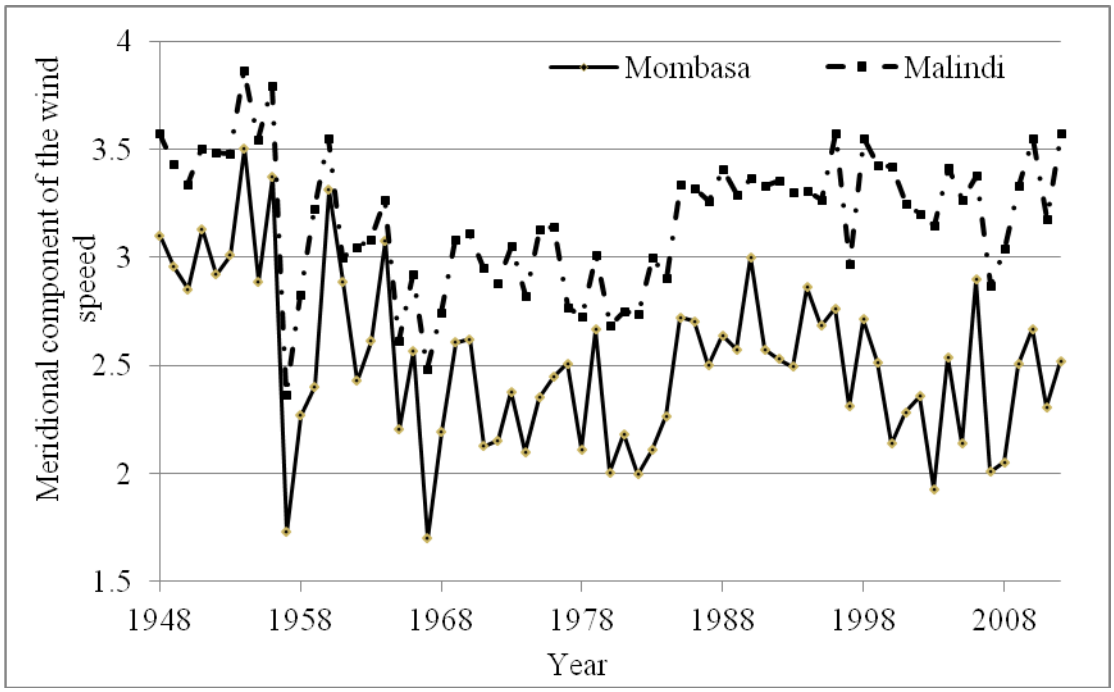

Figure 4.17: Annual average meridional wind speeds for the period 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America

Figure 4.18 shows the annual average wind speed at the two locations for the period 1948-2012. From the graph, it could be observed that the transition period from one wind regime to another occurs during the months of March and November. During March, we have the transition from NEM to SEM, while in November, the transition from SEM to NEM. It could also be observed that the SEM strength varies from 2.5 to 6.5 m/sec while the NEM strength varies from 2.5 to 5 m/sec, therefore, SEM are stronger and persists for a longer duration in comparison to the weaker NEM.

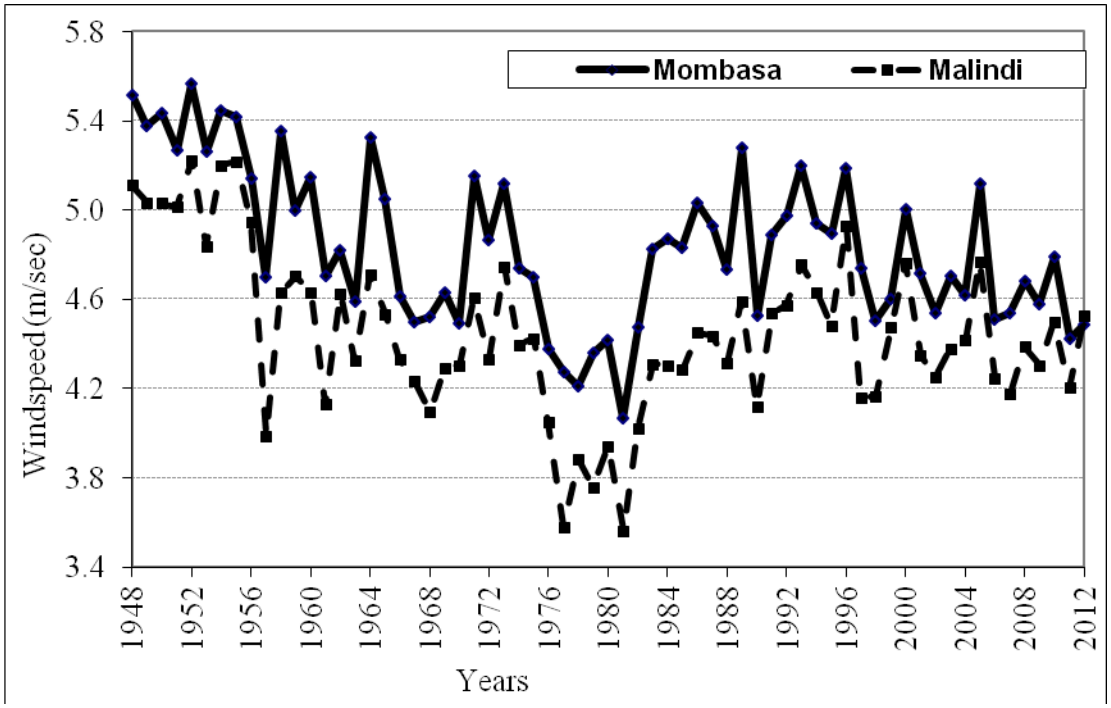

Figure 4.18: Annual average wind speeds for the period 1948-2012 (Data source: National Centre for Environmental Prediction (NCEP), United States of America)

While majority (90%) of the respondents indicated their incomes to have been decreasing over the years during the SEM season, few (18%) indicated their incomes to have been decreasing during the NEM season. They indicated this to be as a result of strong winds during this period which prevented them from going to sea hence contributing to reduced catch and subsequent reduced incomes. Respondents indicated that they lost fishing time and efficiency in their fishing activities during the SEM period. These findings concur with the observation of Crandall (2009), who noted that changes in wind patterns and occurrence of severe storms as a result of climate variability are likely to impact on fish production, species composition, distribution, safety and efficiency of fishing. Previous studies have also shown that the level of production from artisanal marine fishery is dictated by weather the rough sea makes it risky to fish using small crafts (Ikiara, 1999). Morgans (1962) reported decreased density and activity due to a deeper thermocline and cooler waters during this period.

4.3.4 Summary of the Reports of the Focus Group Discussions

The study sought additional information from Focus Group Discussions (FGDs), concerning the climatic stresses that fishers have had to face over the years and how they affected their livelihoods. Participants had perceptions that the current climate in the region is behaving differently than in the past. Some of the reported changes include: i) increased temperatures over the years; ii) changes in seasonal rainfall patterns (with sometimes very heavy rainfall or storms being experienced and sometimes delayed and little rainfall); iii) strong winds and waves. Participants in the FGDs reported to also have experienced extreme events like the 1997/8El Niño. This was stated in all the six sites where FGDs were held.

According to the participants in the FGDs, increased temperatures cause a decline in fish catches, probably a consequence of migration of fish to the deep water columns. Participants in the FGDs reported that heavy rainfall, storms or extreme events (El Niño 1997/8) made the ocean inhospitable for fishing activities. There were increased risks at sea, loss of fishing time and efficiency of fishing, damage to their homes, fishing equipment (boats and gear) and landing sites, increased pollution, hence incidences of diseases like malaria. The FGDs, however, reported that low rainfall had negative effects on fish catches and strong winds make the ocean hostile/ turbulent thus reducing fishing activities. The FGDs stated that the practice of fishing for livelihoods has been reduced because of the changing climate variability.

4.4 Influence of Climate Variability on Household Asset Base

4.4.1 Asset Base

Vulnerable people combine an array of livelihood capital- financial, physical, natural, social and human, to develop livelihood strategies to cope and recover from climatic stresses. A detailed description of these assets is provided below.

4.4.2 Human Capital

Human capital comprises of peoples' capabilities' in terms of their health, education, knowledge and skills. Education opens up new horizons and provides better job opportunities so that people no longer have to depend on natural resources for their livelihoods. In this study, both formal and informal knowledge were assessed. Respondents were asked to state the level of education they had attained and whether they had received any capacity building courses in the last 5 years. These were used as indicators to assess formal education. Education categories were grouped into four: primary, secondary, tertiary and no formal education. As indicated earlier, most of the respondents in both Mombasa and Malindi had attained formal education with majority (61.5%) (n=134) having attained primary school education, 9.6% (n = 21) had secondary school education, a few (1.8%) (n = 4) had tertiary education while 27.1 % (n = 59) had no formal education.

In a changing climate new knowledge is important in coping with new situations and also to use resources efficiently. About 27.5% of the respondents in the study areas had received capacity building courses in the last 5 years. Some of the capacity building courses they had received included environmental awareness courses (53.7%), safety at sea (16.7%), aquaculture (20.4%), business management (5.6%), leadership courses (1.6%) and others (2%) (Figure 4.19).

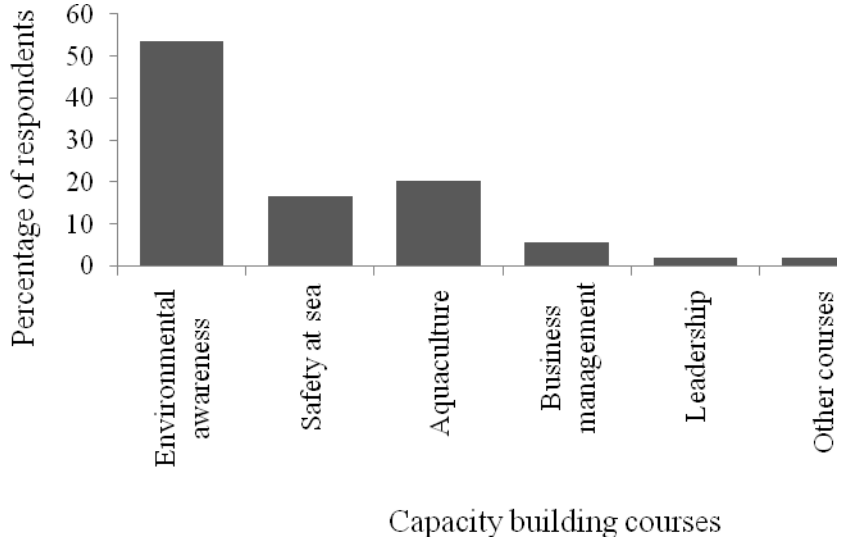

Figure 4.19: Types of capacity building courses received

A chi-square test was done to determine whether a significant association existed

between gear type and education level, and gear type and capacity building courses attended. Results indicate that, there was no significant association between gear type and education level, and gear type and number of courses attended (χ^2=36.27, df = 36, P>0.05 and χ^2=11.83, df = 13, P>0.05) respectively (Tables 4.20 and 4.21). The lack of association may be attributed to the few numbers of respondents who had attained secondary and tertiary education. This is also a skill that is passed from generation to generation and also fishers' learn from each other.

Table 4.20: Relationship between fisher education level and gear type

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	36.273	36	0.456
Likelihood Ratio	30.423	36	0.731
Number of Valid Cases	213		

(a 39 cells (75.0%) have expected count less than 5. The minimum expected count is 0.02)

Table 4.21: Relationship between fisher capacity building courses and gear type

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	11.825	13	0.542
Likelihood Ratio	12.551	13	0.483
Number of Valid Cases	189		

(a 17cells (60.7%) have expected count less than 5. The minimum expected count is 0.28)

Previous studies (Shemdoe, 2011; Shemdoe *et al.,* 2009; Ngware *et al.*, 2008; Jörgensen, 2002) report that, in other natural resources use in Tanzania, majority of farming communities, for example, had attained low levels of education, which hindered them from using state of the art technology in their farming and fishing. Barrett *et al.* (2001) and Dercon (1998) also report that inadequate knowledge and skills obstruct access to alternative employment niches, especially in the non-farm sector.

4.4.2.1 Health

Health status of individuals in a society is an important aspect of human capital. The health status of individuals has repercussions on their potential productivity. In order to assess the health dimension of the fishermen, the propensity to incur injuries is used as an indicator of occupational risk. Fishermen were asked whether they had suffered any injury during their fishing trips and whether it was weather related. The results show that, majority (65%) of the respondents indicated to have suffered injuries that were weather related (Figure 4.20).

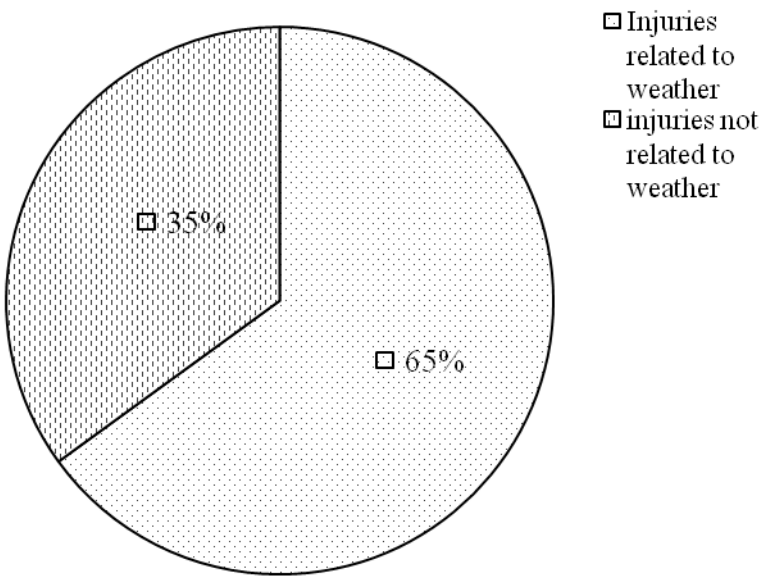

Figure 4.20: Respondents who had suffered injuries that were weather related

Some respondents indicated vulnerabilities of their boats to strong winds as a major cause of the injuries they suffered. They noted that men were most vulnerable because they went fishing everyday even in adverse weather conditions (Figure 4.21). Climate will affect the distribution of climate sensitive diseases. Respondents cited children to be vulnerable to diseases like malaria, pneumonia, and diarrhoea during increased floods. Malaria is a frequently cited example, because its prevalence increases in line with the warmer, wetter climates that are anticipated with climate variability. The results were similar to findings by Kovats *et al.* (2003) who reported increased risk of epidemic malaria, being experienced after the onset of an El Niño event. Other studies have found heavy precipitation to be associated with outbreaks of water-borne diseases (Curriero *et al.*, 2001). Guernier *et al.* (2004), report Africa to be vulnerable

to a number of climate sensitive diseases including malaria, tuberculosis and diarrhoea.

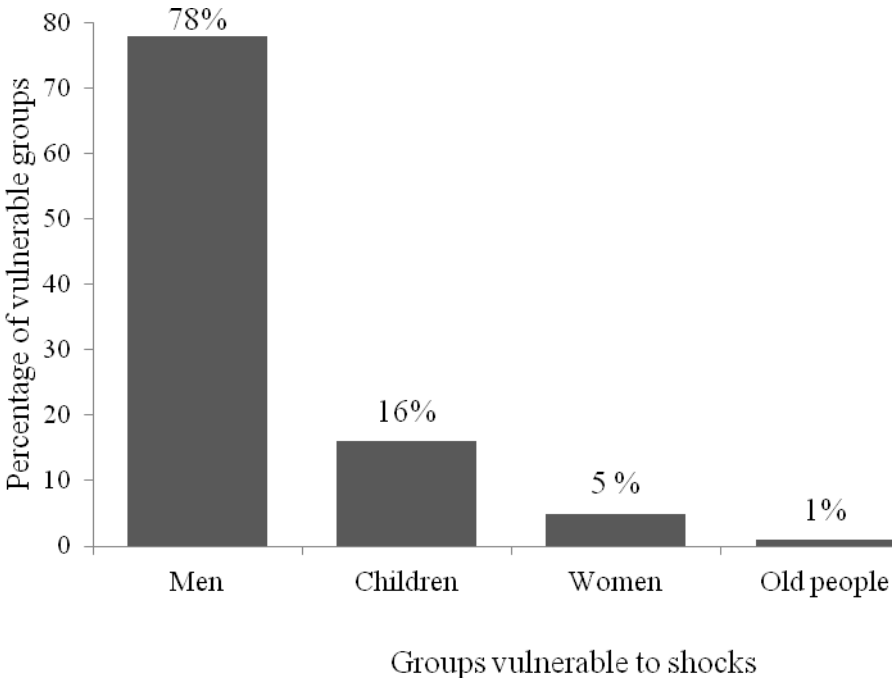

Figure 4.21: Vulnerable people during climatic stresses

4.4.3 Economic or Financial Capital

The most commonly reported obstacle to investment and entrepreneurship is inadequate access to capital (Davies, 2003). Fishermen in the study area were asked whether they had life insurance, pension or had access to loan facilities. These were used as indicators of financial capital. Credit is an important source of future income and individuals with credit facilities are more likely to invest in fishing activities for improved incomes. Figure 4.22 shows that, majority of the respondents in the study areas had neither life insurance (95.3%) nor pension (96%). Only, 3.2 % of the respondents had access to loans.

The number of respondents who did not use credit attributed it to lack of information about credit (41.9%) and lack of security (58.9%) for the loans. Those who had asked for loans were asked to indicate the institutions that gave them assistance. The largest (75%) proportion of assistance was from informal institutions. These results are similar to findings in Vietnam where Vietnamese fishing households for example, who lack collateral in the form of land, are perceived by banks as high risk to lend for

fishing gear upgrades or improvements. As a consequence, most loans are obtained through informal channels (Ministry of Fisheries) (World Bank, 2005).

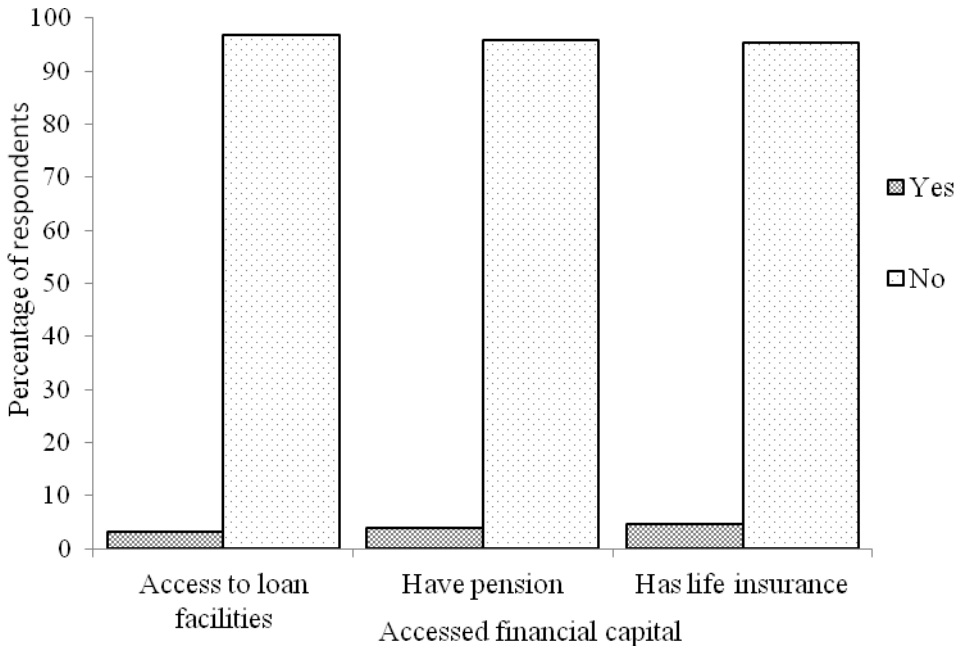

Figure 4.22: Financial capital of respondents

4.4.3.1 Relationship between Education Level, Income and Institutional Support

Results indicate that out of the 7 respondents who received loans, majority (71.4%) had primary education while 28.6% had no formal education. Cross tabulations and X^2 test results did not show any significant association between education level and institutional support received (χ^2= 0.908, df 3, P> 0.05). However, a significant association (χ^2= 9.759, df 4, P< 0.05) was observed between income level and institutional support received (Table 4.22 and Table 4.23). Whereas, education level had no significant effect on accessibility to loans the level of income had a significant effect on accessibility to loans, from institutions.

Table 4.22: Relationship between education level and institutional support Received

	Value	df	Asymp. Sig. (2-sided)
Pearson chi-square	.908(a)	3	0.824
Likelihood ratio	1.673	3	0.643
Number of cases	218		

a 5 cells (62.5%) have expected count less than 5. The minimum expected count is .16.

Table 4.23: Relationship between fisher income levels and institutional support Received

	Value	Degree of freedom	Asymp. Sig. (2-sided)
Pearson chi-square	9.759(a)	4	0.045
Likelihood ratio	11.502	4	0.021
Number of cases	218		

a 5 cells (50.0%) have expected count less than 5. The minimum expected count is .74.

4.4.4 Social Capital

4.4.4.1 Social Cohesion and Institutional Relationships

"Social capital" as defined earlier is a concept that describes the extent and nature of relationships people have with others, the relationships people have with their communities, and relationships between people and various services, institutions and systems. It is also a concept that can be used to understand the linkages between communities or institutions (Stone, 2003). Social capital enables actors to secure benefits by virtue of membership in social networks or social structures (Krishna, 2000). Social and cultural institutions can have a major impact on poor household access to resources.

Fishermen in Kenya by law have to be registered by the Fisheries Department and possess a fishing or boat license. Membership to formal fishermen organizations is used as a measure of fishermen ability to create networks. Respondents were asked to indicate the type of fishing document they held. This was used to measure formal rule compliance. The results show that 37.6% of the respondents in the study areas had a fishing license, 5% had a boat license, and 12.8% had both fishing and boat license, while 28.4% did not have any identification document (Table 4.24).

Table 4.24: Fishing documents held by respondents

Fishing Document	Frequency	Percentage (%)
Fishing license	82	37.6
Boat license	11	5.0
Both Fishing and boat license	28	12.8
None	62	28.4
No response	35	16.1
Total	218	100

a) Membership to Local Organization

Membership to a local organization was used as a measure of networking among fishers. Majority (85.3%) of the respondents indicated that they belonged to community organizations as members. Figure 4.23 shows that, whereas, 69.9% of the respondents belonged to a fishing organization (BMU), 1% belonged to a credit organization while 29.4% belonged to a religious organization. Respondents were asked to state whether their participation in the group helped them face climatic stresses, e.g., floods. About 50.2% of the respondents who belonged to community groups indicated to have received help from these groups during climatic stresses, while 49.8% indicated not to have received help. These findings concur with similar studies by Robledo *et al.* (2004) which showed community organization to be an important factor in adaptive strategies to build resilience among hillside communities in Bolivia. Begossi (1998) also found out that kinships and friendships ties among fishers are important factors that allow them to minimize their uncertainties in case of poor fishing seasons by reducing their vulnerabilities.

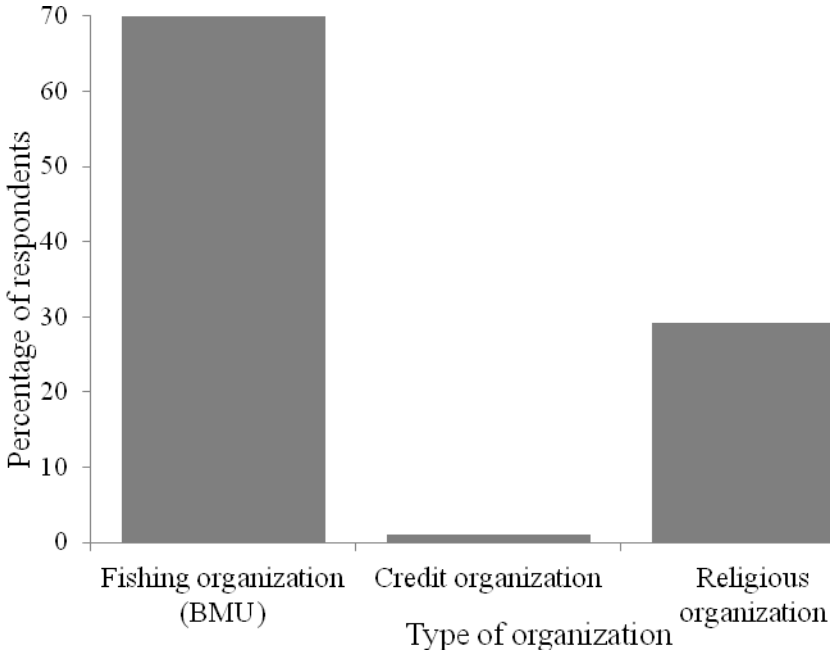

Figure 4.23: Type of organization that respondents belonged

Figure 4.24 indicates that, 45.5% of the respondents received help from private business, NGOs and charities, 27.3% from family, 18.2% from the national government and 9.1% from the civil society. The kind of help received included

credit, nets and food. A cross tabulation to find out whether a relationship existed between type of gears and membership to an organization showed that there was no significant association between membership to an organization and beach seine gear (χ^2= 0.039, df 1, P> 0.05); hook and line (χ^2= 0.385, df 1, P> 0.05); cast nets (χ^2= 0.021, df 1, P> 0.05); hand lines (χ^2= 0.091, df 1, P> 0.05); trammel nets (χ^2= 0.451, df 1, P> 0.05) and traps (χ^2= 1.993, df 1, P> 0.05). The results are contrary to findings by Kingdom and Kwen (2009) who reported significant association between membership to a cooperative society and hook and line and long line.

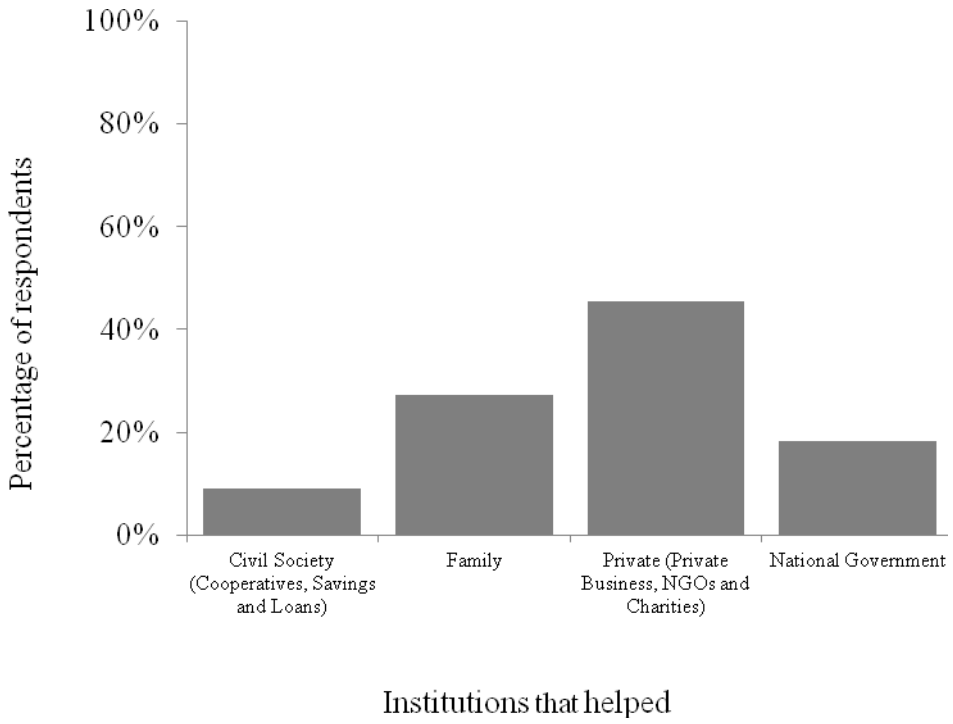

Figure 4.24: Institutions that gave help during climatic stress

4.4.5 Physical Capital

Physical capital comprises at household level, boats, gear, bicycles, land, livestock, motor cycle, etc., and at community level, access to infrastructure such as road networks, electricity, water, landing facilities (jetty), toilet facilities, marketing/ weighing rooms. These assets are important in helping household members to generate income. Asset ownership status of the surveyed households as obtained from

the quantitative survey is presented below. Figure 4.25 shows that, 33.2% of the surveyed respondents own boats, 34.3% own land, 12.9% own livestock, 2.1% own motorcycles, 5% own bicycles, 10.7% own both boats and land, 16.4% own both land and livestock. Other assets owned by respondents included cell phones (71%) cars (2%), 65% radios and television sets (45%). Education level had no significant association with gillnets (χ^2= 1.432, df 3, P> 0.05); trammel nets (χ^2= 3.987, df 3, P > 0.05); hand lines (χ^2= 1.086, df 3, P > 0.05); cast nets (χ^2= 0.879, df 3, P > 0.05); hook and line (χ^2= 1.513, df 3, P > 0.05) and traps (χ^2= 0.793, df 3, P> 0.05). The results are contrary to findings by Kingdom and Kwen (2009) who reported significant association between education level and traps.

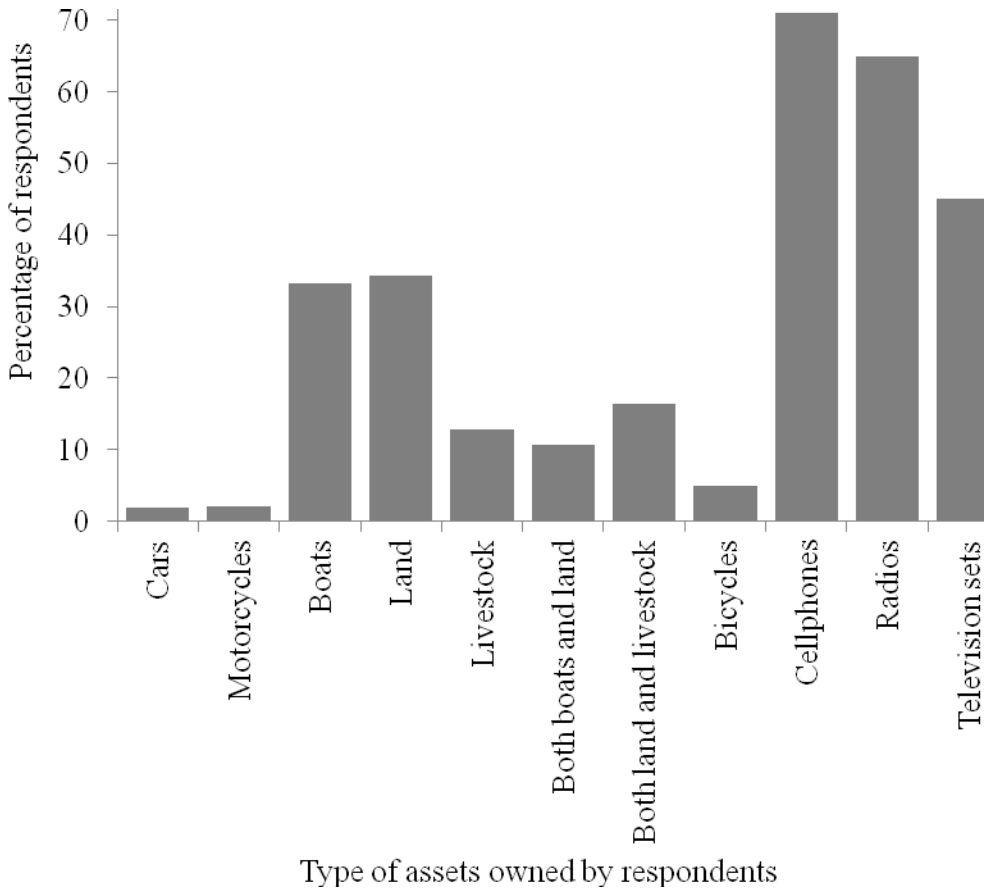

Figure 4.25: Assets owned by respondents

4.4.5.1 Relationship between Gear type and Fishing Income

Table 4.25 shows that although there is a large positive association between gear type and income level (1.00), the correlation is not statistically significant P> 0.05.

Previous studies by Bene and Neiland (2003) observed that the number and size of fishing gear depended on the wealth level of the households.

Table 4.25: Relationship between gear type and fishing income

Spearman's rho		**gear-types**	**Monthly income**
gear-types	Correlation Coefficient	1	0.111
	Sig. (2-tailed)	.	0.102
	Number of Valid Cases	218	218
Fishing income	Correlation Coefficient	0.111	1
	Sig. (2-tailed)	0.102	.
	Number of Valid Cases	218	218

4.4.5.2 Service Infrastructure

An important measure of access to public services is the distance between the residence of households and the facility at hand. The survey questionnaire recorded information on the rating of the accessibility by respondents of the community infrastructure (Figure 4.26). The results show that, whereas, 76.2% of the respondents rated accessibility of roads to be poor, 13.1% rated them to be average, while 10.7% rated them to be good. In terms of landing sites infrastructure, whereas, 77.6% of the respondents rated them to be poor in terms of accessibility, 17.8% rated them to be average while 4.7% rated them to be good. In terms of electricity provision, 91% of the respondents indicated poor accessibility, 8.1% average accessibility while 0.9% indicated it to be good. Cold storage facilities are important to help reduce postharvest losses which are brought about as a result of increased temperatures. The study found out that, majority (97.6%) of the respondents had poor accessibility to cold storage facilities, 1.9% average while 0.5% indicated to have good accessibility to cold storage facilities.

Access to potable water is an important support for fishermen. With regards to accessibility to a potable water supply and public toilet facilities, majority of the respondents in both sites neither had access to a potable water supply (75%) nor public toilet facilities (77.5%). This shows that, most fishermen are not able to access potable water and toilet facilities and this is especially a point of concern since fish handling requires large volumes of clean water.

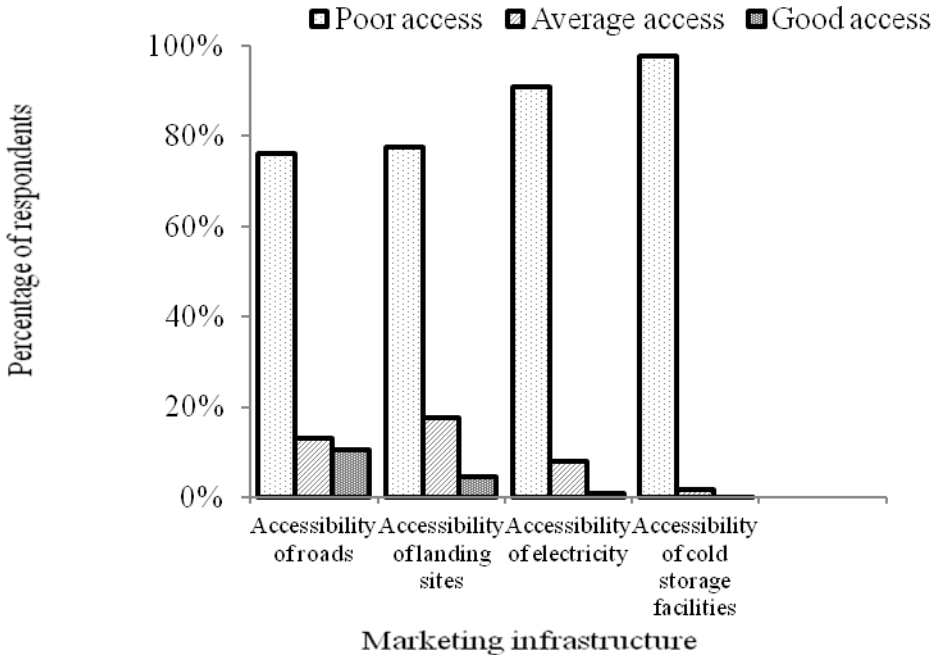

Figure 4.26*:* Rating by respondents of the community's infrastructure facilities

It may be inferred from the findings that there is poor accessibility of infrastructural facilities. This would, therefore, mean that in case of increased climatic stress, fishermen would lose most of their products and this will affect their livelihoods. A study in Nicaragua by Schmitt and Kramer, (2010) found that in the short term, the development of new roads led to the emergence of new products and markets and increased the export from fisheries. Béné *et al.,* (2007) report that a large majority of small-scale fishers are rural dwellers. As a consequence, geographical isolation and low or poor provision of public infrastructure and services (lack of roads, hospitals, water, etc.) have been greater challenges for them. The co authors further explain that small-scale fishers living in remote temporary fishing camps are very likely to be poor, not because of their income level, which can be substantial and sometimes higher than for farmers, but because of their lack of access to basic public services such as health, education and water.

4.4.5.3 Comparison of Components of Physical Assets across Study Sites

Table 4.26 shows components of physical assets with their respective means and standard deviations. Differences among sites were tested with the Mann-Whitney test U

(2-tailed), Z and P values being also available in Table 4.26. The results show that, the z values of boats, mobile phones and potable water were (-2.299, -2.123 and -2.174) respectively with the distribution, differing significantly across sites (P< 0.05). On the the other hand the z values of cars, motorcycles, bicycles, radios and televisions was (-0.299, -0.791, -0.432, -0.432, and -0.121 respectively.However, the distribution did not significantly differ across sites (P> 0.05). It was observed that Malindi had more respondents who owned fishing vessels (mean response, 1.41) compared to Mombasa (mean response, 1.26). Similarly, respondents who owned mobile phones were more in Mombasa (mean response, 1.35) compared to Malindi (mean response, 1.22). Accessibility to potable water was more in Mombasa (mean response, 1.82) compared to Malindi (mean response, 1.69). The mean response for respondents who owned cars in both Mombasa and Malindi was 1.98. The mean response for those who owned motorcycles in Mombasa and Malindi was 1.97 and 1.98, respectively. Respondents who owned bicycles were slightly more in Malindi (mean response, 0.06) compared to Mombasa (mean response, 0.04) while those who owned radios were more in Malindi (mean response, 1.69) compared to Mombasa (mean response, 1.34). It was further noted that respondents who owned television sets were slightly more in Malindi (mean response, 1.57) compared to Mombasa (mean response, 1.54). The distribution of radios, motor bicycles, television sets did not significantly differ across sites (P> 0.05). Similarly, access to service infrastructure (electricity and toilet facilities) did not significantly differ across sites (P> 0.05) with both study sites having access to service infrastructure.

4.4.6 Natural Capital

Natural capital comprises natural resources (fish stocks, land owned and crops cultivated) from which resource flows and services that are important for livelihoods are derived. This study focused on fish stocks that were important for the livelihoods of the respondents. Respondents were asked to indicate their target species and fishing zones in the last 20 or so years. The main fishing zones mentioned by the respondents included open sea, creek and reef. Up to 20 species of fish were identified to be targeted by the respondents. The most commonly mentioned demersals species included rabbit fish (*Siganus sutor*), grunters (*Pomadasys commersonnii*), parrot fish

(*Scarus ghobban*), red snappers (*Lutjanus argentimaculatus*) and barracuda (*Sphyraena jello*). Pelagics species mentioned included cavilla jacks (*Carangoides ferdau),* shark (*Carcharhinus melanopterus*), mullet (*Mugil cephalus*) and sardins (*Sardinella melanura*). With regards to crustaceans, prawns (*Penaeus indicus* similar species *P. latisulcatus,* other *panaeus spp*) and lobsters (*Panulirus ornatus) (similar spp P. delalogoae, P. homarus and P.ongipes)* were mentioned as main target species.

Table 4.26: Fishers' physical assets in Mombasa and Malindi

	Mombasa		**Malindi**		**All sites**		**Z**	**P**
	Mean	S.D	Mean	S.D	Mean	S.D	Score	value
Assets								
Own vessel	1.26	0.440	1.41	0.493	1.34	0.476	-2.299	*0.021
Car	1.98	0.146	1.98	0.126	1.98	0.135	-0.299	0.765
Motor cycle	1.97	0.178	1.98	0.126	1.98	0.150	-0.791	0.429
Bicycle	0.04	0.204	0.06	0.231	0.05	0.219	-0.432	0.665
Mobile phone	1.35	0.481	1.22	0.419	1.28	0.450	-2.123	*0.034
Radio	1.34	0.478	1.69	0.464	1.75	0.434	-0.121	0.904
Television	1.57	0.498	1.54	0.501	1.55	0.499	-0.496	0.620
Service infrastructure								
Potable water	1.82	0.383	1.69	0.464	1.75	0.434	-2.174	*0.030
Toilet facility	1.76	0.431	1.79	0.410	1.78	0.419	-0.512	0.609
Electricity	1.92	0.267	1.86	0.346	1.89	0.314	-1.004	0.315

Z score computed using Mann Whitney U test 2-tailed*Significantly different (P<0.05)

4.4.6.1 Target Species and Fishing Zones

Table 4.27 presents data on the main species targeted by respondents and the main fishing zones. The results show that, 39% of respondents targeted rabbit fish (*Siganus sutor)* within the reef, 33.1% within the open sea and 27.1% within the creek. Whereas 47.3% of the respondents targeted grunters (*Pomadasys commersonnii*) within the creeks, 28.2% targeted grunters within the open sea and 24.5% within the reef. About (39.7%) of the respondents targeted parrot fish in the open sea, (34.4%) within the reef and 25.2% within the creeks. Similarly, 43.5% of respondents targeted snappers (*Lutjanus argentimaculatus*) in the open sea, 35.7% within the creek and 20.9% within the reef. About (40.6%) respondents targeted cavilla jacks (*Carangoides*

ferdau) in the open sea, 32.5% within the reef and 32.5% within the creek. Whereas, 46.1% of the respondents indicated to target mullet (*Mugil cephalus*) within the creek, 26.6% indicated to target mullet within the reef while 27.3% indicated to target mullet in the open sea. Most (57.1%) of the respondents targeted sharks (*Carcharhinus melanopterus*) in the open sea. Respondents who indicated to target prawns and crabs within the creek were 44.9% and 52.5%, respectively while respondents who targeted lobsters and octopus within the reef are 34.6% and 40.5%, respectively. Sardins (*Sardinella melanura*) were mainly targeted within the creek (44%), open sea (31%) and the reef (25%).

These findings of fishers' targeting more than one species concur with previous studies which emphasized the inherent resilience of coastal fishing communities (Bailey and Pomeroy [1996], Fauzi and Anna [2010]). Bailey and Pomeroy argue that coastal communities' dependence on not just a single fish stock but an entire ecosystem reduces fishers' vulnerability to economic downturns and other instabilities.

Table 4.27: Target species and fishing zones of respondents

Target fish species	Fishing Zone					
	Creek		Reef		Open sea	
	Frequency (n)	Percentage %	Frequency (n)	Percentage %	Frequency (n)	Percentage %
Siganus sutor	38	27.9	53	39	45	33.1
Pomadasys commersonnii	52	47.3	27	24.5	31	28.2
Scarus ghobban	33	25.2	45	34.4	52	39.7
Lutjanus argentimaculatus	41	35.7	24	20.9	50	43.5
Carangoides ferdau	43	32.5	36	27.1	54	40.6
Carcharhinusmelanopterus	19	22.6	17	20.2	48	57.1
Mugil cephalus	59	46.1	34	26.6	35	27.3
Sardinella melanura	37	44	21	25	26	31
Penaeus indicus	57	44.9	35	27.6	35	27.6
Panulirus ornatus	36	33.6	34	31.8	37	34.6
Scavenger	56	35.4	49	31	53	33.5
Octopus	19	22.6	34	40.5	31	36.9
Crabs	53	52.5	20	19.8	26	25.7

4.4.6.2 Influence of El Niño on Fishing Activities

Fishers were asked to compare their fishing activities during the El Niño period of 1997/8 to other years. Most of the respondents indicated that the heavy rains experienced during this period had affected their livelihoods. When asked whether fishing during El Niño had made them better off or worse off. Majority (92%) of the respondents indicated that their fishing was made worse; few (6%) said it was better while very few (2%) indicated that they did not know whether El Niño made them better or worse (Figure 4.27).

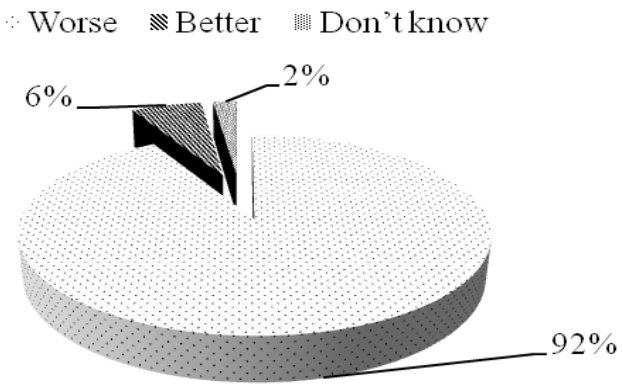

Figure 4.27: Effect of 1997/8 El Niño on respondents

Respondents were asked to indicate whether their incomes had decreased or increased during the 1997/8 El Niño period. Majority (94%) of the respondents' indicated their incomes to have decreased, few of the respondents (2%) indicated their incomes to have increased, a further 2% of the respondents indicated that there had been no change in their incomes while another 2% indicated not to know if it had increased or decreased. Most of the respondents who indicated their incomes to have decreased pointed out climate variability and increased pollution to have been the major causes that hindered them from carrying out fishing activities. 4% of the respondents indicated that some boats had capsized during this period due to strong waves. The findings are in agreement with Adeoti *et al.,* (2010), who reported that, majority of fishers reported loss of income from fishing during times of flooding. This loss is attributed to reduction in the quantity of fish caught. Other forms of losses included loss of household properties, other fixed assets like gears, nets, etc. Francisco *et al.,*

(2009) reported that 30% of the interviewed riverine population in Propria commented that they find a flood to be bad because many people lose their houses, commercial establishments, and plantings. Flooding also brings sediments to the ocean, increasing turbidity of the ocean, and reducing visibility of fish. Fishing effort therefore becomes less efficient.

Respondents were asked to indicate whether they had changed their target species and gear during the El Niño period of 1997. El Niño and La Niña are associated with physical and biological changes in the ocean that affect fish abundance. The findings show that, majority (88%) of the respondents neither changed gear nor target species during this period. The main gear type they used during the period included trammel nets (22%), long line hooks (9%), beach seines (13%), gill nets (20%), cast net (10%), prawn seine (7%), trawl nets (4%), basket traps (6%) and hand lines (11%).

4.4.6.3 Trends of Fish Catch Over the Last 10 or so Years

There is limited evidence of changes in the main species targeted in the different fisheries, however, respondents had observed changes in fish catches over the years. Figure 4.28 shows that, most (57.9%) of the respondents observed a decrease in fish catches over the years, 27% an increase, 8.7% saw no changes in fish catches while 6.3 % did not know whether they had been an increase or decrease in fish catches over the years.

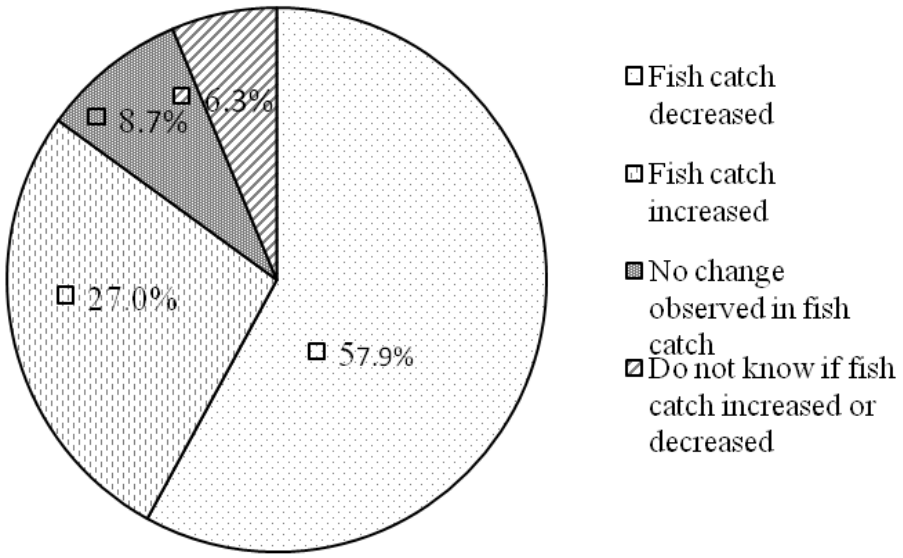

Figure 4.28: Trends of fish catch over the last 10 or so years

Table 4.28 shows that 18.3% of the respondents attributed the decrease in fish catch to increased temperatures, 44.5% to pollution, 19.3% to increased number of fishers, 14.7% to decreased rainfall, 1.4% to increased sea level rise while 1.8% attributed the decrease to other causes, e.g., poor fishing methods to have contributed to decreased fish catches. The fishers contend that the pelagic species have descended to the lower layers from the surface due to variation in surface-water temperature hence increasing their vulnerability.

Table 4.28: Causes of decrease in fish catches

Causes of decrease in fish catches	Frequency (n)	Percentage (%)
Increased number of fishers	42	19.3
Pollution	97	44.5
Increased temperature	40	18.3
Increased sea level rise	3	1.4
Decreased rainfall	32	14.7
Other causes	4	1.8
Total	**218**	**100**

4.4.6.4 Fish Dependent on Coral Reef and the Reef Matrix

About 57% of the respondents targeted fish dependant on coral reef and the reef matrix. Figure 4.29 shows that out of the respondents who target fish dependent on live coral and reef matrix, 38.8% (n=45) had 50-70% on live coral and the reef matrix, followed by 29.3% (n=34) who had more than 70% on live coral and reef matrix. About 27.6% (n=32) had 30-50% dependent on live coral and reef matrix, while 4.3% (n=5) had 10-30% on live coral and reef matrix. The findings imply that the majority of the respondents (68.1%) had more than 50% of their target species dependant on live coral and the reef matrix. This would, therefore, imply that increased temperatures will affect the livelihood of small-scale fishers, since corals are adversely affected by temperature increase.

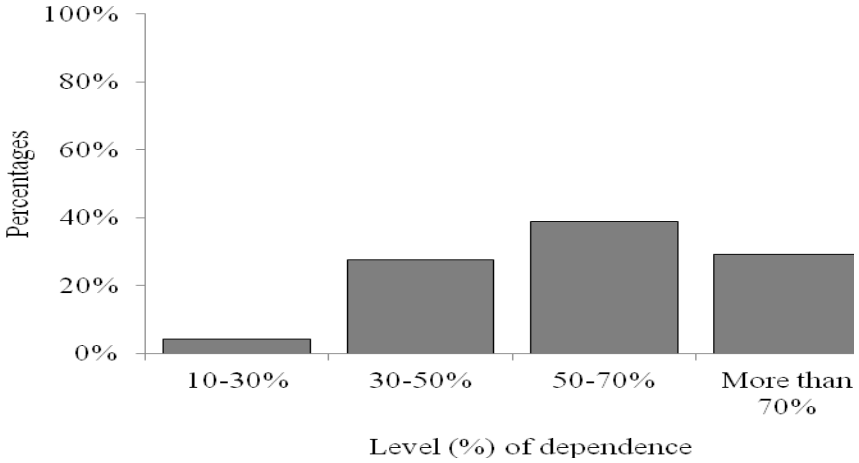

Figure 4.29: Level of catch dependent on live coral and reef matrix

As shown in Figure 4.30, majority (57.9%) of the respondents who targeted fish species dependent on live coral and reef matrix, indicated their fish catch to have been decreasing over the years, 27% to have been increasing, 8.7 % no change in their catch while 6.3% did not to now if their catch had decreased or increased. A previous study carried out by Jones *et al.* (2004) where 15% of local fish species relied directly on corals for food or habitats, found that 75% of coral reef species exhibited a decline in their numbers, and diversity declined by 22%, following a 90% loss in coral cover. This implies that an increase in SST will affect the livelihoods of majority of fishers in the study area who target fish dependent on live coral and the reef matrix.

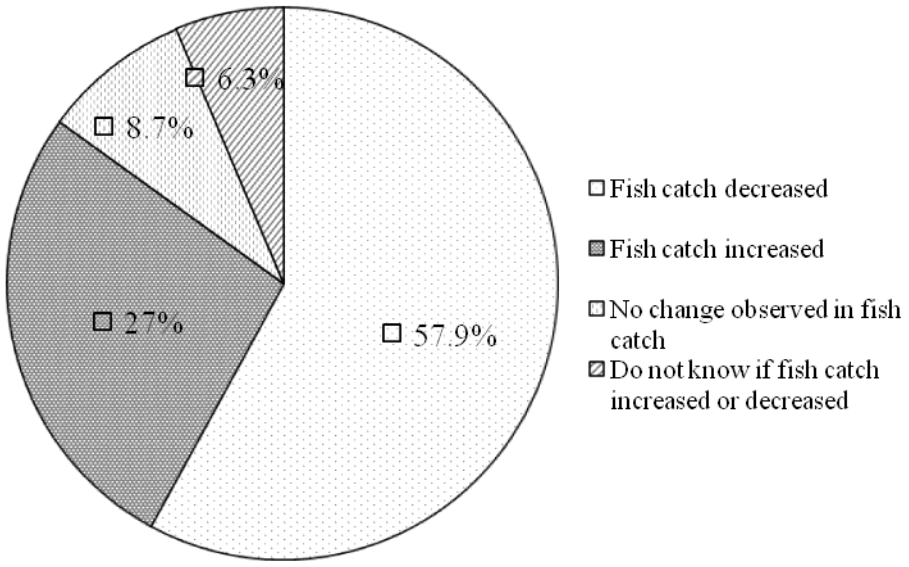

Figure 4.30: Trend of fish species dependent on live coral and the reef matrix

4.4.6.5 Fish Catches in Malindi and Mombasa

Fish species recorded by the Fisheries Department since 1996 for Malindi and Mombasa were considered in this study to ascertain whether climate variability has had any impact on the abundance of the fish catches over the years. The results from the Fisheries Department indicated that both cavilla jacks (*Carangoides ferdau*) and shark (*Carcharhinus melanopterus*) catch had declined over the years; this was also confirmed in this research findings. However, the other fish species catches which the respondents had noted to be on the decline had in fact, increased over the years according to the Department of Fisheries data. This variation could be explained by the fact that there has been an increase in the number of fishermen over the years thus registering increased total catches. However, the total catch per fisherman has actually reduced over the years as indicated by the fishers.

4.4.6.6 Fish Catches in Malindi

The ratio of the individual fish species catches relative to total catch were calculated based on the total number of fish catches in Malindi in the respective years. Some of the demersal fish species noted by the fishers to be declining in Malindi included rabbit fish (*Siganus sutor*), grunter (*Pomadasys commersonnii*), parrot fish (*Scarus ghobban*) and red snappers (*Lutjanus argentimaculatus).* Figure 4.31 shows the fish

ratio of demersal fish catch relative to total catch in Malindi from 1998-2010. The fish catch for various fish species is characterized by both negative and positive catch fluctuations. There was a decrease in rabbit (*Siganus sutor*) fish catch in the period between 1998-1999, 2000-2003, 2004-2005, 2007-2008 and 2009-2010. However, an increased catch was observed in the period between 1999-2000, 2002-2003, 2004-2005, 2006-2007 and 2008-2009 as indicated by the fish ratios. Parrot (*Scarus ghobban*) fish shows decreased catch in the period between 2001-2002, 2003-2006 and 2007-2008 and an increased fish catch in the period 2002-2003, 2006-2007 and 2008-2010, respectively.

An increased catch is observed for red snappers (*Lutjanus argentimaculatus)* in the period between 1998-1999, 2001-2002, 2003-2005 and 2007-2008. A decreased catch is observed in the period 1999-2000, 2002-2003, 2006-2007 and 2008-2009. The period between 2000-2001 and 2005-2006 did not show much difference in catch. Similarly, a decrease in Grunters (*Pomadasys commersonnii*) fish catch was observed in the period between 1999- 2001, 2006-2008 with the lowest catch in 2004. An increased fish catch was observed in the period between 2004-2006 and 2008-2009.

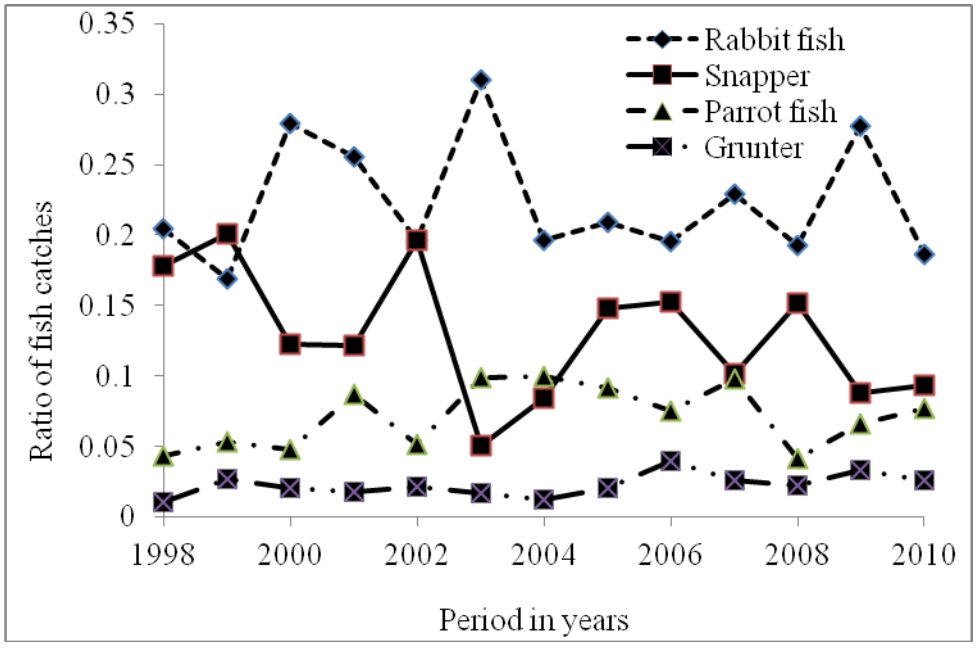

Figure 4.31: Ratio of demersal fish catch relative to total catch in Malindi during the period 1998 – 2010 (Source: Fisheries Department)

Figure 4.32 shows the ratio of pelagic fish catch relative to total catch in Malindi from 1998-2010. The results show that there was decreased catch in cavilla jacks (*Carangoides ferdau*) for the period between 1999-2001; and again, in 2009. However, an increased catch was observed in the period between 2001-2003 and 2009-2010. It was further observed that there was decreased fish catch in mullet (*Mugil cephalus*) in the period between 2000-2001, 2002-2003 and 2006-2009. An increased catch was observed in the period between 1998-2000, 2001-2002, 2003-2006 and 2009-2010 as indicated by the fish ratios. Barracuda (*Sphyraenajello*) fish catch shows an increased catch in the period between 2000-2002, 2004-2008 and a decreased catch in the period between 1998-2000, 2002-2004 and 2008-2010.

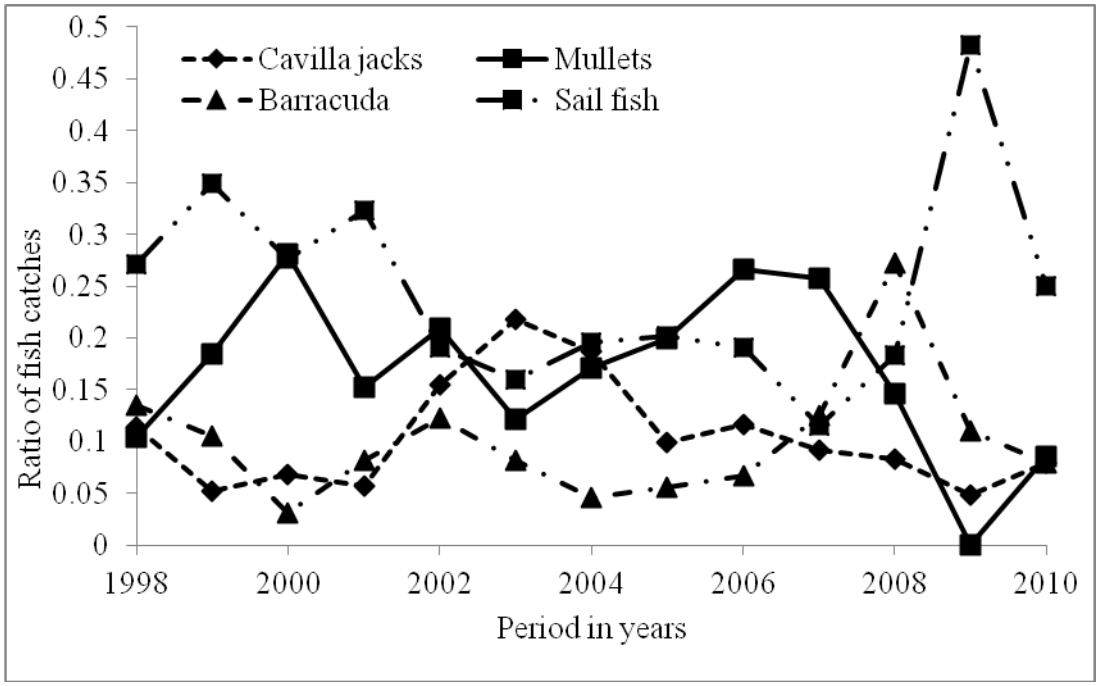

Figure 4.32: Ratio of pelagic fish catch (relative to total catch) in Malindi during the period 1998 – 2010 (Source: Fisheries Department)

Pelagic fish species noted by the fishers to be declining in Malindi included cavilla jacks (*Carangoides ferdau*), mullet (*Mugil cephalus*), shark (*Carcharhinus melanopterus*), and sardins (*Sardinella melanura*). Cavilla jacks (*Carangoides ferdau*) and mullet (*Mugil cephalus*) showed an increasing trend as depicted by the positive gradient of the regression curves (Figures 4.33 and 4.35) while Sharks (*Carcharhinus melanopterus*) showed a down ward trend over the years by the record documented by

the Fisheries Department (Figure 4.34).

Figure 4.33 shows an increasing trend in cavilla jacks (*Carangoides ferdau*) catch during the period of 1998-2010. The highest catch was recorded in 2004 while the lowest was recorded in 2009. Statistical correlation analysis suggests that, cavilla fish catch is inversely correlated with SST (-0.268) and positively correlated with rainfall (0.422). Rainfall explains about 17.8% of the variations of the cavilla jacks fish catches, therefore cavilla jacks catches are slightly favoured by high rainfall amounts.

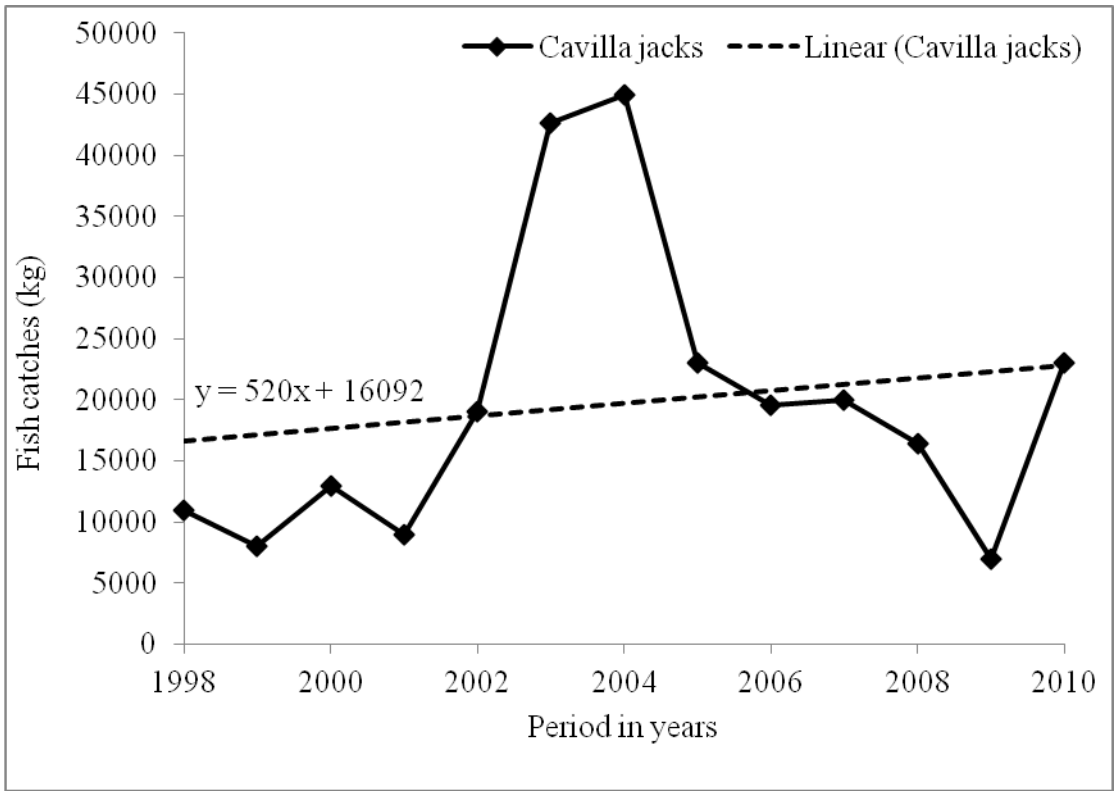

Figure 4.33: Trend of cavilla jacks (*Carangoides ferdau*) fish catch in Malindi during the period 1998 –2010 (Source: Fisheries Department)

Figure 4.34 shows a downward trend in shark (*Carcharhinus melanopterus*) catch during the period of 1998-2010. The highest catch in shark (*Carcharhinus melanopterus*) was recorded in 2005 while the lowest was recorded in 2006 and 2007. Statistical correlation analysis suggests that shark fish catch is inversely correlated with SST (-0.488) and positively correlated with rainfall (0.182). The SST explains about 23.8% of the variations of the shark catches, therefore sharks catches are slightly favoured by reduced or low SST.

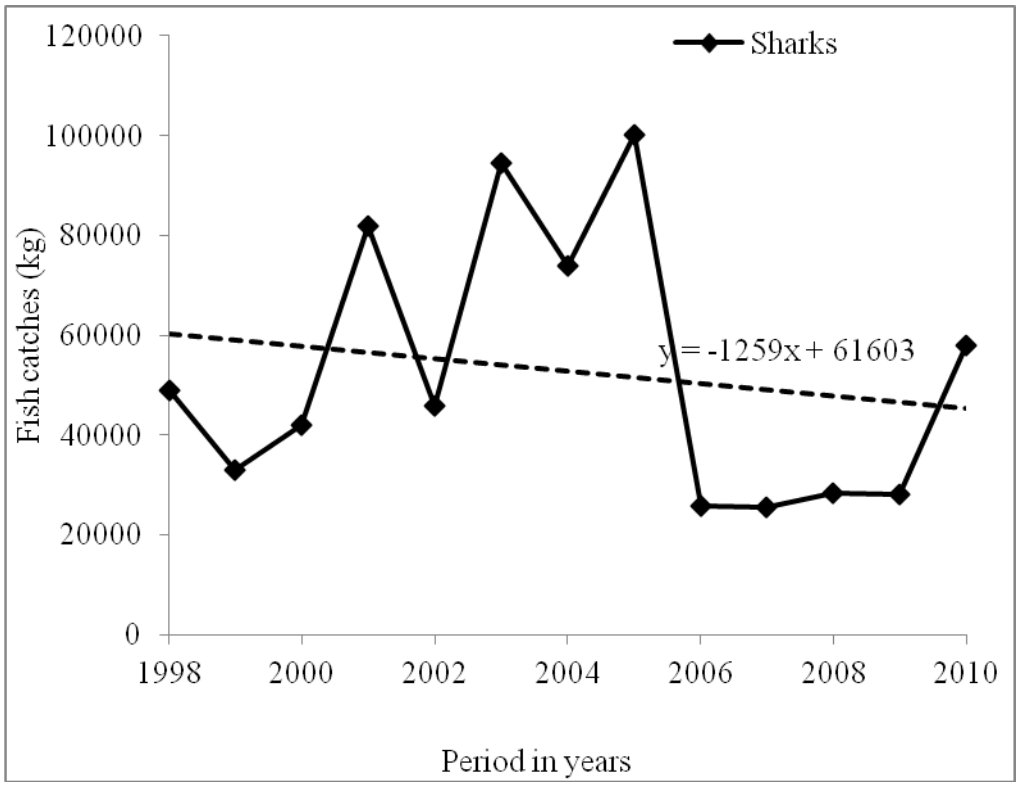

Figure 4.34: Trend of shark (*Carcharhinus melanopterus*) fish catch in Malindi during the period 1998 – 2010 (Source: Fisheries Department)

Figure 4.35 shows an increasing trend in mullets (*Mugil cephalus*) fish catch during the period of 1998-2010. The highest catch was recorded in the year 2007 while the lowest was recorded in the year 1998. Statistical correlation analysis suggest that mullet fish catch is inversely correlated to SST (-0.086) and positively correlated to rainfall (0.016). The SST and rainfall seem not to have any significant effect on the variations of mullet fish catches.

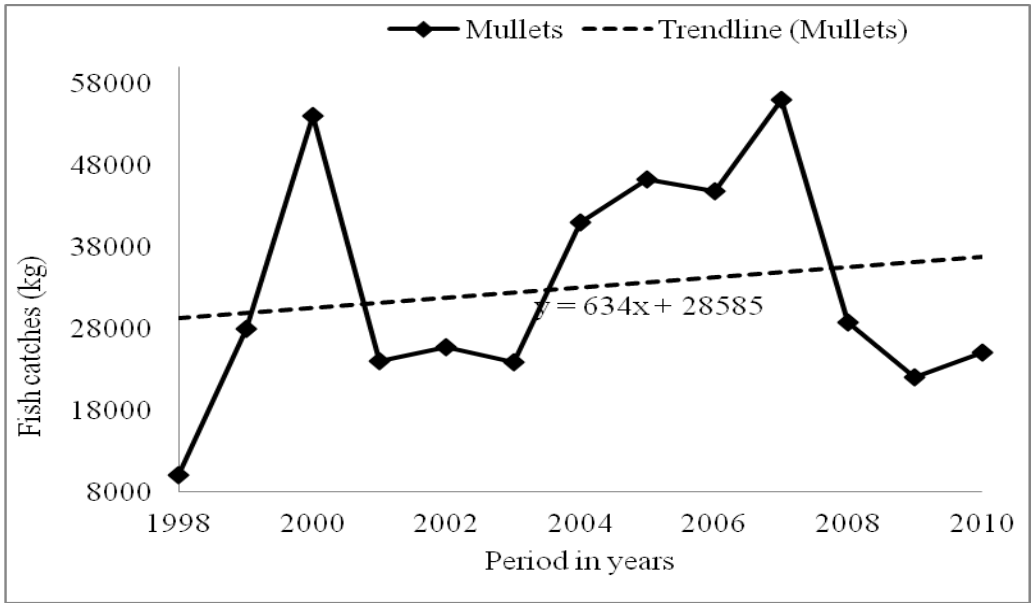

Figure 4.35: Trend of mullet *(Mugil cephalus*) fish catch in Malindi during the period 1998 – 2010 (Source: Fisheries Department)

Figure 4.36 shows an increasing trend in prawn fish catch during the period of 1998-2010. The highest catch was recorded in the years 2007 while the lowest was recorded in the year 2000. Statistical correlation analysis suggests that, prawn fish catch is positively correlated to SST (0.184) and rainfall (0.290). The SST seem not to have any significant effect on the variations of prawn fish catches as it explains about 3%, while rainfall can explain up to 8.4% variations in prawn fish catches.

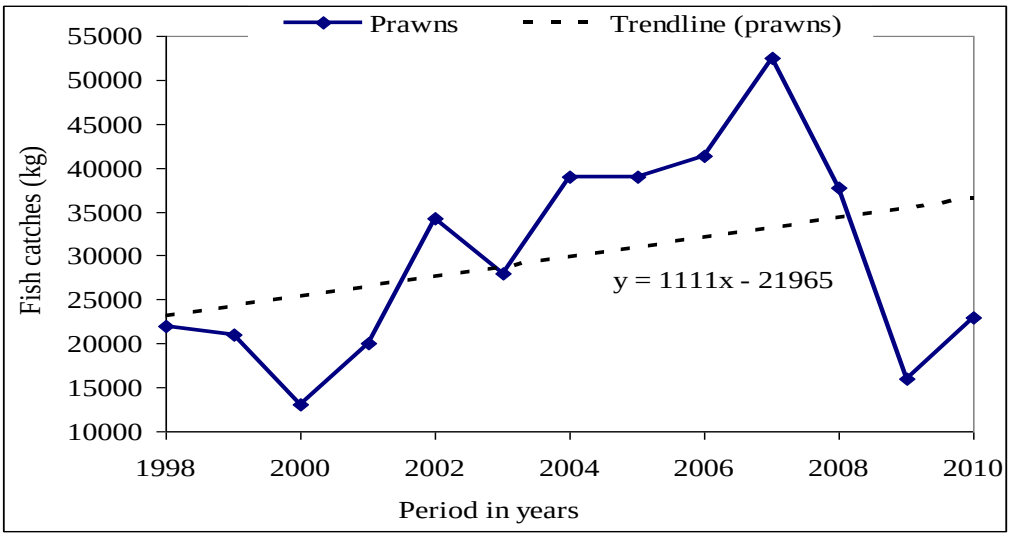

Figure 4.36: Trend of prawn fish catch in Malindi during the period 1998 – 2010 (Source: Fisheries Department)

4.4.6.7 Fish Catches in Mombasa

The ratio of the individual fish species catches were calculated based on the total number of fish catch in Mombasa in the respective years. Figure 4.38 shows the fish ratio of demersal fish catch relative to total catch in Mombasa during the periods 1996-2010. The fish catch for various fish species is characterized by fluctuating catch trends. A decreased catch is observed in rabbit (*Siganus sutor*) fish in the period between 1997-1998, 2000-2003 and 2008-2009 while an increased catch is observed in the period between 1996-1997 and 2004-2007. Similarly, Parrot (*Scarus ghobban*) fish shows a decrease in catch in the period between 1996-1999, 2001-2002, 2003-2004, 2005-2008, 2009-2010 and an increased catch in the period 1999-2000, 2002-2003, 2004-2005 and 2008-2009. A decreased fish catch is observed for red snappers (*Lutjanus argentimaculatus)* in the period between 1996-1997, 1999- 2000, 2002-2003, 2007-2010 and an increased catch in the period 2000-2002, 2004-2007. There was a decrease in Grunters (*Pomadasys commersonnii*) fish catch in the period between 1997-1998 and 1999-2001 and a slightly increased catch in the period between 1998-1999, 2004-2006 and 2007-2010.

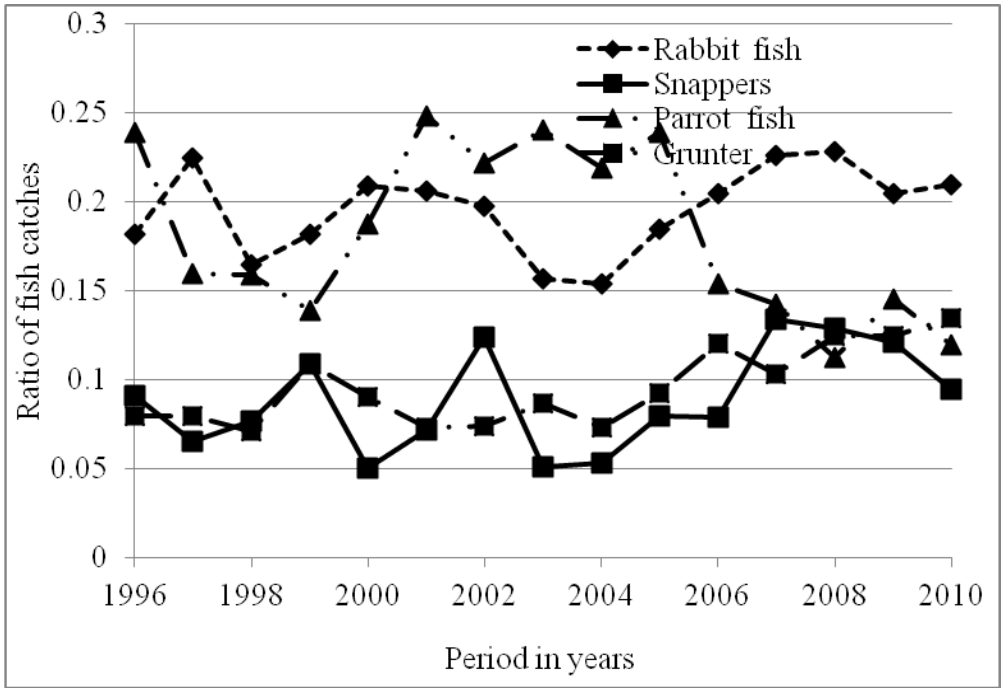

Figure 4.37: Ratio of demersal fish species catches relative to total fish catch in Mombasa during 1996 – 2010 (Source: Fisheries Department)

From the survey, some of the demersal and pelagic fish species reported to be declining in Mombasa included rabbit fish (*Siganus sutor*), grunter (*Pomadasys commersonnii*), parrot fish (*Scarus ghobban*), red snappers (*Lutjanus argentimaculatus)*, cavilla jacks (*Carangoides ferdau*), mullet ((*Mugil cephalus*), and sharks (*Carcharhinus melanopterus*). Records from Fisheries Department showed an increasing trend of the same species (See Figures 4.38, 4.39, 4.40, 4.41).

Figure 4.38 shows an increasing trend in parrot (*Scarus ghobban*) fish catch during the period between 1996-2010. The results show that the highest catch was recorded in the year 2001 while the lowest catch was recorded in 1997.The increase in parrot fish catches may be explained by an increase in the number of fishers during this period. Statistical correlation analysis between parrot fish catch, SST and rainfall, suggest that whereas, parrot fish catch is inversely correlated to SST (-0.565), it is positively correlated to rainfall (0.159). The SST explains about 31.9% of the variations of the parrot fish catches.

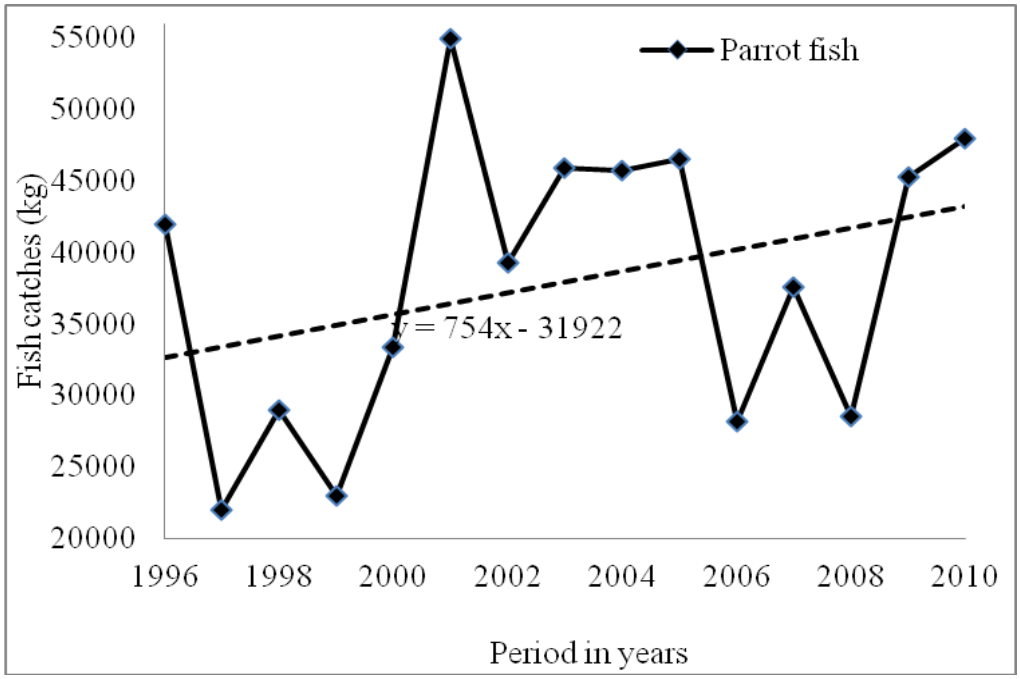

Figure 4.38: Trend of parrot fish *(Scarus ghobban)* catch in Mombasa during 1996 – 2010 (Source: Fisheries Department)

Similarly, Figure 4.39 shows an increasing trend in rabbit (*Siganus sutor*) fish catch during the period between 1996-2010. The highest catch was recorded in the year

2010 while the lowest was recorded in the year 2003. The increase in rabbit fish catch may be attributed to increased number of fishers during this period. Statistical correlation analysis suggests that rabbit fish catch is inversely correlated to SST (-0.435). The SST explains about 18.9% of the variations of the rabbit fish catches.

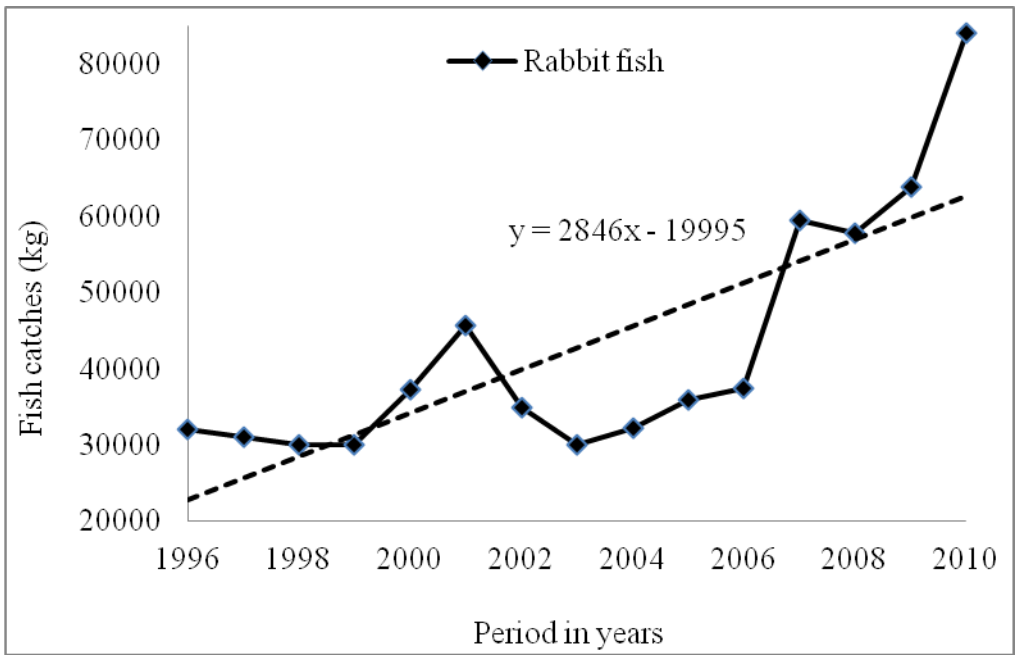

Figure 4.39: Trend of rabbit fish *(Siganus canaliculatus)* catch in Mombasa during 1996- 2010 (Source: Fisheries Department)

Figure 4.40 shows a dereasing trend in mullets (*Mugil cephalus*) fish catch during the period of 1996-2010. The highest catch was recorded in the years 2010 while the lowest was recorded in the year 2009. Much as the relationship among these variables are low, statistical correlation analysis suggests that, mullet fish catch is inversely correlated to SST (-0.042) and positively correlated to rainfall (0.144). The SST and rainfall does not have any significant effect on the variations of mullet fish catches.

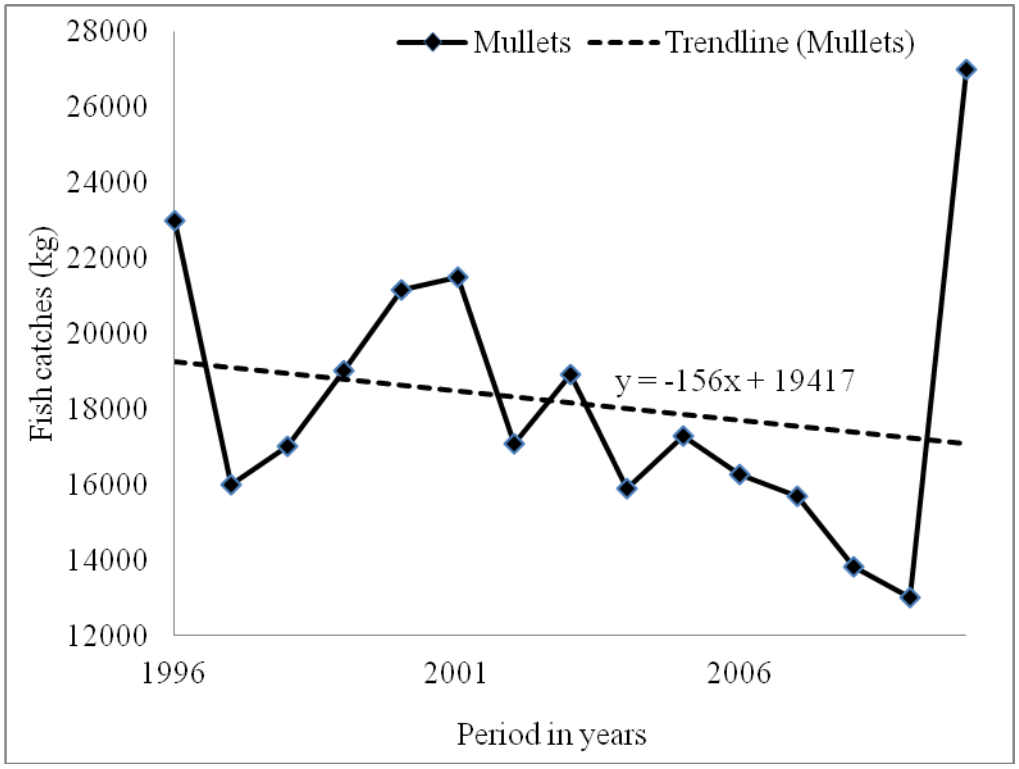

Figure 4.40: Trend of mullets *(Mugil cephalus)* fish catch in Mombasa during 1996 – 2010 (Source: Fisheries Department)

Figures 4.41 and 4.42 show an increasing trend in cavilla jacks (*Carangoides ferdau*) and shark (*Carcharhinus melanopterus*) fish catch during the period of 1996-2010. The highest catch for both cavilla jacks and sharks was recorded in the year 2010 and 2009, respectively. The lowest catch for cavilla jacks and shark was recorded in the years 2003 and 2000/01, respectively. Statistical correlation analysis between cavilla jacks fish catch, SST and rainfall, suggest that whereas, cavilla jacks fish catch is inversely correlated to SST (-0.431), it is positively correlated to rainfall (0.237). Similarly, statistical correlation analysis between shark fish catch, SST and rainfall, suggest that, whereas, shark fish catch is inversely correlated to SST (-0.481), it is positively correlated to rainfall (0.220). Although the earlier findings indicate an increase in SST over the years, the increase in fish catch of most species as suggested by the trend lines may be attributed to other factors, e.g., increased number of fishers over the said period.

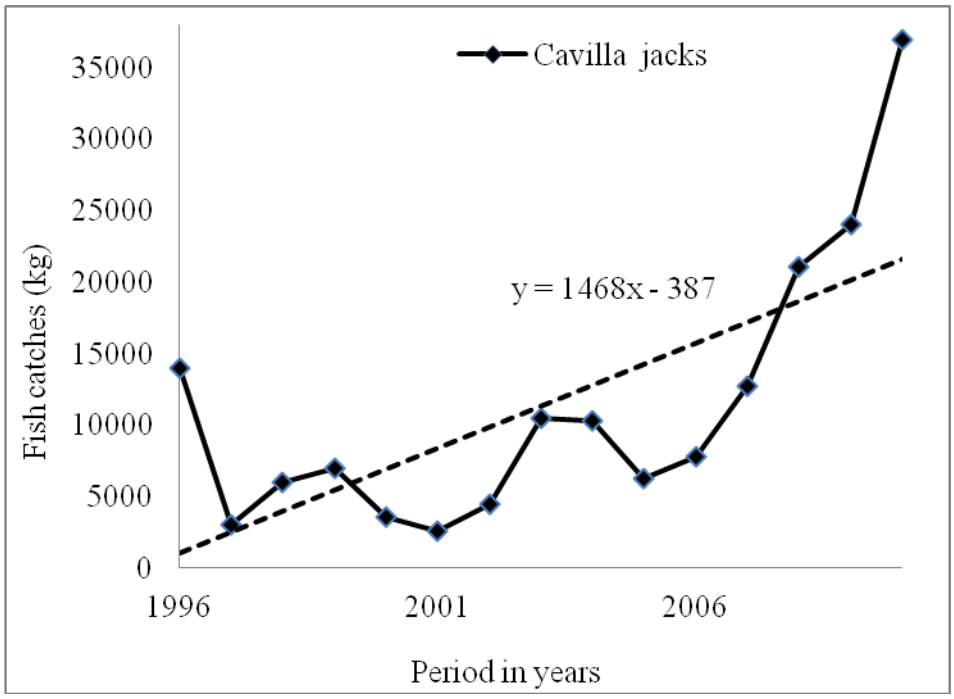

Figure 4.41: Trend of cavilla jacks *(Carangoides ferdau)* fish catch in Mombasa during 1996 – 2010 (Source: Fisheries Department)

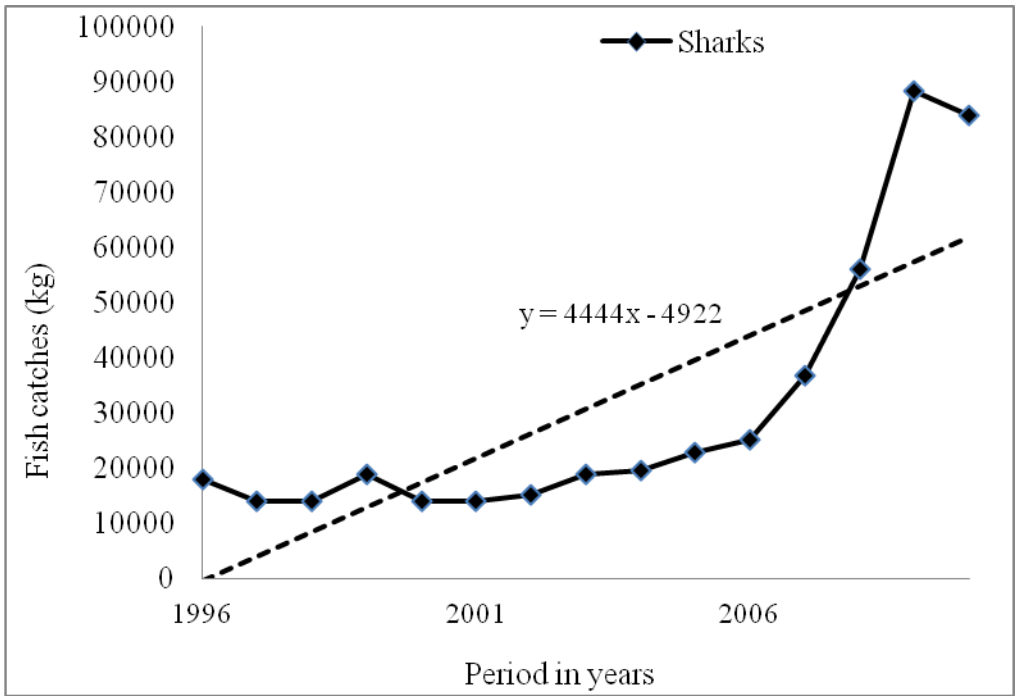

Figure 4.42: Trend of shark *(Carcharhinus melanopterus)* fish catch in Mombasa during 1996 – 2010 (Source: Fisheries Department)

Figures 4.43 shows a decreasing trend in prawn fish catch during the period of 1996-2010. The highest catch was recorded in the years 1998 while the lowest was recorded

in the year 2005. Statistical correlation analysis suggests that, prawn fish catch is positively correlated to SST (0.169) and rainfall (0.435). The SST seem not to have any significant effect on the variations of prawn fish catches as it explains less than 3%, while rainfall can explain up to 18.9% variations in prawn fish catches.

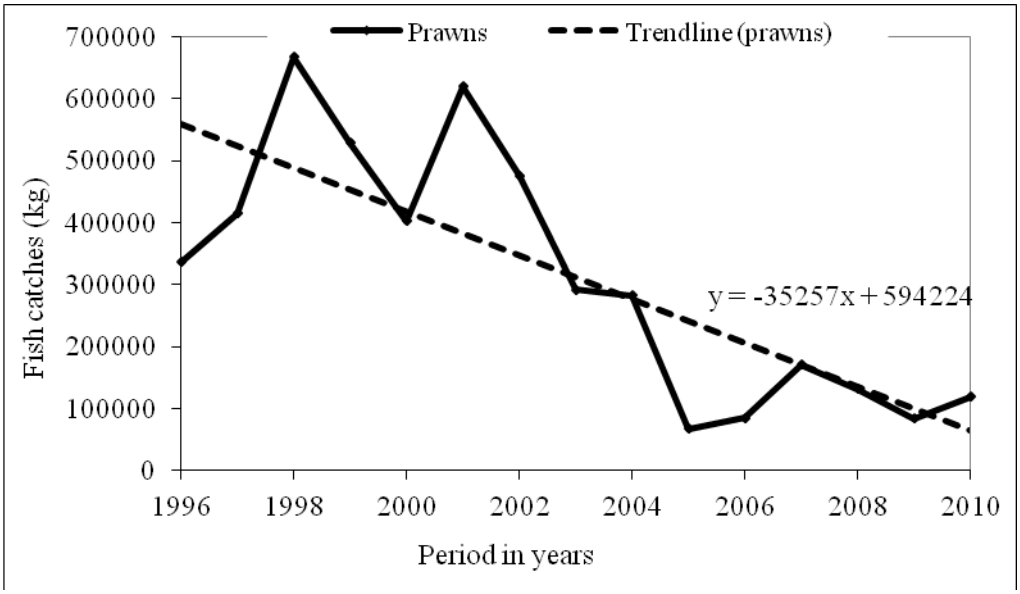

Figure 4.43: Trend of prawn fish catch in Mombasa during 1996 – 2010 (Source: Fisheries Department)

As indicated above, while SSTs in both Malindi and Mombasa have over the years shown an increasing trend, rainfall has shown a decreasing trend.Fisheries Department data for both Malindi and Mombasa show fish catch of various species to have been increasing with a few species showing a decreasing trend in the last 10 or so years. However, respondents in the study areas have observed a general decline in some species of fish. There appears to be conflicting information on the landings of fish. The difference in results may be explained by the fact that the number of fishermen has increased over the years and hence, contributed to increased catch as observed in the records. However, the number of fish caught per fisher may have declined as noted by the respondents.

Data documented by the Fisheries Department in 2004 and 2008, showed a general decline in the number of fish caught per fisher in the study landing sites (Old port, Nyali and Kidongo) (Figures 4.44 and 4.45).

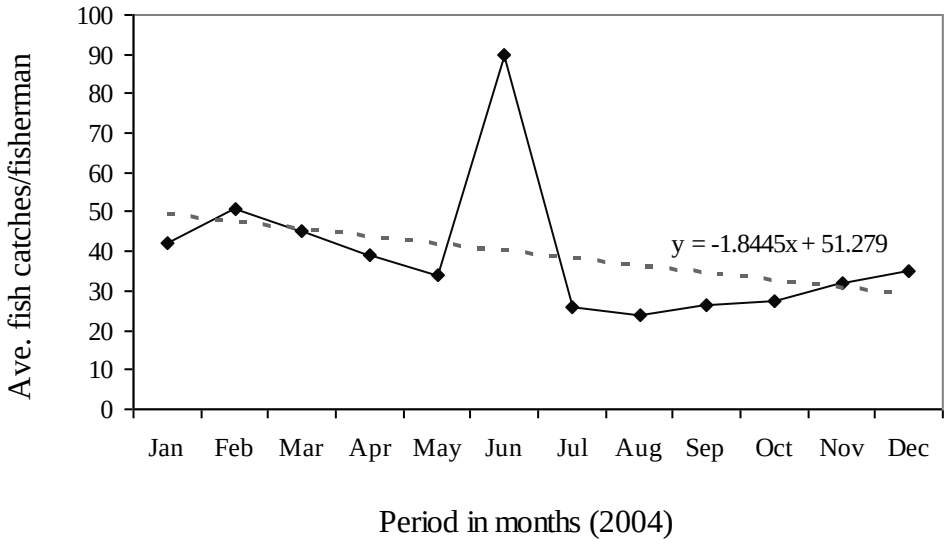

Figure 4.44: Average fish catch per fisher in study landing sites in the year 2004 (Source: Fisheries Department)

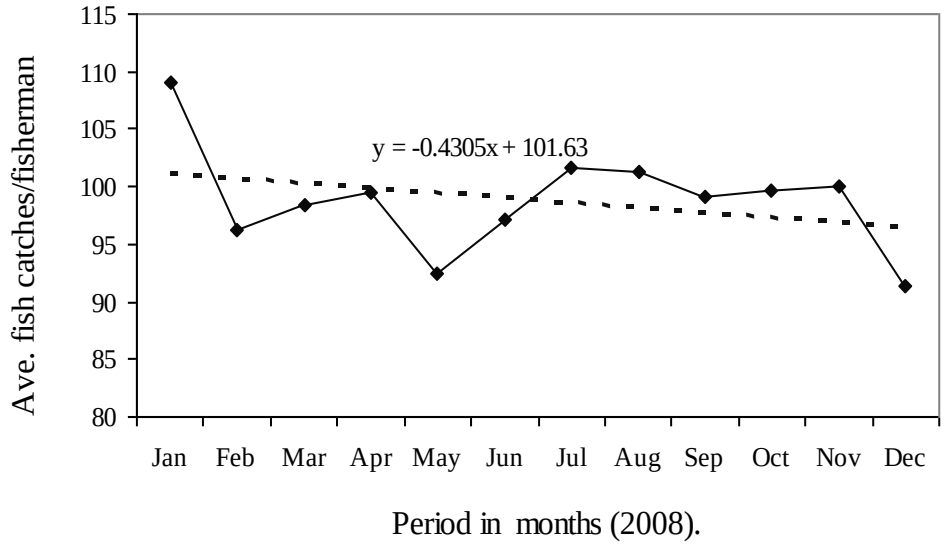

Figure 4.45: Average fish catch per fisher in study landing sites in the year 2008 (Source: Fisheries Department)

As indicated earlier, majority (68.1%) of the respondents had more than 50% of their target species dependent on live coral and the reef matrix. Statistical correlation analysis shows that there is an inverse correlation between fish catches observed by respondents to be declining and sea surface temperatures. The results also show that, there is a positive correlation between rainfall and fish catches thus the findings led to rejection of the null hypothesis that there is no relationship between fish catches and climatic factors such as sea surface temperature, rainfall and wind. Fish catches are

inversely correlated to sea surface temperature and positively correlated to rainfall. Statistically significant correlation between environmental factors and fish abundance have been reported by Bell and Puter (1958), Cushing (1982) and Corten (1986). These findings are in consistent with previous studies by Moyle and Cech (2004) who reported that extremes in environmental factors, such as elevated water temperature, low dissolved oxgygen or salinity and pH, can have deleterious effects on fishes. Sumaila *et al.* (2011) also reported that distributions of marine organisms are generally dependent on optimal environmental conditions (e.g. temperature, oxygen, food availability), long-term changes in temperature and/or other ocean conditions often coincide with observed changes in distribution and fisheries. Murry *et al.* (2005) Suggested that different fish species will vary in their abundance based on their optimum temperature ranges. He further said that increased temperatures will not only affect the productivity of some marine areas but will also have a negative impact on associated marine ecosystems such as coral

General circulation models estimate that by the year 2030 the mean global temperature will increase within the range 0.5 - 4.5ºC, (Bolin et al, 1986, IPCC, 1990). This may appear small, but even the lower end of this range, if achieved, would cause major changes in regional climate. Specifically, such regional climate change, when coupled with an increase in frequency and intensity of extreme weather events such as floods, droughts and cyclones, will have considerable impact on communities and their socio-economic well-being (Alusa and Ogallo, 1992).

4.5 Coping Mechanisms of Fishers' to Climate Variability

This section focuses on coping strategies employed by small-scale fishers to address climate variability, the effectiveness of this coping strategies and capacities in place by relevant institutional stakeholders to deal with current climate variability and future climate extremes in the study areas. In trying to assess the effectiveness of adaptive and current coping strategies three areas were visualized independent of each other. These included current coping strategies against increased sea level rise/ floods; winds; and temperature.

4.5.1 Coping Strategies to Reduce Current Vulnerability to Recurrent Hazards and Future Climate Extremes

In order to cope with the adverse effects of sea level rise, temperatures and winds, the households practiced various adjustments.

Respondents were asked to indicate what they did when uncertainties due to climate variability persisted. Figure 4.46 shows that, 41% of the respondents in both study sites developed different strategies to cater for uncertainties, 58% reported that they would stay as fishers no matter what, while 1% said fishing is the employment of the last resort. The results imply that, whereas some of the respondents developed coping strategies to deal with climate variability, others did not have any alternatives to fishing and indicated that they were reluctant to move out of fishing activities.

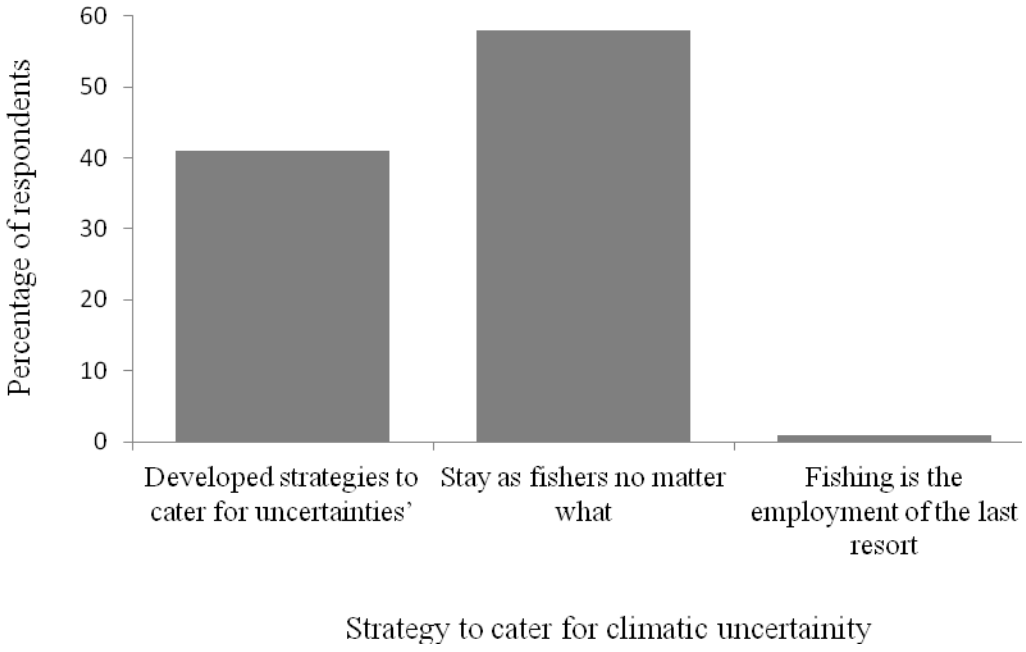

Figure 4.46: Fishers' response to climatic uncertainties

4.5.1.1 Coping Strategies to Climate Variability on the Harvesting Sector

Table 4.29 presents data on the coping strategies adapted by the fishers during the 1997/8 El Niño period and their effectiveness. In this study, effectiveness of coping strategies was indicated in terms of number of Kg of fish catch caught per day during this period with low being less than 5Kg, average 6-10 Kg and high above 10 Kg. Mitlewski *et al.* (1999) reported that, fishers in Emas working in pairs catch up to 40

Kg per day in high season but in the rest of the year they catch up to 15 to 20 Kg per day. In the Pantanal of Mato Grosso do Sul, Catella (2001) estimated the mean catch of the professional fishers at 12.5 Kg per day (Netto, 2006).

Table 4.29: Respondents' coping strategies to climate variability

Coping Strategies	**Ratio**	**Effectiveness (%)**		
Rainfall variability (floods)	**(%)**	**Low (< 5kg)**	**Average (6-10 kg)**	**High (>10kg)**
Use of the same gear but fishing inshore	38.1	56.6	33.7	9.6
Changing gear while investing in modified gear and equipment (increasing efficiency of gear)	9.6	14.3	61.9	23.8
Venturing further into the sea (offshore)	8.3	22.2	56.6	22.2
Increase number of crew (additional labor)	6.9	20	46.7	33.3
Change fishing times including going to fish early	13.3	34.5	48.3	17.2
Increasing effort at sea or fishing power (areas fished and spending more hours at sea)	11.5	24	52	24
Avoid fishing altogether -exit the fishery	16.9	0	0	0
Alternative livelihoods (several income generating activities)	6.0	0	0	0
Diversification within the fisheries sector that is use of multiple gears or species	4.6	30	60	10
Wind variability				
Increased financial capital (investing in boats with bigger engines and more fuel for going further to open sea)	7.8	41	35	24
Avoid fishing during strong winds	29.7	0	0	0
To track changes in seasonal and spatial variations including going fishing early Change fishing location	10.0	18.5	66.7	14.8
Change fishing location	52.5	23.5	41.2	35.3
Temperature Variability				
Invest in boats with refrigeration	15.1	15.2	54.5	30.3
Improve fish processing (drying, smoking fish to preserve)	78	20	80	0

i) Diversification in Fishing Equipment

Diversification is the process by which a household increases its number of income-generating activities, both inside and outside of fisheries. Ellis (2000). Often studied in association with adaptation, diversification is a household risk management strategy used to spread risk, smooth the effects of temporal variations in access to resources, and reduce vulnerability (Allison and Ellis (2001), Hoorweg *et al.* (2008). Respondents were asked to indicate whether they had changed gear during the 1997/8

El Niño period as a coping strategy to increased rainfall (floods) variability. El Niño and La Nina are associated with physical and biological changes in the ocean that affect fish abundance. Results show that majority (90%) of the respondents did not change gear during this period. Only 9.6% of the respondents changed gear by investing in modified gear and equipment. Out of the respondents who changed gear, majority (61.9%) indicated this strategy to be average in effectiveness with most of them getting catches averaging 6-10 Kg. About 23.8% of the respondents indicated this strategy to be high in effectiveness with fish catch averaging more than 10 Kg while a few (14.3%) respondents indicated this strategy to be low in effectiveness with fish catch of less than 5Kg. The average and high effectiveness of this strategy may be explained by the fact that respondents who had invested in better equipment were able to go further into the sea or change fishing grounds and were therefore able to get better catches. Those who indicated low effectiveness perhaps did not change fishing grounds.

In terms of diversification within the fisheries sector, i.e., use of multiple gears or targeting more species, few (4.6%) of the respondents indicated to have used this strategy. Of the respondents who used this strategy, majority (60%) of the respondents indicated this strategy to have been average in effectiveness, followed by 30% who indicated it to be low in effectiveness. About 10% indicated this strategy to be high in effectiveness. The average and high effectiveness of this strategy may be explained by the fact that, the respondents who used this strategy were able to target more species or perhaps, spend more time at sea and were therefore, able to get more catches compared to the others. Most (90%) of the respondents explained not changing gear due to lack of finances. Previous studies by McCay *et al.* (2011), .report that in the Pacífico Norte area of Baja California during and after El Niño events, some cooperatives diversified from lobster and abalone to include other taxa such as finfish, whelk, sea cucumber, and sea urchin.

4.5.1.2 Relationship between Education Level, Age, Period in Fishing and Diversification of Fishing Equipment as a Coping Strategy to Increased Rainfall

Cross tabulations and χ^2test results did not show significant associations between education level (χ^2= 3.056, df 4, P> 0.05), age (χ^2= 0.138, df 2, P> 0.05), period in

fishing (χ^2= 5.977, df 6, P> 0.05) and investing in better equipment as a coping strategy to increased rainfall variability (Tables 4.30-32. The lack of significance may be explained by the fact that very few respondents had invested in better equipment as a coping strategy.

Table 4.30: Relationship between fisher education level and investing in better equipment as a coping strategy to increased rainfall variability

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.056[a]	4	0.548
Likelihood Ratio	3.614	4	0.461
Number of Valid Cases	21		

a. 8 cells (88.9%) have expected count less than 5. The minimum expected count is .29.

Table 4.31: Relationship between age and investing in better equipment as a coping strategy to increased rainfall variability

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.138[a]	2	0.933
Likelihood Ratio	0.136	2	0.934
Number of Valid Cases	21		

a. 5 cells (83.3%) have expected count less than 5. The minimum expected count is 1.00.

Table 4.32: Relationship between period in fishing and investing in better equipment as a coping strategy to increased rainfall variability

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	5.977[a]	6	0.426
Likelihood Ratio	7.004	6	0.32
Number of Valid Cases	21		

a. 11 cells (91.7%) have expected count less than 5. The minimum expected count is .14.

i) Diversification in Fishing Grounds

In terms of diversification of fishing grounds, 38.1 % of the respondents indicated to use the same gear but fish inshore as a coping strategy to increased rainfall variability. Out of those who used this strategy, majority (56.6%) indicated this strategy to be low

in effectiveness with an average fish catch of less than 5Kg. About 33.7% of the respondents indicated this strategy to be average in effectiveness with an average fish catch of between 6-10 Kg. Only 9.6% of the respondents indicated this strategy to be high in effectiveness with an average fish catch of more than 10 Kg. The low effectiveness of this strategy may be explained by the fact that there may have been too many fishers on the fishing grounds competing for the same fishery resources. Further, the respondents may have spent less time on the fishing grounds compared to the others. For the respondents who indicated average and high effectiveness of the strategy it may be attributed to additional labour going fishing earlier than the others. Previous studies by Allison and Ellis (2001), report that in coastal artisanal fisheries, Galicia (northeast Spain) fishermen used diverse pattern of fishing activities with respect to the species exploited, location of fishing grounds and gear used to deal with fluctuating environmental conditions.

4.5.1.3 Relationship between Education Level, Age and Period in Fishing and Using Same Gear but Fishing Inshore as a Coping Strategy to Increased Rainfall

Similarly, cross tabulations and χ^2 test results did not show significant associations between education level (χ^2= 8.346, df 6, P> 0.05), age (χ^2= 1.323, df 2, P> 0.05), period in fishing (χ^2= 1.210, df 6, P> 0.05) and using the same gear but fishing inshore as a coping strategy to increased rainfall variability (Tables 4.33-35).The lack of significance may perhaps be explained by the low number of fishers who used this strategy.

Table 4.33: Relationship between fisher education level and using same gear but fishing inshore as a coping strategy to increased rainfall variability

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.346[a]	6	0.214
Likelihood Ratio	8.986	6	0.174
Number of Valid Cases	83		

a.7 cells (58.3%) have expected count less than 5. The minimum expected count is .19.

Table 4.34: Relationship between age and using same gear but fishing inshore as a coping strategy to increased rainfall variability

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.323[a]	2	0.516
Likelihood Ratio	1.278	2	0.528
Number of Valid Cases	83		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 2.70.

Table 4.35: Relationship between period in fishing and using same gear but fishing inshore as a coping strategy to increased rainfall variability

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.210[a]	6	0.976
Likelihood Ratio	1.1	6	0.982
Number of Valid Cases	83		

a. 7 cells (58.3%) have expected count less than 5. The minimum expected count is .48.

i) Increasing Fishing Distance (Venturing into the Open Sea)

The changes in the near-shore waters and the decline of fish catches may necessitate shifting fishing operations to the offshore and deep sea. Few (8.3%) of the respondents indicated to have ventured further into the sea as a coping strategy to deal with reduced fish catches. Out of those who used this strategy, majority of the respondents (56.6%) indicated this strategy to be average in effectiveness. About 22.2% indicated the strategy to be high in effectiveness while 22.2% indicated the strategy to be low in effectiveness. The average and high effectiveness of this strategy may be explained by the fact that perhaps those who ventured into deep sea had better equipment and were therefore able to get better fish catches. Those who indicated the strategy to be low in effectiveness may have had poor fishing equipment which contributed to reduced fish catches.

ii) Increasing the Number of Crew

Reduced fish catches may force fishers to increase the number of crew or additional labour so as to meet their target in terms of fish catch. With regards to the fishers adding crew to fishing expeditions, very few (6.9%) of the respondents adopted this strategy to deal with the increased variability in yield. Out of those who used this strategy, whereas 46.7% of the respondents indicated this strategy to be average in

effectiveness, 33.3% indicated it to be high in effectiveness and 20% indicated it to be low in the effectiveness.

iii) Increasing Fishing Effort, Changing Times of Fishing and Exiting the Fishery

About 11.5% of the respondents indicated to increase fishing effort to deal with reduced fish catch. They did this by increasing the areas fished and spending more hours at sea. Out of those who used this strategy, 52% of the respondents indicated this strategy to be average in effectiveness, 24% low in effectiveness and a further, 24% indicated this strategy to be high in effectiveness.

About 13.3% of the respondents deal with rainfall variability by going fishing early in order to reduce risks. Most (48.3%) of the respondents indicated this strategy to be average in effectiveness, 17.2% indicated it to be high in effectiveness while 34.5% indicated it to be low in effectiveness. In terms of exiting the fishery, 16.9% of the respondents used this strategy to deal with actual reduced catch rates. Previous studies by Cinner *et al.* (2009a ; 2012), in the West Indian Ocean region on fishers' responses to four hypothetical scenarios on declining catch rates showed that most respondents in Kenya and Mauritius would stop fishing in the event of 50% decline in fish catch rates compared to those who would fish harder, change gear or change location. However, actual results in this study showed that only 16.9% of respondents exited fishing in response to reduced catch rates. A study of entry and exit from L. Victoria emphasized the role of flexibility of fishers, concluding that many continued fishing because of a lack of livelihood alternatives, or economic inflexibility (Ikiara and Odink, 2000).

iv) Alternative Livelihoods

One indicator of livelihood flexibility is whether respondents engaged in multiple occupations. The results indicate that 6% of the respondents said that they had sought alternative livelihoods to deal with increased rainfall variability. Out of the respondents who sought alternative livelihood options, 45% opted to do small businesses, 15% farming, 28% formal employment, 8% aquaculture (Photo 1) while 4% indicated other activities. Allison and Ellis (2001) report similar findings in coastal artisanal fisheries for small pelagic species South Java, Indonesia, where

fishers' switch between rice-farming, tree-crop farming and fishing in response to seasonal and interannual variations in fish availability and Lake Victoria, Kenya, where fishing and farming (and livestock herding) have become inextricably linked over many generations in the overall objective of achieving household nutritional security.

Photo 4.1: Fishers constructing fish ponds at Kidongo as an alternative livelihood. *(Photo by B. Akunga)*

4.5.2 Coping Strategies to Wind Variability

In terms of coping strategies to wind variability, few (7.8%) of the respondents indicated to have increased financial capital (investing in boats with bigger engines and more fuel to go further to open sea). Out of those who used this strategy, 35.3% indicated this strategy to be average in effectiveness, 41.2% indicated it to be low in effectiveness while 23.5% indicated it to be high in effectiveness. The results suggest that at least more than half of the respondents were able to go to better fishing grounds because they had better equipment and were therefore able to get better catches. These results would imply that these fishers would cope better during strong winds.

About 29.5% of the respondents avoid fishing during strong winds while 10.2% goes fishing early to deal with wind variability. Out of those who went fishing early, 66.7% indicated this strategy to be average in effectiveness, 18.5% low while 14.8% indicated it to be high in effectiveness. Most of the respondents use simple fishing vessels to carry out fishing activities. Strong winds therefore hindered their activities and therefore most respondents opted to go fishing early as a coping strategy.

The results support the findings of Nagy *et al.* (2006) who reported that fishermen had learned a cautious behaviour to avoid weather related risks thus reducing their vulnerability.

4.5.2.1 Migration as a Coping Strategy

Climate variability can be considered as a factor that changes households' vulnerabilities while migration is one possible strategy in response to climate variability. The study revealed that, fishers employed different coping strategies such as relocating temporarily to another fishing site to deal with climate variability. Figure 4.47 shows that, 52.5% of the respondents indicated to have migrated during their fishing career while 47.5% had not migrated. These findings are similar to those by Fauzi and Anna (2010) who argue that fishers employ a variety of techniques such as temporal and seasonal migration and income diversification to cope with uncertainty.

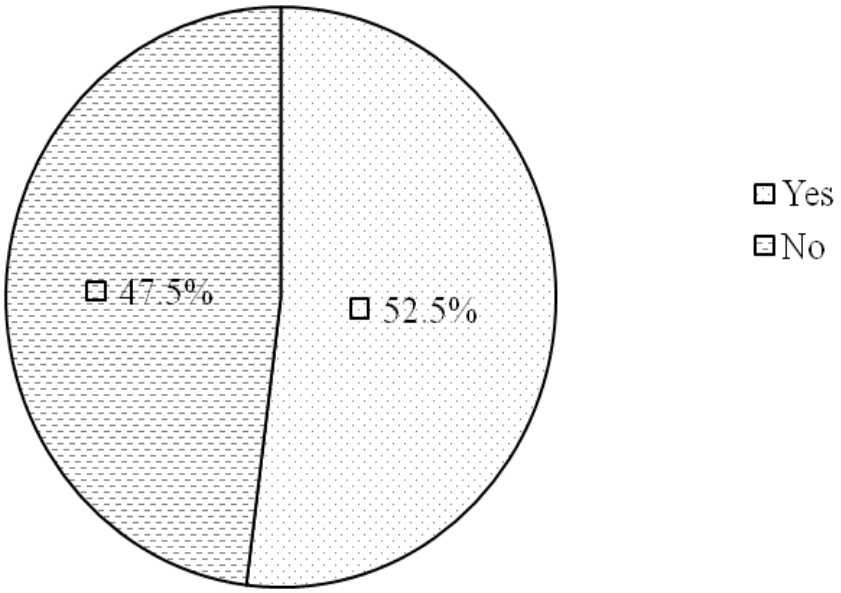

Figure 4.47: Fishers' migration during their fishing career

Majority (76%) of respondents indicated to have migrated during the South East Monsoon winds as opposed to during the North East Monsoon winds (24%) (Figure 4.48).

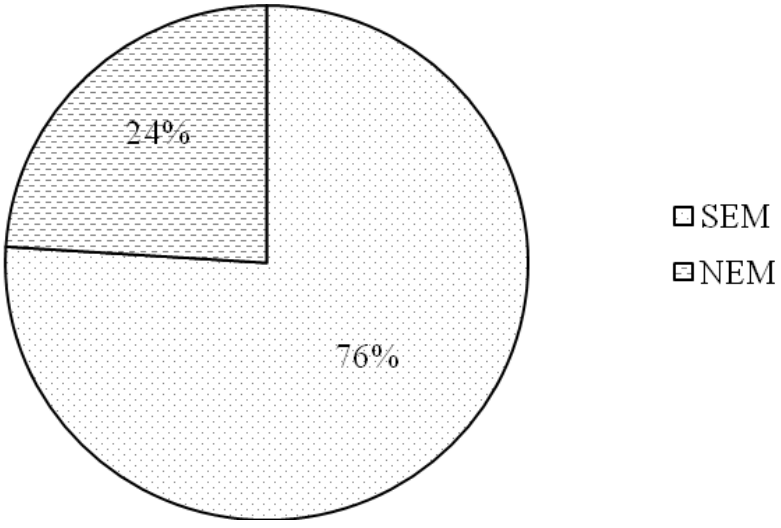

Figure 4.48: Period of movement

Most of the respondents who had migrated indicated the main reason to have been changes in yield in their fishing grounds. Migration occurs both within Kenya and from neighbouring countries into Kenya. Crona et al. (2010), observed that the

destination of Tanzanian migrants were the districts of Msambweni (Gazi, Shimoni, Vanga, Jimbo), Tana delta (Kipini, Ozi and Ziwayuu), Malindi (Watamu, Mayungu, Ngomeni) and Kilifi (Takaungu, Mnarani) Kenya fishers also migrate to other areas. Kipini and Lamu are target areas for fishers migrating from Ngomeni, Watamu and Kilifi. Kipini fishers also go to Lamu. Fishers from South Coast moved north during the North East monsoon season to seek calmer waters. The Kenyan fishers who migrated seasonally along the coast were said to follow fish stocks or access calmer fishing waters during the South East monsoon winds. The long rains in Mombasa and Malindi are brought about by the South East monsoon winds and occur between April and June. The short rains which are brought about by the North East monsoon winds occur between October and December. Similar results were reported by Hernández and Rossi (2003) and Norbis *et al*., (2005) who report that, because of the spatial and temporal changes of the estuarine front and resource availability, as well as the increasing trend of river flows, many fishermen migrated seasonally or definitively away from the front along the coast following resources in order to reduce their long-term vulnerability to hydro-climatic fluctuations and avoid bad catch years.

4.5.2.2 The Migration Decision

The migration decision can be interpreted as a measure of the riskiness of the households' environment and a possible insurance to climatic stresses. Figure 4.49 shows that 45% of the respondents indicated that the owner of the vessel made the migration decision, 34% indicated to have made the decision to migrate on their own, while 21% indicated that both the owner and the respondent were involved in the decision to change fishing grounds.

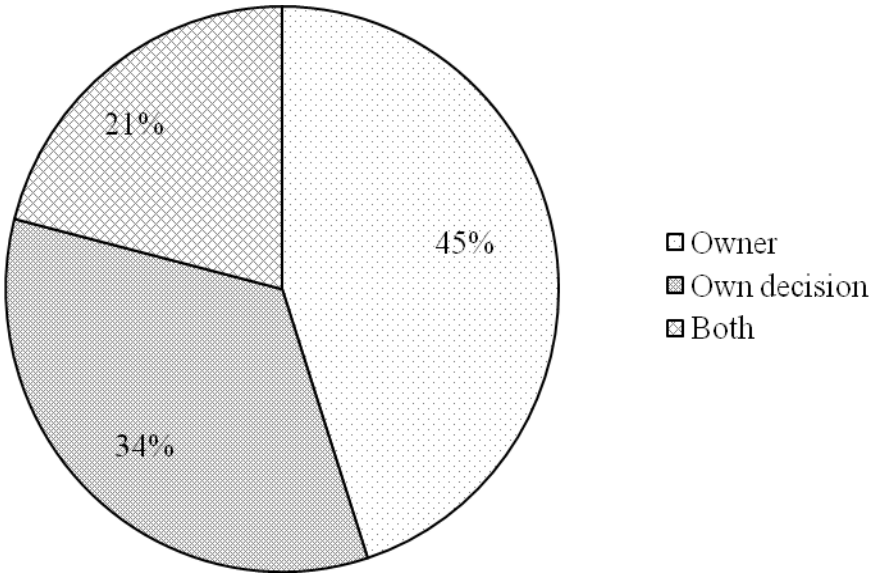

Figure 4.49: Migration decision by respondents

Those who had never migrated were asked to give reasons against migration. Reasons for not migrating ranged from no new opportunities (50.1%), don't want conflict (56.3%), did not want to go (60%), cost of living high (66.1%), family attachment (68.4%) and species were good in their fishing grounds (78.5%) (Figure 4.50).

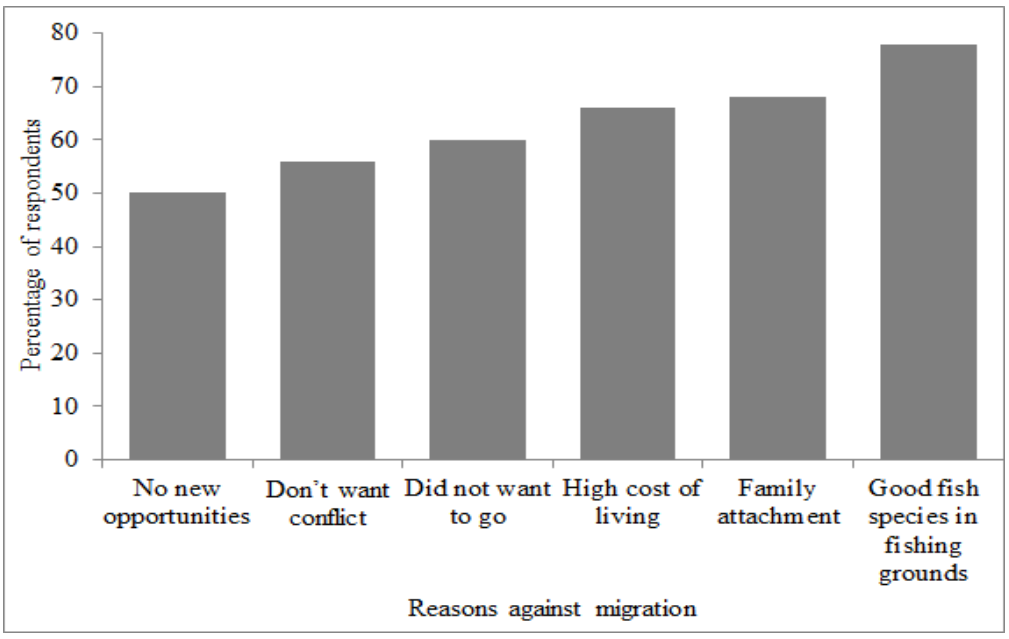

Figure 4.50: Reasons for not migrating

Out of the respondents who had migrated, 41.2% indicated this strategy to be average in effectiveness in terms of fish catches, 35.3 % indicated it to be high in effectiveness while 23.5% indicated it to be low in effectiveness. The results support findings by Allison and Ellis (2001) who reported that, full-time fishers from the north coast (Java Sea) villages track seasonal and spatial variation in fish stock availability with long shore and inter-island migrations.

4.5.2.3 Determinants that Influence Migration as a Coping Strategy to Climate Variability

Table 4.36 shows results of a binary logistic regression model on fitting determinants that influence migration as a coping strategy to wind variability. The results of the binary logistic model of selected variables indicates that, education, period in fishing, fishing distance, membership to an organisation and accessibility to credit facilities were not significant ($P>0.05$) determinants influencing migration as a coping strategy to climate variability. However, age and vessel ownership were significant ($P<0.05$) factors influencing migration. The results indicated that fishers who owned vessels were 0.122 times more likely to migrate than those who did not own vessels. This can perhaps be explained by the fact that vessels owners were able to make independent decisions and did not need to consult anybody to migrate unlike those who did not own vessels. Similarly, fishers who were below 35 years of age were 0.065 times more likely to migrate than those above 35 years of age. Respondents who were younger were considerably freer to move because they did not have family attachments. Respondents who had formal education were 1.08 times more likely to migrate than those who had no education. This may be explained by the fact that those who had formal education could get alternative livelihoods compared to those who had no formal education and therefore were able to take the risk to migrate The study further found out that those who had incomes less than Ksh 10,000 were 2.7 times more likely to migrate than those who had incomes of more than Ksh 10,000.. These results could be explained by the fact that respondents with limited financial resources were more likely to migrate in an effort of looking for alternative livelihoods to improve their welfare.

Table 4.36: Determinants of migration as a coping strategy to climate variability

Explanatory variables	B	S.E.	Wald	df	p-value	Odds ratio
a) Education	0.08	0.703	0.013	1	0.909	1.083
b) Age	-2.73	1.062	6.614	1	*0.01	0.065
c) Period in fishing	0.095	0.724	0.017	1	0.895	1.1
d) Fishing distance	-1.239	0.661	3.518	1	0.061	0.29
e) Vessel ownership	-2.106	0.941	5.003	1	*0.025	0.122
f) Member of organisation	-0.665	0.774	0.739	1	0.39	0.514
g) Access to credit	0.175	0.593	0.088	1	0.767	1.192
h) Income	0.998	0.533	3.501	1	0.061	2.713
Constant	4.478	1.89	5.612	1	0.018	88.079

The findings led to the failure to reject the null hypothesis that there is no significant association between education level and period in fishing and migration and gear as coping strategies to climate variability. However, age and vessel ownership had a significant influence on migration as a coping strategy. Previous studies by Bird and Deshingkar (2009), Connel *et al.* (1976), Dayal and Karan (2003) and Moss *et al.* (2005) report a very high migration rate among illiterates or those with a very low level of education among fishers. Djamba *et al*. (1999), Yang and Guo (1999) considered age to be an important predictor of migration.

4.5.3 Coping Strategies to Temperature Variability

Technology can potentially play an important role in adapting to climate variability and change. Efficient cooling systems solutions represent some of the options that can lead to improved outcomes and increased coping under conditions of increased temperature variability. In terms of coping strategies to increased temperature variability, 15.1% of the respondents indicated that they had invested in boats with refrigeration to deal with postharvest losses while 78% indicated to have made improvements in fish processing in terms of drying and smoking of fish to minimise post-harvest losses. Out of 15.1% who invested in boats with refrigeration, 54.5% indicated this strategy to be average in effectiveness, 30.3% indicated it to be high in effectiveness while 15.2% indicated it to be low in effectiveness. The results imply that most (74.8%) of the respondents indicated investment in refrigerated boats as an effective way in coping with temperature variability. Refrigeration increased the shelf

life of the fish products and hence they were able to minimise post-harvest losses. Out of the 78% respondents who indicated to invest in improving fishing processing (drying and smoking), 80% of the respondents indicated this strategy to be average in effectiveness while 20% indicated this strategy to be low in effectiveness. Similarly, those who processed their fish in terms of drying and smoking increased the shelf life of their fish products and were hence were able to get better financial returns since they minimised post-harvest losses.

4.6 Institutional Capacities in Place to Cope with Climate Variability

4.6.1 Institutional Support to Respondents

Institutions may influence livelihoods in many ways: for instance, the access that people have to assets, the benefits they derive from them, as well as incentives for the development of assets, depend upon institutional arrangements. Institutions in their different forms play an important role in dealing with the vulnerabilities of local people to climate variability. To assess the role of institutions in facilitating adaptation, respondents were asked whether they had received any external interventions to support their households during times of climatic related stresses. Figure 4.51 shows that, few (18.2%) of the respondents had received external intervention during times of climatic stresses.

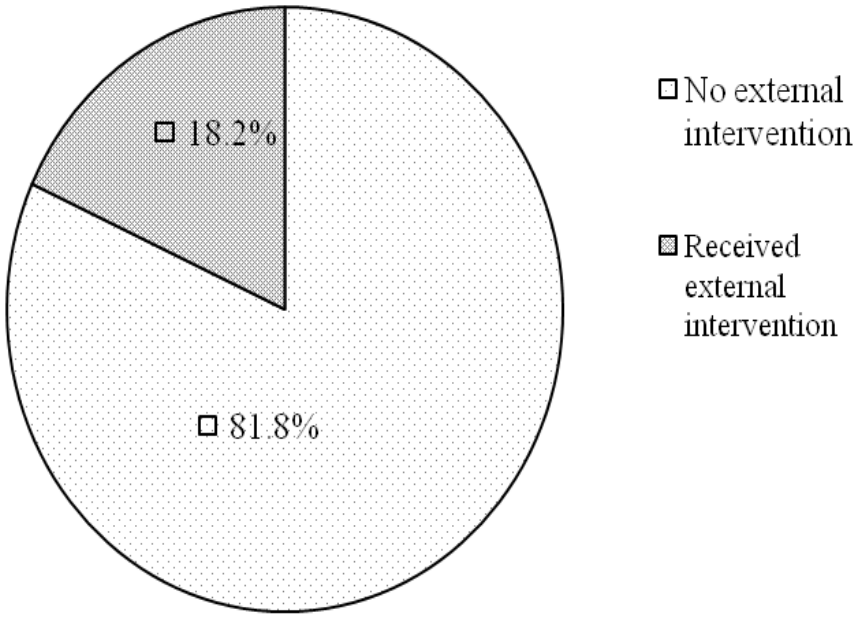

Figure 5.51: External intervention received during climatic stresses

The type of assistance respondents received from the various institutions to help reduce unpredictability associated with climate events ranged from production support (10.2%), market support (34.6%), access to weather information and knowledge, i.e., provision of early warnings (48.1%), food aid (10%), information and training / skills development (24.2%) (Figure 4.52).

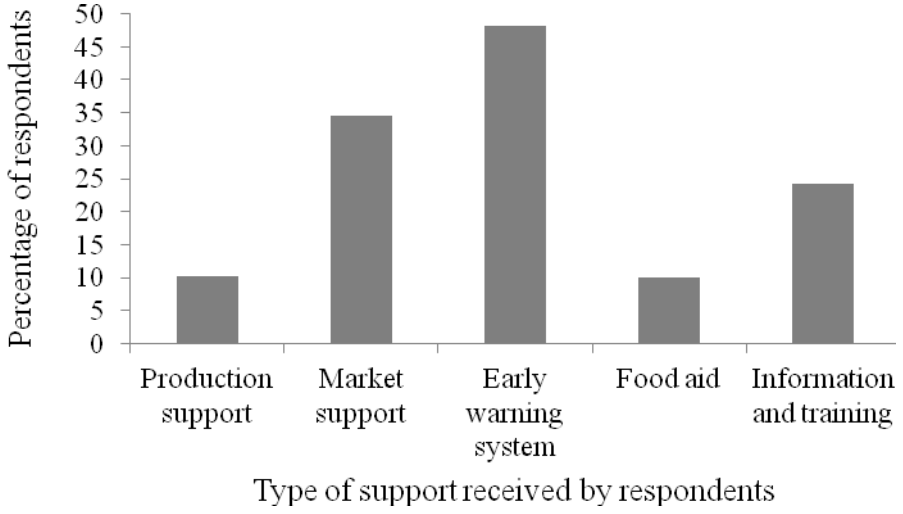

Figure 4.52: Type of support received from various institutions

4.6.1.1 Production Support

Results show that production support ranged from fishing equipment, e.g., boats, nets, coolers (10.2%), construction of landing sites (19.5%), and credit (5.9%). Most (56%) of the credit that the respondents received came from informal institutions. The credit received acts as social safety nets that seek to protect households against income shocks. Fulanda *et al.* (2009) and Crona *et al.* (2010) report that access to credit from financial institutions is difficult for many coastal people, particularly for fishers.

4.6.2 Risk Reduction Initiatives by Institutions

Risk reduction initiatives seek to address vulnerabilities through early warning systems and reducing risk exposure by enhancing coastal and flood defences, including natural ones that also help to enhance ecological resilience.

4.6.2.1 Access to (and Provision of) Information on Risk Reduction

The availability and access to information such as early warning systems, could contribute to a more robust adaptive capacity among fisher populations. Respondents were asked to assess the effectiveness of the current capacities of public institutions in dealing with climatic stresses and establish whether access to knowledge and information on weather and climate forecasts has facilitated coping mechanisms among small-scale fishers. Figure 4.53 shows that whereas 49.1 % (n=107) of the respondents indicated that the Metrological Department provides early warnings to fishers, 32.1% (n=70) indicated it provides real time flow of information, while 18.8% (n=41) indicated not to know.

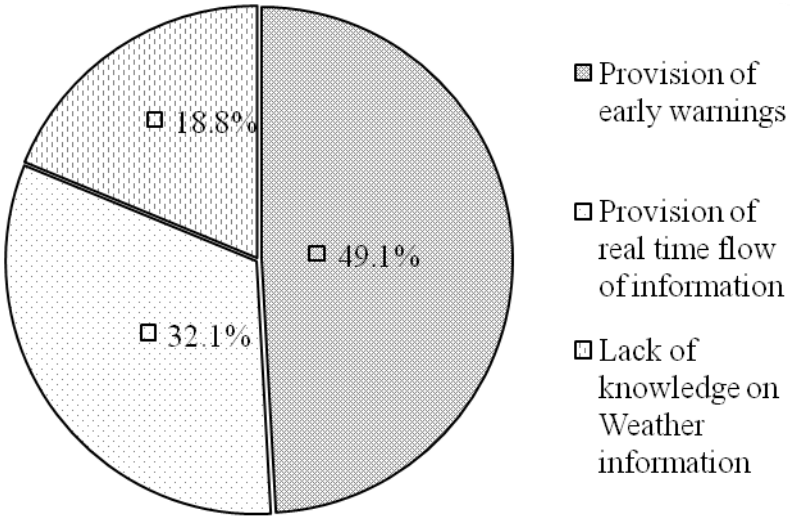

Figure 4.53: Fishers' opinion on type of information provided by Metrological Department

Table 4.37 shows the rating of fishers of the Metrological Department to provide early warnings. The majority (63.8%) of the respondents rated it to be low in effectiveness, 30.2% rated it to be medium while 6% rated it to be high in effectiveness. Majority (61.5%) of respondents who had primary education rated Metrological Department to be low in effectiveness in provision of early warnings to fishers, 34.1% rated them to be medium while 4.4% rated them to be high. Similarly, 47.4% of the respondents who had secondary education rated them to be low in effectiveness, 36.8% rated them to be medium while 15.8% rated them to be high. Further, 80% of the respondents who had tertiary education rated Metrological Department to be high in effectiveness in provision of early warnings to fishers while 20% rated them to be medium. None of the respondents rated them to be high in effectiveness. Probably the low rating is because of the low standard of education among fishers such that they may be expecting the Metrological Department to give them daily of hourly forecasts.

A cross tabulation between education level and access to climate information on early warnings showed that there was no significant association (χ^2= 8.862, df = 6, P> 0.05) observed between education level and access to climate information on early warnings (Table 4.38). Probably the low rating may also be attributed to the low standard of education among fishers such that they may be expecting the Metrological Department to give them daily or hourly forecasts.

Table 4.37: Relationship between education level and climate information on early warnings

		Provision of early warnings			
		Effectiveness			
Education	**Percentage within either education or provision of early warning**	**Low (0-30%)**	**Medium (36-70%)**	**High (above 70%)**	**Total**
Primary	Count	83	46	6	135
	Education	61.5%	34.1%	4.4%	100.0%
	Provision of early warning	59.7%	69.7%	46.2%	61.9%
Secondary	Count	9	7	3	19
	Education	47.4%	36.8%	15.8%	100.0%
	Provision of early warning	6.5%	10.6%	23.1%	8.7%
Tertiary	Count	4	1	0	5
	Education	80.0%	20.0%	0.0%	100.0%
	Provision of early warning	2.9%	1.5%	0.00%	2.30%
No formal education	Count	43	12	4	59
	Education	72.9%	20.3%	6.80%	100.0%
	Provision of early warning	30.9%	18.2%	30.8%	27.1%
Total	Count	139	66	13	218
	Education	63.8%	30.3%	6.0%	100.0%
	Provision of early warning	100.0%	100.0%	100.0%	100.0%

Table 4.38: Relationship between education level and climate information on early warnings

	Value	**Degrees of freedom**	**Asymp. Sig. (2-sided)**
Pearson chi-square	8.862 (a)	6	0.181
Likelihood ratio	8.506	6	0.203
Number of valid cases	218		

a 5 cells (41.7%) have expected count less than 5. The minimum expected count is .30.

The study sought additional information from relevant key informants with regards to strategies that the government is taking to deal with current vulnerability to recurrent climate hazards and future climate risks that may affect small-scale fishers and initiatives to enhance local adaptive capacity. The study ascertained that the government had put in place strategies to deal with current climate vulnerability to recurrent hazards that affected small-scale fishers. These strategies are discussed below.

4.6.3 Contribution to Adaptive Capacity

Building capacity to cope with environmental stresses is an important step towards adapting to climate change. It emerged from key informants that climate knowledge is accumulated through observation; monitoring and analysis and this information is shared between scientists, managers and fishermen. Among the top-down adaptive strategies cited by key respondents included climate prediction technologies at institutional levels. The Metrological Department is running models for current climate change and future scenarios, strengthening disaster early warning systems, expanding observation data network and developing data archives. They are also doing capacity building on human capital, e.g., offering trainings for staff on climate issues, e.g., weather forecasting.

With regards to enhancing local adaptive capacity, some key stakeholders were involved in initiatives to increase the participation of stakeholders in adaptation efforts by encouraging community participation in afforestation programmes and protection of existing natural barriers. Some of the programmes they are involved in dealing with climate variability issues include; Miti Mingi (Kwale and Taveta), Kazi kwa Vijana (introduced in all counties) – where youth are involved in afforestation programmes (Likoni, Jomvu), farm forestry, where farmers are encouraged to plant trees on their farms as a way of reducing pressure on mangrove cutting. The Kenya Forest Service (KFS) has encouraged communities to establish community forest associations of which beach management units are also members. Through these CFAs, sensitization on mangroves and sustainable use of mangroves is carried out. Gazi community forest association is running a programme on carbon credit scheme. Adger *et al.* (2005) report that in Sri Lanka, natural barriers such as sand dunes, mangrove forests and coral reefs dampened the energy of the Indian Ocean tsunami waves helping to protect some coastlines from their full impact.

4.6.4 Information Dissemination

Key stakeholders were also involved in dissemination of climate research information through peer-reviewed journals, reports and articles in newspapers and magazines, conferences, seminars, annual fisheries fora and increasing communication between different stakeholders through using local language networks, e.g., (RANET radio network).

The way in which a system generates, collects, analyses and disseminates knowledge is an important determinant of adaptive capacity. Early warning systems can help fishers assess potential risks, reduce lost or unproductive fishing days and ultimately reduce deaths (Badjeck *et al.,* 2010). Adger *et al.* (2005) reports that fishermen in the Bay of Bengal receive up-to-date weather forecasts and severe weather warnings via mobile phone messages, reducing the number of vessels caught at sea by typhoons. Improved communications are critical in reducing risks associated with increased weather variability and storms by providing early warning systems and timely weather forecasts (Allison *et al.*, 2007).

4.6.5 Technological Innovations

Some of the key informants were involved in supporting small-scale fishers in aquaculture and mari-culture activities. The Fisheries Department is actively involved in helping set up aquaculture farms, e.g., constructing fish ponds in the flooded areas in Mtwapa and Kidongo. Some of the key stakeholders interviewed also indicated to be involved in promoting alternative livelihoods activities, e.g., mari-culture and agriculture.

4.6.6 Research

Some of the key informants were involved in research in marine and fresh water fisheries, climate change and coral reefs, environmental and ecological studies.They did this in order to provide scientific data and information for sustainable exploration, management and conservation of fisheries resources and aquatic environment, and contribute to national strategies towards food security, poverty alleviation and creation

of employment.

4.6.7 Marketing and Production

The Fisheries Department was involved in enforcing current fisheries regulations and putting in place necessary marketing infrastructure, i.e., cold storage facilities in Vanga, Malindi, Mombasa and Lamu to deal with postharvest losses as an adaptation strategy to climate variability. The Department is also encouraging fishers to invest in boats with bigger engines to venture into the deep sea.

4.6.8 Policy

About 56.3% of the respondents said that climate information has not been adequately factored into most of the sectors of the country's economy, including government developing policies and plans. In terms of the government piloting adaptation and capacity building in support of policy setting, planning and adaptation practices, it is doing this to a limited extent. The government has put in place the National Climate Change Response Strategy (NCCRS). The purpose of this strategy is to generate robust measures needed to address the challenges posed by the current climate variability and climate change. The government is yet to come up with a climate policy. NCCRS has identified key interventions in most of the sectors in the country. Some of the key interventions in coastal and marine fisheries ecosystems include:

i. The establishment of a biodiversity monitoring network to identify species that will be impacted by climate change and may assist in the identification of species that could be used as climate change indicator species.

ii. Developing regional-scale maps depicting which areas require shore protection (e.g., dykes, beach nourishment) and which areas will be allowed to adapt naturally.

iii. Analysis of the environmental consequences of shore protection and promotion of shore protection techniques that do not destroy all habitats.

iv. Improving early warning systems and flood hazard mapping for storms.

v. Protection of water supplies from contamination by salt water.

vi. Reduction of human impacts including sewage; deforestation, overfishing, coast line infrastructure on aquatic and marine ecosystems that will increase distance and reduce the capacity to resist and recover from climate change.

vii. Reforesting coastal and river catchments and wetlands, particularly those affected by extreme events such as cyclones.

viii. Stabilization of shorelines by establishing vegetation buffer zones at the sea fronts lakeshores, riverbanks, where mangroves and riparian vegetation occur.

ix. Encouraging a coastal and water shed basin management approach that links land - use practices to marine and fisheries resources.

x. Establishing networks of marine protected areas, including small community closures, comprising species resilient to climate change impacts. These can serve as buffer zones and for seeding regeneration.

xi. Implementation of adaptive management of fishing capacity using climate and environmental forecasts when possible. For extreme events, strengthen and utilize co-management and a broad ecosystem approach to obtain a healthy aquatic and marine ecosystem.

xii. Developing policies and laws that reduce emissions and increase carbon storage, and which promote an ecosystem based -management of fisheries.

xiii. Developing economic incentives to diversify livelihood options without dependence on climate sensitive marine resources.

xiv. Developing financing mechanisms using non-consumptive options for supporting marine ecosystem research and development, for example, the global carbon fund and biodiversity banking.

xv. Strengthening co-management and community-based management institutions and ability to enforce restrictions.

xvi. Undertaking biological engineering and restoration of stress tolerant organisms.

Some of the stakeholders noted that in terms of support and strengthening policies, knowledge and institutional capacity the government was doing this to a limited

extent. Some of the programmes and projects outlined in Kenya Vision 2030 in the Metrological Department include the Metrological Systems Modernisation Programme. The objective of this programme is to improve Kenya's disaster preparedness as mitigation as well as promoting public education awareness among vulnerable communities and decision makers.

Key in the policy, legal and institutional reforms in the Medium Term Plan of Vision 2030, is the transformation of Kenya Metrological Department (KMD) into a semi-autonomous government authority called Kenya Metrological Authority. The delinked Kenya Metrological Authority will be capable of generating and borrowing funds in order to offer more efficient and effective services within and outside the country.

The Forest Act 2005 and Kenya's Forest Draft Policy formulated in 2005, has several objectives which include: increasing forest and tree cover; conserving and rehabilitating the natural forest and woodlands for environmental protection and biodiversity conservation and enhancing participatory forest management. The current forest policy aims to promote sustainable management of forests to serve as water catchments, biodiversity conservation and carbon sinks.

The government through the Fisheries Department has developed the prawn fisheries management plan. There are plans to develop other fish management plans. In addition, adequate attention has been depicted towards the promotion of aquaculture in order to ease pressure in major water bodies. The government has substantially increased its funding towards aquaculture development during the last five years. Due to the perishable nature of fish, the government is putting in place the necessary marketing infrastructure to support fish production and marketing. Three cold storage facilities are under construction in Vanga, Malindi and Lamu.

4.6.9 Fiscal Policy

One of the objectives of the fiscal policy in the Medium Term Plan 2008-2012 of Kenya Vision 2030, was to increase government spending on poverty related outlays, improve the well-being of Kenyans by reducing poverty levels and minimize

inequality. This objective was not realised. Other objectives include improving access to markets, value addition, increase access to fisheries inputs, financial services, environmental education and awareness, and reduce losses due to floods, droughts, climate change and desertification.

4.6.10 The Integrated Coastal Zone Management Plan

Article 4 of the United Nations Framework on Climate Change commits nations, as part of their adaptation strategies, to developing integrated plans for coastal zone management (ICZM) to prevent climate change effects from eroding the benefits of development. ICZM strives to balance environmental, economic, and social, objectives within the limits set by natural dynamics. It aims to draw on the participation of all stakeholders to define and achieve these objectives and to resolve potential conflicts among competing interests. Intended to coordinate the relevant policy instruments and actors at multiple scales, and to guide planning that integrates short-term demands as well as medium- and long-range needs, ICZM is considered a suitable framework for climate change adaptation in coastal areas and forms an essential part of a national climate change plan. Such a plan would incorporate the management of risks associated with climate change such as sea level rise, erratic weather patterns, weather extremes and storms into broader development programmes. The concept of integrated coastal management (ICM), also referred to as coastal resource management (CRM), has been considered as the most appropriate framework for addressing current and long-term coastal zone management issues, including increasing poverty, loss of coastal habitats and resources, degradation of water quality, and adaptation to SLR and other impacts of global climate change. It is also a means for involving key stakeholders in identifying and anticipating future opportunities at the local/community level (Perez, 2003). Hence ICM is a key instrument in achieving sustainable development in coastal areas. Kenya has developed an ICZM Plan.

4.7 Interactions and Linkages

All the key informants indicated that they had linkages with the local community, other government institutions, research institutions, NGO's and regional universities. This is especially important for coordination of adaptive efforts. Ostrom (1990) indicates that the capacity of societies to adapt is boosted by connections across scales because local organisations gain knowledge and strength by connecting with national or local organisations.

4.7.1 Constraints to Adaptation

Observations from both the fishers and key stakeholders indicate that, whereas there seems to be accumulation of knowledge and information on climate variability by institutions, it is not sufficiently accessible to fishermen for them to reduce and adapt to current risk. It was further noted that fishers do not depend on the flow of information from the managers. Lack of both access to information and knowledge as well as lack of public awareness about current climate vulnerability were cited as the main constraints to adaptation. Other challenges expressed by key stakeholders included; lack of education of local leadership. It was indicated that most of the leaders were illiterate or semi-literate, therefore making the starting of projects and sustainability difficult. Pollution from industries along the coast and especially salt industries were also cited as constraints to adaptation efforts. Finally, financial limitation to carry out all projected programmes was cited as a key constraint to adaptation.

4.7.2 Mangrove Afforestation

Additional information on adaptation to climate variability was sought from focus group discussions**.** Participants from all the FGDs reported that they had faced negative impacts of sea level rise such as inundation of low lying areas, erosion of beaches, increased flood and storm damage. They indicated to have had a combination of planned and reactive adaptation measures to hydro-climatic variability as an adaptation option to increased sea level rise. Fishers, through their BMUs, were involved in mangrove planting which they cited as providing important services,

including acting as buffer against storms and providing important habitats for fish (see Photo 4.2).

Photo 4.2: Planting of mangroves (Kidongo) in Mombasa as an adaptation strategy to increased sea level. *(Photo by B. Akunga).*

4.7.3 Construction of Sea/Stone Walls

Some of the adaptations strategies cited by some of FGDs included construction of sea/stone walls as an adaptation strategy for protection against storm surges (Photo 4.3). Smit and Pilifososova (2001) and Daw *et al.* (2009) indicate this to be anticipatory adaptation that is initiated before expected impacts manifest. Some of the key stakeholders cited being involved in building ramps to prevent soil erosion as a result of increased sea level. However these may not be effective in the long run because they may actually interfere with the breeding grounds of fish.

Photo 4.3: Construction of a sea/stone wall at Ngomeni village in Malindi. *(Photo by B. Akunga).*

4.8 Fishers' Perceptions on Fish Abundance and Influencing Factors.

Fishers' perception of the influence of climate variability on fish abundance is the extent of their agreement to which variables such as rainfall, temperature and wind influence fish abundance. Fisher' knowledge of fish stocks is largely based on their observations during fishing, which generally takes place in certain seasons (Huntington, 2000).

4.8.1 Fishers' Opinion on Influence of Temperature Variability on Fish Abundance

Table 4.39 shows the opinion of fishers on temperature variability and its influence on fish abundance. . It was observed that majority (92.2%) of the respodents agreed that temperature variability had an influence on fish abundance. Most (79.4%) of the respondents strongly agreed, 12.8 % agreed, 3.2% were neutral, 2.3% disagreed while 2.3% strongly disagreed. These findings are similar to Daw *et al.* (2008) who noted that increased temperatures, causes reduction of fish yields. Rising temperatures render oxygen less soluble (Idvisi, *et al.,* 2003), thus, deoxygenation results into movement of fish into deep and cool waters.

Table 4.39: Fishers' opinion on influence of temperature variability on fish abundance

Respondents' Responses	Frequency	Percentage (%)
Strongly agree	173	79.4
Agree	28	12.8
Neutral	7	3.2
Disagree	5	2.3
Strongly disagree	5	2.3
Total	**218**	**100**

4.8.2 Fishers' Opinion on Influence of Rainfall Variability on Fish Abundance

Table 4.40 shows the opinion of fishers on rainfall variability and its influence on fish abundance. It was observed that majority (91.3%) of the respondents had the opinion that rainfall variability had an influence on fish abundance. Most (79.3%) of the respondents strongly agreed, 12.0 % agreed, 5.1% were neutral, 2.8% disagreed while 0.9% strongly disagreed. This findings concur with previous studies by Goudswaard, *et al.* (2002) which indicated that during spawning, lungfish population decreased when the breeding habitat are deteriorated by factors such as drought.

Table 4.40: Fishers' opinion on influence of rainfall variability on fish abundance

Respondents' Responses	Frequency	Percentage (%)
Strongly agree	172	79.3
Agree	26	12.0
Neutral	11	5.1
Disagree	6	2.8
Strongly disagree	2	0.9
Total	**218**	**100**

4.8.3 Fishers' Opinion on Influence of Wind Variability on Fish Abundance

Table 4.41 shows the opinion of fishers on wind variability and its influence on fish abundance. It was observed that majority (95.5%) of the respondents were of the opinion that wind variability had an influence on fish abundance. Most (84.9%) of the respondents strongly agreed, 10.6 % agreed, 1.8% were neutral, 1.8% disagreed while few 0.9% strongly disagreed. Trotman (2002) notes that extreme weather such as tropical cyclones can be very damaging to the fisheries industries as they cause

destruction on the fishing gear, fishing vessels and coral reefs which is a major setback to the fishing community due to reduced fish catch and by extension the general population.

Table 4.41: Fishers' opinion on influence of wind variability on fish abundance

Respondents Response	Frequency	Percentage (%)
Strongly agree	184	84.9
Agree	23	10.6
Neutral	4	1.8
Disagree	4	1.8
Strongly disagree	2	0.9
Total	**218**	**100**

4.9 Perception Determinants of Rainfall Variability as a Key Factor that may have a Direct Influence on Fish Abundance

The results of the estimated coefficients for the models showing perception determinants of rainfall variability, temperature variability and wind variability as key factors that may have an impact on fish abundance using ordinal logistic regression model are shown in Tables 4.42 – 4.44

Table 4.42 shows the estimated coefficients for the model showing perception determinants of rainfall variability as a key factor that affects fish abundance using ordinal logistic regression model .The Wald test statistic for the predictor period in fishing is (0.198, 0.281, and 0.155) with associated p-values of (0.657, 0.596 and 0.694). The Null hypothesis is that all regression coefficients in the model are equal to 0. In this case given that the alpha level was set at 0.05 we fail to reject the null hypothesis and conclude that the regression coefficients for period in fishing have not been found to be statistically different from zero in estimating rainfall variability as a key factor that influences fish abundance given education and age are in the model.

Similarly, the Wald test statistic for the predictor level of education is (0.196, 0.033, and 2.460) with associated p-values of (0.658, 0.855 and 0.117). Given that the alpha level is set at 0.05 we fail to reject the null hypothesis and conclude that the regression coefficients for level of education have not been found to be statistically

different from zero in estimating the perception fishers have on rainfall variability being a key factor that may influence the abundance of fish given period in fishing, and age are in the model.

Further, ordinal logistic regression model for the predictor age coefficient were not found to be statistically different from zero in estimating the perception fishers' have on rainfall variability being a key factor that may influence fish abundance. Wald test statistic for age 2.704 with an associated p- value of 0.100) respectively given the other predictors are in the model.

Table 4.42: Perception determinants of rainfall variability as a key factor that affects fish abundance

			Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
								Lower Bound	Upper Bound
Threshold	Rainfall effect	Strongly agree	0.783	0.75	1.092	1	0.296	-0.686	2.253
		Agree	1.779	0.766	5.394	1	0.02	0.278	3.281
		Neutral	2.716	0.81	11.248	1	0.001	1.129	4.303
		Disagree	4.16	1.012	16.886	1	0	2.176	6.144
		Strongly disagree	0	.	.	0	.	.	.
Location	Fishing period (years)	Less than 10	0.311	0.701	0.198	1	0.657	-1.062	1.685
		10 to 20	-0.344	0.65	0.281	1	0.596	-1.619	0.93
		20 to 30	-0.213	0.542	0.155	1	0.694	-1.275	0.849
		More than 30	0(a)	.	.	0	.	.	.
	Age (years)	18 - 35 years	-0.645	0.392	2.704	1	0.1	-1.414	0.124
		36 - 60 years	0(a)	.	.	0	.	.	.
	Education	Primary	0.178	0.402	0.196	1	0.658	-0.61	0.966
		Secondary	-0.123	0.673	0.033	1	0.855	-1.443	1.197
		Tertiary	1.652	1.053	2.46	1	0.117	-0.412	3.717
		None	0(a)	.	.	0	.	.	.

Link function: Logit a. This parameter is set to zero because it is redundant.

4.10 Perception Determinants of Temperature Variability as a Key Factor that Affects Fish Abundance

Table 4.43 shows the modelling of perception determinants of temperature variability as a key factor that affects fish abundance using ordinal logistic regression model. The ordinal logistic regression analysis appeared to show no relationship between the perception fishers have on temperature variability being a key factor that may influence fish abundance and perception determinants (education and experience in fishing) given that the alpha level is set at 0.05. The Wald test statistic for the predictor period in fishing is (0.002, 1.690, and 0.092) with associated p-values of (0.965, 0.194 and 0.761). The Null hypothesis is that all regression coefficients in the model are equal to 0. In this case alpha was set at 0.05 therefore we fail to reject the null hypothesis and posit that the regression coefficients for period in fishing have not been found to be statistically different from zero in estimating temperature variability as a key factor that influences fish abundance given education and age are in the model.

Similarly, the Wald test statistic for the predictor level of education is (0.960, 0.004 and 0.593) with associated p-values of (0.327, 0.948 and 0.441). Given that alpha level is set at 0.05 we fail to reject the null hypothesis and posit that the regression coefficients for level of education have not been found to be statistically different from zero in estimating the perception fishers have on temperature variability being a key factor that may influence the abundance of fish given period in fishing and age are in the model.

The Wald test statistic for the predictor age is 12.150 with an associated p- value of 0.000. There appears to be a relationship between age and the perception fishers have on temperature variability being a key factor that may influence the abundance of fish given period in fishing and level of education are in the model. Albernethy *et al.* (2007) suggest that older fishers have better knowledge about reef dynamics and natural resources than younger fishers. The results imply that the older fishers have better knowledge on how the reefs are impacted by temperature and hence influencing fish abundance.

Table 4.43: Perception determinants of temperature variability as a key factor that affects fish abundance

			Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
								Lower Bound	Upper Bound
Threshold	Temperature effect	Strongly agree	0.731	0.765	0.912	1	0.34	-0.769	2.23
		Agree	1.915	0.785	5.957	1	0.015	0.377	3.454
		Neutral	2.511	0.811	9.593	1	0.002	0.922	4.099
		Disagree	3.238	0.87	13.847	1	0	1.532	4.943
		Strongly disagree	0	.	.	0	.	.	.
Location	Fishing period (years)	Less than 10	0.033	0.772	0.002	1	0.965	-1.479	1.546
		10 to 20	-0.961	0.739	1.69	1	0.194	-2.411	0.488
		20 to 30	0.17	0.561	0.092	1	0.761	-0.929	1.27
		More than 30	0(a)	.	.	0	.	.	.
	Age (years)	18 - 35 years	-1.324	0.38	12.15	1	0	-2.069	-0.58
		36 - 60 years	0(a)	.	.	0	.	.	.
	Education	Primary	0.413	0.421	0.960	1	0.327	-0.413	1.238
		Secondary	0.046	0.704	0.004	1	0.948	-1.334	1.425
		Tertiary	1.026	1.333	0.593	1	0.441	-1.586	3.639
		None	0(a)	.	.	0	.	.	.

Link function: Logit a. This parameter is set to zero because it is redundant.

4.11 Perception Determinants of Wind Variability as a Key Factor that Affects Fish Abundance

Table 4.44 shows the modelling of perception determinants of wind variability as a key factor that affects fish abundance using Ordinal logistic regression model. The ordinal logistic regression analysis appeared to show no association between the perception fishers have on wind variability being a key factor that may influence fish abundance and perception determinants (education, age and experience in fishing) ($P > 0.05$). The Wald test statistic for the predictor period in fishing is (0.513, 1.157, and 0.149) with associated p-values of (0.474, 0.282 and 0.699). The Null hypothesis is that all regression coefficients in the model are equal to 0. In this case the alpha level is set to be 0.05, therefore, we fail to reject the null hypothesis and posit that the regression coefficients for period in fishing have not been found to be statistically

different from zero in estimating wind variability as a key factor that may influence fish abundance given education and age are in the model. There appears to be no relationship between the perception fishers have on wind variability being a key factor that may affect fish abundance and period in fishing.

Similarly, the Wald test statistic for the predictor level of education is (1.472, 0.350 and 2.816) with associated p-values of (0.225, 0.554 and 0.093). Given that the set alpha level is 0.05 we fail to reject the null hypothesis and posit the regression coefficients for level of education have not been found to be statistically different from zero in estimating the perception fishers have on wind variability being a key factor that may influence the abundance of fish given period in fishing and age are in the model. There appears to be no relationship between the perception fishers have on wind variability being a key factor that may affect fish abundance and education.

The Wald test statistic for the predictor age coefficient was not found to be statistically different from zero in estimating the perception fishers' have on wind variability being a key factor that may influence fish abundance (Wald test statistic for age 0.169 with an associated p- value of 0.681) given the other predictors are in the model. There appears to be no relationship between age and the perception fishers have on wind variability being a key factor that may affect fish abundance and age. Previous studies have shown that fishers' acquire ecological knowledge through observation, experience and interaction with local environment (Berkes and Folke, 2002). which is based on long term observations of the behavior of fish their interaction with the environment within a particular area, generated through activity participation in the fishing process (Berkes &Folke, 2002; Gosse, *et al.*,2001).

Table 4.44: Perception determinants of wind variability as a key factor that affects fish abundance

			Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
								Lower Bound	Upper Bound
Threshold	Wind effect	Strongly agree	1.748	0.869	4.045	1	0.044	0.045	3.451
		Agree	3.088	0.908	11.566	1	0.001	1.308	4.867
		Neutral	3.618	0.944	14.697	1	0	1.768	5.468
		Disagree	4.736	1.106	18.332	1	0	2.568	6.904
		Strongly disagree	0	.	.	0	.	.	.
Location	Fishing period (years)	Less than 10	-0.64	0.894	0.513	1	0.474	-2.392	1.112
		10 to 20	-0.792	0.736	1.157	1	0.282	-2.234	0.651
		20 to 30	-0.221	0.572	0.149	1	0.699	-1.343	0.9
		More than 30	0(a)	.	.	0	.	.	.
	Age (years)	18 - 35 years	-0.189	0.459	0.169	1	0.681	-1.089	0.711
		36 - 60 years	0(a)	.	.	0	.	.	.
	Education	Primary	0.608	0.501	1.472	1	0.225	-0.374	1.59
		Secondary	0.458	0.774	0.35	1	0.554	-1.059	1.975
		Tertiary	1.97	1.174	2.816	1	0.093	-0.331	4.271
		None	0(a)	.	.	0	.	.	.

Link function: Logit a. This parameter is set to zero because it is redundant.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study focused on three objectives. The first one was to determine the extent of climate variability (SST, rainfall and wind) experienced in the study area and its influence on fish catches and the livelihoods of fishing communities. The second objective was to investigate mechanisms developed by small-scale fishing communities to cope with their Vulnerabilities, factors influencing their coping strategies and institutional capacities in place to deal with current and future climate extremes. The third objective was to assess the perceptions of local small-scale fishers on fish abundance and influencing factors. This chapter, therefore, summarises the major findings of the study, presents conclusions and recommendations from the findings and finally, presents areas for further research.

5.2 Summary of Fishers Socio-Economic Characteristics

The study found out that most (61.5%) of the respondents in both study sites had attained primary education level with very few (1.8%) having attained tertiary education. Majority (77.1%) of the respondents' age ranged between 36 - 60 years of age with most of the respondents having been married. Most of the respondents had 3-5 dependants. With regards to fishing experience, majority (62.4%) of the respondents had been fishing for 20 – 30 years. Most (91.7%) of the respondents considered fishing as their main source of income with about (33%) of the respondents monthly fishing incomes being above Ksh 12,500.

5.3 Summary of Results

The first objective of this study was to determine the extent of climate variability (SST, rainfall and wind) experienced in the study area and its influence on fish catches and the livelihoods of fishing communities. Respondents observed that the current climate in the region was behaving differently compared to the past 10 or so years

with (i) increased temperatures over the years, (ii) changes in seasonal rainfall patterns (with sometimes very heavy rainfall or storms being experienced and sometimes delayed and little rainfall), (iii) strong winds and changed timings of winds. Period in fishing and monthly incomes were significant factors influencing fishers' perceptions on increased temperatures and changed timings of winds over the years. Additionally, monthly income was a significant factor influencing fishers' perceptions on delayed and reduced rainfall over the years.

In terms of livelihood assets, with regards to human capital, the study found out that most of the respondents in both study sites had attained primary education level with a few having received capacity building courses in the last 5 or so years. There was no significant association between gear type and education level and gear type and number of courses attended over the years.

With regards to financial capital, very few of the respondents in the study areas had life insurance, pension or access to loans. Inaccessibility to loans was attributed to lack of security and information about financial services. Education level had no significant effect on accessibility to loans but the level of income had.

With regards to social capital, most of the respondents belonged to local organisations with most of them reporting to have received help from these organisations during times of climatic stresses. In contrast, no significant associations were found between membership to an organization and gear type.

With regards to physical infrastructure, whereas the distribution of boats, mobile phones and potable water differed significantly across sites, but that of cars, motorcycles, bicycles, radios and televisions sets did not. Majority of the respondents rated the accessibility to infrastructural facilities (roads, electricity, water and fish landing sites) to be poor. Education level was not a significant factor influencing gear type.

In terms of natural capital, respondents indicated their main fishing zones to be within the creeks, coral reefs and open sea. Most of the respondents indicated to have observed decreased fish catches over the years with most of them attributing the decrease to increased pollution, increased fishers, increased temperatures, decreased

rainfall and sea level rise. More than half of the respondents indicated to target fish dependant on coral reef and the reef matrix. This would therefore, imply that increased temperatures will affect the livelihood of small-scale fishers. Most respondents indicated that their fish catch had reduced during the El Niño period of 1997/8 and that they neither changed gear nor targeted different species during this period. Statistical correlation analysis showed an inverse correlation between fish catches observed by respondents to be declining and sea surface temperatures. A positive correlation between rainfall and fish catches was observed.

The second objective sought to investigate the mechanisms developed by small-scale fishing communities to cope with their vulnerabilities, factors influencing their coping strategies and institutional capacities in place to deal with current and future climate extremes. The research found out that respondents in both study sites have developed various coping strategies to deal with climate variability. Migration was identified as an important coping strategy to climate variability. Few respondents had changed gear as a coping strategy to climate variability. Most respondents cited the coping strategies to be low to average in effectiveness. There were no significant association between education, period in fishing and gear and migration as coping strategies to climate variability. However, whereas, there was no significant association between age and gear, a significant association was observed between age and migration. Younger fishermen were more likely to migrate than older ones.

With regards to institutional capacities that are in place to cope with current climate variability and future climate extremes it was noted that key stakeholders were to some extent involved in adaptive strategies to climate variability. The adaptive strategies included; climate prediction technologies at institutional levels, capacity building, information dissemination, technological innovation and research.

The third objective was to assess the perceptions of local small-scale fishers on fish abundance and influencing factors. The ordinal logistic regression model of selected variables, education and experience in fishing were found not to be significant determinants influencing the perception small-scale fishers have on climate variables (temperature, rainfall and wind) being key factors that may have a direct influence on fish abundance. There appeared to be a relationship between age and the perception fishers have on temperature variability being a key factor that may influence the

abundance of fish given period in fishing and level of education were in the model. However, no significant relationships were observed between age and the other climate variables in the study.

5.4 Conclusions

The ultimate goal of the research is to influence the research and policy agenda to show that fisherfolk will be impacted in complex ways by climate variability and associated ecosystem and environmental variables that determine distribution, migration, and abundance of fish. The fisherfolk need to be increasingly aware of the issues that affect their livelihoods, which could result in a more targeted research approach and policy development.

The following conclusions are drawn from the study:

i. The study showed that there had been perceived and recorded variations in climate over the last 20 or so years. Period in fishing and monthly incomes were found to be significant determinants that influence the perception fishers have on increased temperatures and changed timings of winds over the years. Income level had a significant effect on accessibility of loans from institutions. There was no significant association between gear type and education level and gear type and number of courses attended.

ii. The study showed that small-scale fishers had to some extent adopted various coping strategies to deal with climate variability. A large number of respondents cited the coping strategies to be low to average in effectiveness. A significant association was observed between age and migration. There was no significant association observed between education level and access to climate information. It was further established that various key stakeholders had to some extent, put in place various strategies to cope with current climate variability and future climate extremes.

iii. The study indicated that education and experience in fishing determinants did not significantly influence the perception small-scale fishers have on climate variables (temperature, rainfall and wind) being key factors that may have a

direct impact on the abundance of fish. There appeared to be a relationship between age and the perception fishers have on temperature variability being a key factor that may influence the abundance of fish.

5.5 Recommendations

Given that education is important in helping fishermen to diversify their livelihoods in order to find supplementary income outside their fishing activities, the Government should aim at promoting free primary and secondary education among small-scale coastal fishing communities to increase their literacy rates.

The small-scale fishers need to be grouped into cooperatives (SACCOS) to enable them get cheaper credits. This will enable them adopt new technologies to help them adapt to climate extremes and diversify their livelihoods. This is vital for attempting to alleviate poverty and create sustainable livelihoods.

i. The current poor accessibility of service infrastructure is a great impediment to socio-economic growth. The Government should invest in public service infrastructure to facilitate fishing economic activities.

ii. The Government, through the Department of Fisheries should enhance management strategies that would reduce impacts of climate variation on fisher folk. These may include fisheries protection of juveniles through gear limitations, closed seasons and areas for enhancing stock productivity. The Department should also develop management plans for specific fisheries that are especially vulnerable to climate variations.

iii. There is need to increase participation of all stakeholders in adaptation efforts. There is need to establish collaborative mangrove management areas and plans. These plans will encourage the involvement of local users in the planting, restoration of and conservation of mangroves.

5.6 Areas of Further Research

This study provides preliminary insights into some of the climatic factors affecting fishery-based households in Mombasa and Malindi. However, it does not provide a clear insight into how some of the key modes of climate variability like El Niño Southern Oscillation and Indian Ocean Dipole affect fish distribution, (particularly in terms of changes in productivity of the western equatorial Indian Ocean, and connections with areas outside of the western equatorial Indian Ocean) and catches beyond 200 nautical miles off Kenyan coast and western Indian Ocean.

We also need to know what impact lagged processes, particularly biological lags, might have on fisheries populations and associated catches are largely unexplored. This might also affect the small-scale fishing households.

In addition, fluctuations in fisheries populations might not simply be determined by any single environmental factor, but rather might be influenced by non-linear combinations of several factors including changes in fishing effort, targeting practices and fleet dynamics (Hsieh et al., 2008). Including aspects of fishing behaviour will be an important next step in conducting more comprehensive investigations into the influence of climate variability on fisheries and fishery-based livelihoods.

There is need to disentangle the effects of numerous mechanisms that can result in climate variability. This is a challenge since, in addition to external forcing (e.g., variability in solar irradiance), there are potential complex interactions between internal mechanisms.

REFERENCES

Abram, N.J., Gagan, M.K., Cole, J.E., Hantoro, W.S. and Mudelsee, M. (2008). Recent intensification of tropical climate variability in the Indian Ocean. Nature Geoscience 1:849–853.

Adebayo, K., Dauda, T.O., Rikko, L.S., George, F.O.A., Fashola, O.S., Atungwu, J.J., Iposu, S.O., Shobowale, A.O. and Osuntade, O.B. (2011). Emerging and Indigenous Technology for Climate Change Adaptation in Southwest Nigeria. Research Paper, African Technology Policy Studies Network (ATPS), Nairobi, Kenya.

Adeoti, A., Olayide, O. and Coster, A. (2010). Flooding and Fishers' Welfare in Lagos State, Nigeria. Journal of Human Ecology 32(3): 161-167

Adger, W.N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I. and Nelson, D. R. (2009). Are there social limits to adaptation to climate change? Climatic Change, 93(3-4), 335-354.

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C, O'Brien, K, Pulhin, J., Pulwarty, R., Smit, B. and Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II. In: Parry, M. L., Canziani, O.F., Palutikof J.P., van der Linden P.J., Hanson, C.E (eds) Fourth Assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp 717-743

Adger, W.N. (2006). "Vulnerability." *Global Environmental Change* 16 (3): 268-281.

Adger, W.N. and Vincent, K. (2005). Uncertainty in adaptive capacity Comptes Rendus Geosciences, 337 (4) (2005), pp. 399–410.

Adger, W.N., Hughes, T.P., Folke, C., Carpenter, S.R. and Rockstro, M J. (2005). Social-ecological resilience to coastal disasters. Science309:1036–1039.

Adger, W.N., Kelly, P.M. and Ninh, N.H. editors. (2001). Living with environmental change: social vulnerability, adaptation and resilience in Vietnam. Routledge, London, UK.

African Monsoon Multidisciplinary Analyses (AMMA) (2005). The International Science Plan for AMMA.

Agar, M. and MacDonald, J. (1995). Focus groups and ethnography. Human Organization: 78-86.

Agrawal, A. and Perrin, N. (2009). Climate adaptation, local institutions and rural livelihoods. In Adger, W.N., Lorenzoni, I. and O'Brien, K. eds. Adapting to climate change: thresholds, values, governance. Cambridge, UK, Cambridge University Press.

Agrawal, A. (2008a). "The role of local institutions in adaptation to climate change." Washington DC: World Bank.

Agrawal, A., McSweeney, C and Perrin, N. (2008b). Local institutions and climate change adaptation. In: Bank, W. (Ed.), The Social Dimensions of Climate Change.Washington, DC.

Agrawal, S. and Van Aalst, M. (2008). Adapting development cooperation to adapt to climate change. Climate Policy 8, 183–193.

Agrawal, A. and Perrin, N. (2008). CALI Methodological note, Manuscript. The World Bank

Agrawal, A. and Lemos, M. (2007). A Greener Revolution in Making? Environmental Governance in the 21st Century." *Environment* 49(5): 36-45

Aiken, K.A., Bacon, P.R. and Mooyoung, R. (1992). Recovery after Hurricane Gilbert: Implications for disaster preparedness in the fishing industry in Jamaica. Proceedings of Gulf and Caribbean Fisheries Institute 41:261–83. [82].

Alam, M., Rahman, A., Rashid, M., Rabbani, G., Bhandary, P. and Bhadwai, S. (2007). "Background Paper *Impacts, Vulnerability and Adaptation to Climate Change in Asia,*" Beijing, China, April 11–13.

Alexander, M.A., Deser, C. and Timlin, M.S. (1999). The re-emergence of SST anomalies in the North Pacific Ocean, J. Clim. 12, 2419–2433.

Allan, R.J., Lindesay, J.A. and Parker, D.E. (1996). El Ninõ–Southern Oscillation and Climatic Variability. CSIRO Publishing: Collingwood, Victoria.

Allison, E.H., Perry, A.L., Badjeck, M-C., Adger, W.N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L. and Dulvy, N.K. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. Fish 10:173–196. doi:10.1111/j.1467-2979.2008.00310.x

Allison, I. (2009). The Copenhagen Diagnosis: Updating the World on the Latest Climate Science, UNSW Climate Change Research Center, Sydney, Australia, 2009, p. 11

Allison, E.H., Andrew, N.L. and Oliver, J. (2007). Enhancing the resilience of inland fisheries and aquaculture systems to climate change. Journal of Semi-Arid Tropical Agricultural Research 4(1).

Allison, E.H. and Horemans, B. (2006). Putting the principles of the sustainable livelihoods approach into fisheries development policy and practice. *Marine Policy,* 30: 757–766.

Allison, E.H., Adger W.N., Badjeck, M-C., Brown, K., Conway, D., Dulvy, N.K., Halls, A., Perry, A. and Reynolds J.D. (2005). Effects of climate change on the sustainability of capture and enhancement fisheries important to the poor: analysis of the vulnerability and adaptability of fisher folk living in poverty.

Allison, E.H. (2004). The fisheries sector, livelihoods and poverty reduction in Eastern and Southern Africa. In: *Rural Livelihoods and Poverty Reduction Policies* (eds: Ellis, F. and Freeman, H.A). Routledge, London. (Publication due September 2004).

Allison, E.H. and Ellis, F. (2001). The livelihoods approach and management of small-scale fisheries. *Marine Policy* 25(5): 377–388.

Alusa, A.L. and Ogallo., L.J. (1992). Implications of expected climate change in the eastern African Region: an Overview. UNEP Regional Seas Reports and Studies No. 149.

Anderies, J.M., Janssen, M.A. and Ostrom, E. (2004). A framework to analyze the robustness of social–ecological systems from an institutional perspective. Ecology and Society 9(1), 18.

Armitage, D. and Johnson, D. (2006). Can resilience be recognized with globalization and increasingly complex resource degradation in Asian coastal regions? *Ecology and Society.*

Arntz, W.E. (1986). The two faces of El Niño 1982 to 1983. Meeresforschung 31:1–46.

Asche, F. and Smith, M. (2010). Trade and Fisheries: Key Issues for the World Trade Organization. World Trade Organization, Geneva.

Asian Development Bank (ADB) (2009). The Economics of Climate Change in Southeast Asia: A Regional Review (Mandaluyong City, Philippines: ADB, 2009), pp. 115–16.

Awuor, C.B., Orindi, V.A. and Adwera, A.O. (2008). Climate change and coastal cities: the case of Mombasa, Kenya. *Environment and Urbanisation,* 20(1): 231242.

Badjeck, M.-C., Allison, E.H., Halls, A.S. and Dulvy, N.K. (2010). Impacts of climate variability and change on fishery-based livelihoods. Marine Policy 34, 375–383.

Badjeck, M-C. (2008). Vulnerability of coastal fishing communities to climate variability and change: implications for fisheries livelihoods and management in Peru University of Bremen, Germany.

Badjeck, M-C (2004). Oil or Fish? Natural resource use and livelihood security of fisherfolk in Cameroon's coastal zone - Draft. Sustainable Fisheries Livelihoods Programme, FAO, Rome.

Bailey, C, and Pomeroy, C. 1996. Resource dependency and development options in coastal Southeast Asia. Society and Natural Resources 9: 191–99.

Bakker, K., del Moral L., Downing, T., Giansante, C., Garrido, A., Iglesias, E., Pedrega, l. and Riesco, P (1999). Working Paper 3: A Framework for Institutional Analysis. Societal and Institutional Responses to Climate Change and Climatic Hazards: Managing Changing Flood and Drought Risk (SIRCH), Environmental Change Unit, University of Oxford.

Balston, J. (2009). An analysis of the impacts of long-term climate variability on the commercial barramundi (*Lates calcarifer*) fishery of north-east Queensland, Australia. Journal: Fisheries Research - FISH RES, vol. 99, no. 2, pp. 83-89.

Barret, C.B., Reardon, T. and Webb, P. (2001). Non- Farm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics and policy implications Food Policy 26, 315-331.

Begossi, A. (1998). A Property rights for fisheries at different scales; applications for conservation in Brazil.Fisheries Research Vol 34. Pg 269-278.

Bekele, W. (2006). Analysis of farmers' preference for development intervention programs: A case study of subsistence farmers from East Ethiopian highlands*: The author Journal compilation African Development Bank 2006,* Oxford Black Well Publishing LTD. UK.

Bell, F.H. and Putter, A.T. (1958). Climate temperature changes and commercial yields of some marine fisheries, *Journal of the Fisheries Research Board of Canada, 15*, 626-683, 1958.

Béné, C., Macfadyen, G. and Allison, E.H. (2007). *"Increasing the contribution of small-scale fisheries to poverty alleviation and food security"*. Food and Agriculture Organization of the United Nations, Rome, 2007 FAO Fisheries Technical Paper 481.

Béné, C. and Neiland, A.C. (2003). Contribution of Inland fisheries to rural livelihoods in Africa: an overview from the Lake Chad basin areas. In Welcome, R. and Petr, T. (Eds.), Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Vol. II. FAO Reg. Office for Asia and the Pacific, Bangkok, Thailand. RAP Publication 2004/17. pp: 1-14.

Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: Lessons from resilience thinking. Natural Hazards 41(2):283–295, oi:10.1007/s11069-006-9036.

Berkes, F., Colding, J. and Folke, C. (editors) (2003). Navigating social–ecological systems: building resilience for complexity and change. Cambridge University Press, Cambridge, UK.

Berkes, F., Colding, J. and Folke, C. (2002). Navigating social ecological systems: Building resilience for complexity and change. Cambridge: Cambridge University Press.

Berkes, F. and Folke, C. (2000). Back to the future: ecosystems dynamics and local knowledge In Gunderson, L. and Holling, C P: Understanding transformation in human and natural systems (pp.121-146) Washington DC; USA. Island Press.

Bicknell, J., Dodman, D. and Satterthwaite, D. (eds.), (2009). Adapting Cities to Climate Change: Understanding and Addressing the Development challenges. London, UK, Earthscan.

Bird, K. and Deshingkar, P. (2009). "Circular Migration in India" ,Poly Briefing No.4 prepared for World Bank Development Report, Overseas Development Institute, London.

Blaikie, P. (1995) Changing environments or changing views? A political ecology For developing countries.

Blankespoor, B., Dasgupta, S., Laplante, B. and Wheeler, D. (2010). *The Economics of Adaptation to Extreme Weather Events in Developing Countries.* Working Paper 199. Center for Global Development, Washington, D.C., USA.

Bless, C and Achola, P. (1990). Fundamentals of Social Research Methods. Lusaka: Government Printers.

Boko, M., Niang, I., Vogel, C., Githeko, A., Medany, M., Osman, B., Elisha R. Tabo and Yanda, P. (2007). Africa, Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group 11 to the Fourth assessment Report of the Intergovernmental Panel on Climate Change. Parry, M.L., Canziani, O.F., Palutikof, J.P., Van der Linden, P.J. and Hanson, C.E. (ed). Cambridge, Cambridge University Press.

Bolin, B., Jäger, I. and Döös, B.R. (1986). The greenhouse effect, climate change and ecosystems. In Bolin, B., Döös, B.R. Jäger, I. and. Warrick, R.A. *The Greenhouse Effect, Climate Change and Ecosystems, SCOPE,* 29, 1-32. Wiley & Sons, Chichester.

Bond, R., Kapondamgaga, P., Mwenebanda, B., Raghvendra, P., Yadav, S. and. Anees, R. (2007). Monitoring the livelihood platform: reflections on the operation of the Livelihood Asset-Status Tracking method from India and Malawi. Journal Impact Assessment and Project Appraisal volume (25), pages (301—315), issue (4).

Bond, G. (2001), "Persistent solar influence on North Atlantic climate during the Holocene," Science294:2130-2136.

Bosire, J.O. (2006). Ecological recovery of reforested mangroves in Kenya. PhD Thesis. Vrije Universiteit Brussel, 138 pp.

Bowden, J.H. and Semazzi, F.H.M. (2007). Empirical analysis of intraseasonal climate variability over the Greater Horn of Africa. Journal of Climate 20:5715–5731.

Brakel, W.H. (1984). Seasonal dynamics of suspended sediment plumes from the Tana and Sabaki rivers, Kenya: Analysis from Landsat Imagery Remote sensing of the Environment.

Brissenden, M. (2006) PM changes tack on climate change, wins on IR. Australian Broadcasting Corporation, 14 November.

Broad, K., Pfaff, A.S.P. and Glantz, M.H. (1999). Climate information and conflicting goals: El Niño 1997–1998 and the Peruvian fishery. Public philosophy, environment, and social justice, Carnegie Council on Ethics and International Affairs, New York; 21–22 October 1999.

Brondizio, E.S., Ostrom, E. and Young, O.R. (2009). Connectivity and the governance of multilevel social–ecological systems: the role of social capital. Annual Review of Environment and Resources 34 (1), 253–278.

Brooks, N., Adger, W.N. and Kelly, P.M. (2005). "The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation." *Global Environmental Change* 15(2): 151-163.

Buck, E.H. (2005). Hurricanes Katrina and Rita: fishing and aquaculture industries `damage and recovery. In, CRS Report for Congress. Washington DC, Congressional report service, The Library of Congress.

Bunce, M., Brown, K. and Rosendo, S. (2010). Policy misfits, climate change and crossscale vulnerability in coastal Africa: how development projects undermine resilience. Environmental Science & Policy 13, 485–497.

Bunce, L., Townsley, P., Pomeroy, R. and Pollnac, R. (2000). Socio-economic manual for coral reef management. Australian Institute of Marine Science Townsville

Burki, S.J. and Perry, G E. (1998). Beyond the Washington Consensus: Institutions Matter, World Bank, Washington D.C.

Burton, I. (2004). Climate Change and the Adaptation Deficit. In: Adam Fenech, ed., *Climate Change: Building the Adaptive Capacity*. Papers from an

International Conference on Adaptation Science, Management, and Policy Options.Lijiang, Yunnan, China, May 17 -19 2004. Meteorological Service of Canada, Environment Canada, Toronto. Cabrido, Candido (1999). Ebbing Coasts: Coastal Area Planning. In Philippine Planning Journal, Vol. XXX, No. 2, University of the Philippines School of Urban and Regional Planning (UP-SURP) April 1999 pp. 1-12.

CAF. (2000). Las lecciones del El Niño: Memorias del fenómeno El Niño 1997 to 1998: retos y propuestas para laregión Andina, volumen V: Perú. Corporación Andina de Fomento.Carvalho, AR., (2002). *Valoração econômico-ecológica da Planície de inundação do Alto rio Paraná*. Maringá: Universidade Estadual de Maringá. 139 p. [Tese de Doutorado].

Cane, M.A., Zebiak, S.E. and Dolan, S.C. (1986). Experimental forecast of El Niño. Nature 321: 827-832.

Carvalho, A.R. (2002). Valoração econômico-ecológica da Planície de inundação do Alto rio Paraná. Maringá: Universidade Estadual de Maringá. 139 p. Tese de Doutorado].

Castle, E.N. (1998). A conceptual framework for the study of rural places. *American Journal of Agricultural Economics,* 80: 621-631.

Catella, A.C. (2001). *A pesca no Pantanal de Mato Grosso do Sul, Brasil*: descrição, nível de exploração e manejo (1994-1999). Manaus: Universidade do Amazonas. 351 p. [Tese de Doutorado].

Chambers, R. and Conway, G. **(**1992). Sustainable rural livelihoods: practical concepts for the 21st century. IDS Discussion Paper 296, IDS, Brighton, Sussex, UK.

Chambers, R. (1989). Vulnerability, coping and policy. IDS Bulletin.

Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R. K, Kwon, W-T., Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C. G., Räisänen, J., Rinke, A., Sarr, A. and Whetton, P. (2007). Regional Climate Projections. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L (eds.). *Climate Change 2007*: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt K B, Tignor M and Miller H L (eds)]. Cambridge University Press. Cambridge, United Kingdom and New York, NY, USA.

Church, J.A. and White, N.J. (2006). A 20th century acceleration in global sea level rise, Geophysical Research Letters, 33, L01602, doi:10.1029/2005GL024826.

Cinner, J.E., McClanahan, T.R., Graham, N.A.J., Daw, T.M., Maina, J., Stead, S.M., Wamukota, A., Brown, K. and Bodin, Ö. **(**2012). Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. *Global Environmental Change*

Cinner, J.E., McClanahan, T.R., Graham, N.A.J., Pratchett, M.S., Wilson, S.K. and Raina, J.B. (2009a). Gear-based fisheries management as a potential adaptive response to climate change and coral mortality. *Journal of Applied Ecology* 46:724–732.

Connel, J., Dasqupta, B., Laishay, R. and Lipton, M. (1976). Migration from rural areas: The evidence from village studies (Delhi: Oxford University Press.)

Conway, D., Allison, E., Felstead, R. and Goulden, M. (2005). Rainfall variability in East Africa: implications for natural resources management and livelihoods. Philosophical Journal of Environmental Economics and Management 42: 336-359

Corlien, M. Varkevisser, I.P. and Brownlee, A. (1991). Designing and conducting health systems research projects. Part I: proposal development and field word; Part II: Data analysis and report writing.

Corten, A. (1986). On the causes of the recruitment failure of herring in the central and northern North Sea in the years 1972-1978, Journal du Conseil, Conseil *International pour'l Exploration de la Mer, 42, 282-294.*

Coulthard, S. (2008). Adapting to environmental change in artisanal fisheries insights from a South Indian lagoon. Global Environmental Change 18(3):479–489.

Crandall, A. (2009). Local Perceptions of Water Variability and Wetlands in Lake Victoria. Institute for the Study of Diplomacy Edmund A. Walsh School of Foreign Service Georgetown University.

Crate, S. (2008). Gone the Bull of Winter? Grappling with the cultural implications of and anthropology's role(s) in global climate change. Current anthropology 49(4):569 – 595.

Creswell, J.W. (1994). Research design: Qualitative and quantitative approaches Thousand Oaks: Sage.

Crona, B., Wanyonyi, I. Ochiewo, J., Ndegwa, S. and Rosendo, S. (2010). Fishers' Migration along the Kenyan Coast Implications for Management on Coastal Fisheries Policy Brief. Daniels, R.C., White, T.W., and Chapman, K.K. (1993). Sea-level rise: Destruction of threatened and endangered species habitat in South Carolina. Environ. Manage. **17,** 373-385.

Curriero, F.C., Patz, J.A., Rose, J.B. and Lele, S. (2001). The association between extreme precipitation and water borne disease outbreaks in the United States, 1948–1994. American Journal of Public Health. 2001; 91(8):1194–1199

Cushing, D.H. (1982). Climate and fisheries.London:AcademicPress;1982.

Cutter, S.L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E. and Webb, J (2008). A place-based model for understanding community resilience to natural disasters Global Environmental Change, 18 (2008), pp. 598–606.

Cutter, S.L., Boruff, B.J. and Shirley, W.L (2003). "Social vulnerability to environmental hazards." Social Science Quarterly84(1): 242-261.

Czaja, R. and Blair, J. (1996). Designing Surveys: A guide to decision and procedure. Thousand Oaks, CA Pine Forge Press

Darling, E.S., McClanahan, T.R., Coˆte´, I., McClanahan, T., Maina, J. and Pet-Soede, L. (2010). Effects of the 1998 coral mortality event on Kenyan coral reefs and fisheries. Ambio 31, 543–550. M., 2010. Combined effects of two stressors on Kenyan coral reefs are additive or antagonistic, not synergistic. Conservation Letters 3, 122–130.

Davies, S. (1996). Adaptable Livelihoods: Coping with Food Insecurity in the Malian Sahel. London: MacMillan. Davies, J. R. (2003). Rural Non –Farm Economy: Livelihood and the Diversification, Issues and Options.NRI Report 2573.

Daw, T.M., Adger, N., Brown, K. and Badjeck, M.C. (2009). Climate change and capture fisheries. Climate change implications for fisheries and aquaculture. Overview of current scientific knowledge. In: Cochrane, K., Young, C.D., Soto, D., Bahri, T. (Eds.), FAO Fisheries and Aquaculture Technical Paper. Food and Agricultural Organization, Rome, pp. 95–135.

Dayal, H. and Karan, A.K. (2003). Labour migration from Jharkhand, Institute for human development, New Delhi.

Dazé, A., Ambrose, K. and Ehrhart, C. (2009). Climate vulnerability and capacity analysis (Handbook). London: CARE International.

de Haan, L. and A. Zoomers (2003). Development geography at the crossroads of livelihood and globalisation. *Tijdschrift voor Economische en Sociale Geografie*94(3):350–362.

Dercon, S. (2001). "Assessing vulnerability to poverty".Jesus College and CSAE, Department of Economics, Oxford University.

Dercon, S. **(**1998). Wealth, risk and activity choice: cattle in Western Tanzania. Journal of Development Studies, 55: 1-42.

Department for International Development, DFID (2001). Sustainable livelihoods guidance sheets, London, UK.

Department for International Development, DFID (1999). Sustainable rural livelihoods guidance sheet, London, UK.

Derksen C and Brown, R (2012). "Spring snow cover extent reductions in the 2008-2012 period exceeding climate model projections," GRL, 39:L19504

Djamba, Y., Goldstein, A. and Goldstein S. (1999). "Permanent and temporary migration in Vietnam during a period of economic change", *Asia Pacific Population Journal*, 14(3), 25-48.

Downing, T.E., Ringius, L., Hulme, M. and Waughray, D. (1997). Adapting to climate change in Africa. mitigation and adaptation strategies for global change, **2**, 19-44.

Drinkwater, K.F., Beaugrand, G, Kaeriyama, M., Kim, S., Ottersen, G, Perry, R.I., Portner, H.O., Polovina, J.J. and Takasuka, A. (2010). On the processes linking climate to ecosystem changes.J Mar System **79**:374–388.

Eakin, H. and Bojo´rquez-Tapia L.A. (2008). Insights into the composition of household vulnerability from multicriteria decision analysis. Global Environ Chang 18:112–127. doi:10.1016/j.gloenvcha.2007.09.001

Ellis, F. (2000). Rural livelihoods and diversity in developing countries. Oxford, UK, Oxford University Press.

Enete, A., Ignatius, I.M., Josephat, C.M., Anthony, N.O., Elizabeth, A.O. and Fidelis, E. (2011). Indigenous Agricultural Adaptation to Climate Change: Study of Southeast Nigeria. *Research Paper*, African Technology Policy Studies Network (ATPS) Nairobi, Kenya.

FAO. (2012). SOFIA*:* The state of world fisheries and aquaculture. FAO, Rome. 209 pp. (available at http://www.fao.

FAO. (2010). The state of world fisheries and aquaculture 2010. FAO Fisheries and Aquaculture Department, Food and Agriculture Organisation of the United Nations, Rome.

FAO. (2009). FishStat Plus. Universal software for fishery statistical time series. Available at www.fao.org/fishery/statistics/software/fishstat/en.

FAO. (2008). The state of world fisheries and aquaculture (2008) (SOFIA), FAO Fisheries and Aquaculture Department, Rome ;2009.

FAO (2007a). Fisheries Statistics-Capture Production.FAO Fisheries Series Vol 100/1.Rome 539 PP.

FAO. (2007b). Adaptation to climate change in agriculture, forestry and fisheries: Perspective framework and priorities. Interdepartmental. Working Group on Climate Change. Food and Agriculture Organization of the United Nations Rome, 32 p.

FAO. **(**2005). Increasing the contribution of small-scale fisheries to poverty alleviation and food security. FAO Technical guidelines for responsible fisheries No. 10. FAO. 79 pp. Rome

FAO. (2004). The state of world fisheries and aquaculture. Rome: FAO.

FAO. (2003). Fishery country profile: Peru. FAO, FID/CP/PER Rev. 2. Rome.

FAO. (2002). FAO Yearbook: Fisheries Statistics-Commodities, Vol. 91. Rome, Italy.

Fauzi, A, and Anna, Z. (2010). Social resilience and uncertainties: the case of small-scale fishing households in the north coast of Central Java. MAST 9 (2): 55–64.

Ford, J.D. and Smit, B. (2004). A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. Arctic 57:389 – 400.

Fraenkel, J.R. and Wallen, N.E. (2000). How to design and evaluate research in education, 4th Edit. New York, the McGraw-Hill Companies. Inc

Francisco, S., Rodrigues, H., Suzete, S., Igor, Pinheiro, R, Alysson, S., Renisson, N., Arisvaldo, V. (2009). Environmental Perception of the São Francisco Riverine Population in Regards to Flood Impact. *J Hum Ecol*, 28(1): 37-46.

Fulanda, B., Munga, C., Ohtomi, J., Osore, M., Mugo, J. and Hossain, Y. (2009). The structure and evolution of the coastal migrant fishery of Kenya. Ocean and Coastal Management **52:**459–466.

Funk, C., Dettinger, M.D., Michaelsen, J.C., Verdin, J.P., Brown, M.E., Barlow, M. and Hoell, A. (2008). Warming of the Indian Ocean threatens eastern and southern African food security but could be mitigated by agricultural development. Proceedings of the National Academy of Sciences 105:11081–11086.

Funk, C., Senay, G., Asfaw, A., Verdin, J., Rowland, J., Michaelson, J., Eilerts, G Korecha, D. and Choularton, R (2005). Recent drought tendencies in Ethiopia and equatorial-subtropical eastern Africa. Washington DC, FEWS-NET.

Gallopin, G.C., Gutman, P. and Maletta, H. (1989).Global impoverishment, sustainable development and the environment: a conceptual approach. International Social Science Journal 121: 375-397.

Gamez, A, and Angeles, M. (2010). Borders within: tourism growth, migration and regional polarization in Baja California Sur (Mexico). Journal of Borderland Studies 25 (1): 1–18.

Gay, L. (1992). Educational Research Competencies for Analysis and Application Second Edition. New York: Macmillan Publishers.

Gay, L.R. (1976). Education Research Competencies for Analysis and Application; Ohio : Charles Company.

Gearheard, S., Matumeak, W., Angutikjuaq, I., Maslanik, J., Huntington, H.P., Leavitt, J., Kagak, D.M., Tigullaraq, G. and Barry R.G. (2006). It's not that simple: A collaborative comparison of sea ice environments, their uses, observed changes, and adaptations in Barrow, Alaska, USA, and Clyde River, Nunavut, Canada. Ambio 35(4):203–211, doi:10.1579/0044-7447(2006)35[203:INTSAC]2.0.CO;2.

Gedalof, Z. and Smith, D.J. (2001). Interdecadal climate variability and regime-scale shifts in Pacific North America. *Geophys. Res. Lett.*, **28**, 1515–1518.

George, F.O.A. (2010). Indigenous and Emerging Technologies for climate change Adaptation in Aquaculture and Fisheries. *Journal of* Sustainable Development, Vol.7, No.2, 34-42.

Ghazouani, S. and Goaied, M. (2001).' The determinant of Urban and Rural Poverty in Tunisia' Laboratoire d'Eonometrie Appliquee (LEA) faculte des Sciences Economiques et de Tunis.

Gillet, V. (2003). Case study: the vulnerability and adaptive capacity of the Belize fisheries sector to severe weather events. Climate and severe weather events in Asia and the Caribbean. rand Barbados Beach Resort, Barbados: Caribbean Disaster Emergency Response Agency; 24–25 July 2003.p.33. [83]

Glantz, M.H. (1992). Climate variability climate change and fisheries. Cambridge: Cambridge University Press.

Goddard, L. and Graham, N.E. (1999). Importance of the Indian Ocean for simulating rainfall anomalies over eastern and southern Africa. *J. Geophys. Res.*, 104, 19 099–19 116.

Goodman, L.A. (1961). Snowball Sampling. Ann Math Stat 1961; 32 (1):148-70

Goreau, T. (2000). Conservation of coral reefs after the 1998 global bleaching event. Conservation Biology 14: 5-15.

Gosse, K., Wroblewski, J. and Neis, B. (2001). Closing the loop: Commercial fish harvesters' local ecological knowledge and science in a study of coastal cod in Newfoundland and Labrador, Canada. In N. Haggan, C. Brignall, & L. Wood, *Putting fishers' knowledge to work* (pp.25-35). Vancouver, British, Colombia, Canada: Fisheries Centre Research Reports, University of British Colombia.

Goudswaard, K.; Frans, W., and Chapman, L. (2002). Decline of the African Lungfish (*Protoplerus aethiopicus*) in Lake Victoria (East Africa), *East African Wildlife Society African* Journal of Ecology, 40; 42-52.

Goulden, M. and Naess, L.O. (2009). Accessing diversification, networks and traditional resource management as adaptations to climate extremes. Adapting to Climate Change: Thresholds, Values, Governance Adger, N., Lorenzoni, I. and O'Brian, K. Cambridge University Press.

Government of Kenya (2008a). Malindi District Development Plan 2008-2012, Nairobi, Ministry of Finance and Planning, Nairobi, Government Printers.

Government of Kenya (2008b). Mombasa District Development Plan 2008–2012, Ministry of Finance and Planning. Nairobi.

Government of Kenya (2009). National Population and Housing Census; Kenya Country Fact Sheet December, 2011.

Government of Kenya (1999). National Population and Housing Census. Vol 1. Ministry of Planning and National Development, Central Bureau of Statistics.

Government of Kenya (1989). National Population and Housing Census. Vol 1. Ministry of Planning and National Development, Central Bureau of Statistics.

Government of Kenya (1979). National Population and Housing Census. Vol 1. Ministry of Planning and National Development, Central Bureau of Statistics.

Government of Kenya (2009). State of Coast Report: Towards Integrated Management of Coastal and Marine resources in Kenya National Environment Management Authority (NEMA), Nairobi

Graham, N.A.J., Wilson, S., Jennings, S., Polunin, N., Robinson, J., Bijoux, J. and Daw, T. (2007). Lag effects in the impacts of mass coral bleaching on coral reef fish, fisheries, and ecosystems. Conservation Biology 21, 1291–1300

Graham, N.A.J., Wilson, S.K, Jennings, S., Polunin, N.V.C., Bijoux, J.P. and Robinson, J. (2006). Dynamic fragility of oceanic coral reef ecosystems. *Proceedings of the National Academy of Sciences of the United States of America,* 103: 8425–8429.

Grandcourt, E.M. and Cesar, H.S.J. (2003). The bio economic impact of mass coral mortality on the coastal reef fisheries of the Seychelles. Fisheries Research, 60: 2–3.

Gray, W.M. (2009). "Global Warming and Hurricanes,". http://icecap.us/docs/change/Global Warming & Hurricane Paper.

Gray, W.M. (2009). "Climate change: Driven by the ocean, not human activity," 2nd Annual Heartland Institute Conference on Climate Change, March 2009. http://tropical.atmos.colostate.edu/Includes/Documents/Publications/gray2009.

Grootaert, C. (1998). Social capital: the missing link? The World Bank, Social Capital Initiative Working Paper, Rep. No. 3 (unpubl.)

Guernier, V., Hochberg, M E., Guegan, J.F. (2004). Ecology drives the worldwide distribution of human diseases. *PLOS Biology*. Oxford. 2(6): pp. 740 – 746. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents. html

Gu, G. and Adler, R.F (2004). *Seasonal Evolution and Variability Associated with the West African Monsoon System,* Journal of Climate 17, 3364-3377).

Hales, S., Weinstein, P. and Woodward, A. (1999). Ciguatera (fish poisoning), El Niño, and Pacific sea surface temperatures. Ecosystem Health, 5(1): 20–25.

Harper, R. and Kelly, M. (2003). "Measuring Social Capital in the United Kingdom".Office for National Statistics.

Hasselmann, K. (1976). Stochastic Climate Models, Part I: Theory, *Tellus*, **28**, 473–485.

Hastenrath, S., Nicklis, A and Greischar, L (1993). Atmospheric–hydrospheric mechanisms of climate anomalies in the western equatorial Indian Ocean. *J. Geophys. Res*.,**98D**,20 219–20 235.

Hawkins. (2010). Our evolving climate: communicating the effects of climate variability.

Heck, S., Béné, C and Reyes-Gaskin, R (2007). Investing in African Fisheries: building links to the Millennium Development Goals. *Fish and Fisheries* 8: 211-226.

Hegerl, G.C., Storch, H., Hasselmann, K., Santer, B. D., Cubasch., U. and Jones P. D. (1996): Detecting greenhouse gas induced Climate Change with an optimal fingerprint method. J. Climate 9, 2281-2306.

Heinz, C. (2002). *Human Links to Coastal Disasters*. Washington D.C.: The H. John Heinz III Center for Science, Economics and the Environment.

Heitzmann, K., Canagarajal, R.S. and Siegel, P.B. (2002): Guidelines for Assessing Risk and Vulnerability Social Protection Discussion Paper No. 0218, Washington , D.C. (The World Bank).

Hernández, J. and Rossi, P (2003). Characterization of the artisanal fishermen settlements of the frontal zone of the Río de la Plata, In: *Research for environmental management, fisheries resources and fisheries in the saline front*. Montevideo, Uruguay: EcoPlata.

Hilhorst, D. and Bankoff, G. (2004). Introduction: mapping vulnerability G. Bankoff,

G. Frerks, D. Hilhorst (Eds.), Mapping Vulnerability: Disasters, Development and People, Earthscan, Sterling, VA (2004), pp. 1–9.

Hill, W. (1989). Organisations lehre: Ziele, Instrumente und Bedingungen der

Organisation sozialer Systeme. Band 1. Bern et al.

Hoegh-Guldberg O, Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale P.F., Edwards, A. J., Caldeira, K., Knowlton, N., Eakin C.M., Iglesias-Prieto, R, Muthiga, N., Bradbury, R.H., Dubi, A and Hatziolos M.E. (2007). Coral reefs under rapid climate change and ocean acidification. *Science*318**,** 1737-1742.

Holling, C.S. (1995). What Barriers? What Bridges? In Barriers and Bridges to the Renewal of Ecosystems and Institutions, edited by L. Gunderson, C. S. Holling and S. S. Light. NewYork: Columbia University Press.

Hoorweg, J.C, Wangila, B. and Degen, A. (2008). Livelihoods and income diversification among artisanal fishers on the Kenyan coast. In Inside poverty and development in Africa: critical reflections on pro-poor policies, ed. Rutten M, Leliveld A, Foeken D, Brill, Leiden.

Hovelsrud, G.K. and West, J. (2008). Socioeconomic consequences of climate change in fisheries: A progress report of ongoing research. In: Browman, H.I., ed. Report on the Conference Fisheries Management and Climate Change in the Northeast Atlantic Ocean and the Baltic Sea: Implications for resource management policy. TemaNord Series. Copenhagen: Nordic Council of Ministers. 49 – 52.

Hovelsrud, G.K. and Winsnes, C., eds. (2006). Conference Proceedings: NAMMCO Conference on User Knowledge and Scientific Knowledge in Management Decision Making. 4 –7 January 2003, Reykjavik, Iceland. Tromsø, Norway: The North Atlantic Marine Mammal Commission. 95p.

Hsieh C.H., Anderson, C. and Sugihara, G. (2008). Extending nonlinear analysis to short ecological time series. Am Nat 17:71–80

Huntington, H. (2000). Using Traditional Ecological Knowledge in Science: Methods and Applications. *Ecological Applications Vol.10 No 5, 1270-1274*

Huq, S. and Reid, H. (2007). *Community Based Adaptation: An IIED Briefing* (London:International Institute for Environment and Development.

Hurrell, J.W., Kushnir, Y., Ottersen, G. and Visbeck, M. (2003*). The North Atlantic Oscillation: Climatic Significance and Environmental Impact*. *Geophys. Monogr.,* Vol. 134, Amer. Geophys. Union, 279 and viii pp.

Idvisi, N., Luthy, S., Capo, T.R. and J. E. Serafy, J.E. (2003). Behaviour, Oxygen Consumption and survival of stressed Juvenile Sailfish (Istrophores platypterus) in capacity. Marine and fresh water behaviour and physiology 36: 51-57.

Ikiara, M.M. (1999). Sustainability, livelihoods, production and effort supply in a developing fishery: The case of Kenya's L.Victoria Fisheries, PhD Dissertation University of Amsterdam.

Ikiara, M. and Odink, J. (2000). Fishermen resistance to exit fisheries. Marine Resource Economics **14**: 199-213

ILO (2000). 'Safety and Health in the Fishing Industry'. Report for discussion at Tripartite Meeting on Safety and Health in the Fishing Industry. International Labour Office, Geneva, 13-17 December 1999.

IOTC (2008). Report of the eleventh session of the scientific committee of the Indian Ocean Tuna Commission, Victoria Seychelles: 166 pp.

IPCC (2013): The Physical Science Basis - Summary for Policymakers, Observed Changes in the Climate System, p. 15, in IPCC AR5 WG1 2013.

IPCC (2007a). Climate Change 2007: Impacts, Adaptation and Vulnerability – Contribution of Working Group II to the Forth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, Cambridge University Press.

IPCC (2007b): *Climate Change 2007: Synthesis Report.* Un-edited copy prepared for COP 13.

IPCC (2001a). Coastal zones and marine ecosystems. In: McCarthy, J.J., Canziani, O.F.,Leary, N.A., Dokken, D.J. and White, K.S., *Climate Change 2001:*

Impacts, Adaptation, and Vulnerability. Cambridge University Press, UK, 1032 pp.

IPCC (2001b). *Climate change 2001.Impacts, Adaptation and Vulnerability. Contribution of working Group II to the third assessment report of IPCC*. Cambridge University Press, Cambridge.

IPCC (2001c). Watson, R.T. and the Core Writing Team (eds.).*Climate Change 2001: Synthesis Report.* A Contribution of Working Groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

IPCC (1990). *Impacts assessment of climate change* – report of Working Group II. Canberra,Australian Government Publishing Service.

ISDR, Terminology on Disaster Risk Reduction, (2009). ISDR, Terminology on Disaster Risk Reduction International Strategy for Disaster Reduction UN Publications, Geneva

Iwasaki, S., Razafindrabe, B.H.N. and Shaw, R. (2009). Fishery livelihoods and adaptation to climate change: A case study of Chilika lagoon, India. Mitigation and Adaptation Strategies for Global Change 2009;14(4):339–55.

Jallow, B., Toure, S, Barrow, M. and Mathieu, A. (1999). Coastal zone of The Gambia and the Abidjan region in Cˆote d'Ivoire: sea level rise vulnerability, response strategies, and adaptation options. Climate Research1999; 12(2–3):129–36. [81]

Jazairy, I., Alamgir, M. and Panuccio, T. (1992). The State of World Rural Poverty: An Inquiry into its Causes and Consequences. New York: New York University Press for IFAD.

Johnson, T. (2012). Fisheries Adaptation to Climate Change. Alaska Sea Grant Marine Advisory Program; University of Alaska Fair Banks

Jones, G.P., McCormick, M .I., Srinivasan, M. and. Eagle, J.V. (2004). Coral decline threatens fish biodiversity in marine reserves. Proceedings of the National Academic sciences **101**:8251-8258

Jörgensen, R. (2002). Challenges to Organic Farming and Sustainable Land Use in the Tropics and Subtropics. J. Agric. Rural Dev. Tropics Subtropics, 103(2): 103-105.

Joubert, A. and Hewitson, B. (1997). Simulating present and future climates of southern Africa using general circulation models, *Progress in Physical Geography*,21: 51-78.

Jul-Larson, E., Kolding, J., Overa, R., Raakjaer Nielsen, J., and van Zweiten, P.A.M. (2003). Management, co-management or no management? Major dilemmas in southern African freshwater fisheries 1. Synthesis report. *FAO Fisheries Technical Paper* 426/1, FAO, Rome.

Kahn, M.E. (2005). The death toll from natural disasters: the role of income, geography, and institutions. *The Review of Economics and Statistics* 87(2):271–284.

Kairo J.G., Dahdouh-Guebas, F., Bosire, J. and Koedam, N. (2001). Restoration and management of mangrove systems—a lesson for and from the East African region. South African *Journal of Botany* 67:383–389.

Kalnay, E., Kanamitsu, M., Kistler, R., Collins, W., Deaven, D., Gandin, I., Iredell, M., Saha, S., White, G., Woollen, J., Zhu, Y., Leetmaa, A., Reynolds, R., CheJliah, M., Ebisuzald, W., Higgins, W., Janowiak, J., Mo, K.C., Ropelewsld, C., Wang, J., Jenne, R. and Joseph, D. (1996): The NCEP/NACR reanalysis 40-year project. *Bull. Amer. Meteor*. Soc., 71: 437-471.

Kayanne, H., Ijima, H., Nakamura, N., McClanahan, T.R., Behera, S. and. Yamagata, Y. (2006). Indian Ocean dipole index recorded in Kenyan coral annual density bands. Geophysical Research Letters 33:10–14.

Kennedy, V.S. (2002). Anticipated effects of climate changes on estuarine and coastal fishes. *Fisheries* .

Kingdom, T. and Kwen, K. (2009). World Journal of Fish and Marine Sciences 1 (4): 313-319, 2009 ISSN 1992-0083© IDOSI Publications, 2009 *World J. Fish and Marine Sci.,* 1 (4): 313-319, 2009

Kissling, E.; Allison, E.; Seeley, J.; Russell, S.; Bachmann, M.; Musgrave, S. and Heck, S. (2005). 'Fisherfolk are among Those Most at Risk to HIV: A Cross-Country Comparison of Estimated Prevalence and Numbers Infected among Groups at Risk', *AIDS* 19: 1939-45.

Kitheka, J.U., Ongwenyi, G.S. and Mavuti, K.M. (2002). Dynamics of suspended sediment exchange and transport in a degraded mangrove creek in Kenya. Ambio, Vol. 31. No. 7−8. pp. 580−587.

Kombo, D.K. and Tromp, D.L.A. (2006). Proposal ant Thesis writing, an introduction. Nairobi. Pauline's Publications Africa. Don Bosco Printing press.

Kovats, R.S. (2003). El Niño and health. *Lancet*, 362:1481–1489. Kerlinger, F.N. (1979). Foundations of Behavioral Research. New Delhi.Swifeet Publishers.

Krishna, A. (2000). Creating and Harnessing Social Capital. In: Dasgupta, P. and I. Serageldin, Social Capital: A Multifaceted Perspective. The World Bank, Washington. D.C.

Kwok, R. and Rothrock, D.A. (2009) "Decline in Arctic sea ice thickness from submarine and ICESAT records: 1958-2008," Geophysical Research Letters, v. 36, paper no. L15501, 2009

Latif, M., Dommenget, D., Dima, M. and Grotzner, A. (1999). The role of Indian Ocean sea surface temperature in forcing East African rainfall anomalies during December–January 1997/98. *J. Climate,* **12**, 3497–3504.

Lea, R. (2000). Observations On Fishes associated with the 1997-98 El Nino Off California CalCOFI Report.41:117-129.

Leach, M, Scoones, I. and Stirling, A. (2010). Dynamic Sustainabilities: Technology, Environment, Social Justice Earthscan, London.

Lehodey, P., Alheit, J., Barange, M., Baumgartner, T., Beaugrand, G., Drinkwater, K., Fromentin, J.M., Hare, S.R., Ottersen, G., Perry, R.I., Roy, C., van der Lingen, C.D. and Werne, F. (2006): Climate Variability, Fish, and Fisheries Journal of

Climate, Special Section, 2006, Vol. **19**: 5009-5030. American Meteorological Society.

Lehodey, P, Chai, F. and Hampton, J. (2003). .*Fish Oceanogr* 12:483–494.

Lehodey, P. (2001): The pelagic ecosystem of the tropical Pacific Ocean: Dynamic spatial modelling and biological consequences of ENSO. *Progress in Oceanography*,Vol. 49, Pergamon, 439–468.

Levitus, S., Antonov, J.I., Boyer., T.P., Locarnini, R.A. and Garcia, H.E (2009). "Global ocean heat content 1955–2008 in light of recently revealed instrumentation problems," Geophys. Res. Lett. 36, L07608

Lindell, M.K. and Perry, R.W. (2004). *Communicating Environmental Risk in Multiethnic Communities*.Sage,Thousand Oaks, California, USA.

Lindzen, R.S. and Choi, Y.S. (2010). "On the observational determination of climate sensitivity and its implications," *Journal of Geophysical Research*, submitted February 12, 2010.

Lindzen, R.S. and Choi, Y.S. (2009). "On the determination of climate feedbacks from ERBE data," *Geophysical Research Letters* 36: L16705, doi:10.1029/2009GL039628.

Lindzen, R.S., Chou, M.-D., and Hou, A.Y. (2001), "Does the earth have an adaptive infrared iris?" *Bulletin of the American Meteorological Society* 82:417-432.

Lorenz, E.N. (1963). Deterministic Nonperiodic Flow, *J. Atmos.Sci.*, **20**, 130–141.

Lutz, W. (2008). Forecasting Societies' Adaptive Capacities to Climate Change (Future Soc). Annex I – Description of Work. Funded Research Proposal, European Research Council, Advanced Investigator Grant. Unpublished document. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

MacAskill, E. (2007). Europeans angry after Bush climate speech 'charade'. The Guardian. 29 September 2007.

Macfadyen, G. and Allison E. (2009). Climate change, fisheries, trade and competitiveness: understanding impacts and formulating responses for Commonwealth small states. Commonwealth Secretariat, London.

McCay, B.J., Weisman, W. and Creed, C.F. (2011). Coping with environmental change: systemic responses and the roles of property and community in three fisheries. In World fisheries: a social-ecological analysis, ed. Ommer R, Perry I, Cury P, Cochrane K, Wiley-Blackwell, Oxford.

Mahon, R. (2002). Adaptation of fisheries and fishing communities to the impacts of climate change in the CARICOM region. In Mainstreaming adaptation to climate change (MACC), p.33. Washington, DC. The Caribbean Centre for Climate Change.

Majluf, P., Barandearán, A. and Sueiro, J.C. (2005). Evaluacion Ambiental del Sector Pesquero en el Peru.Washington, DC. World Bank.

Mallick, D.L., Rahmnan, A., Alam, M., Juel, A.S.M., Ahmad, A.N. and Alam S.S. (2005). Case study 3: Floods in Bangladesh: A shift from disaster management towards disaster preparedness. *IDS Bulletin* 36(4): 53+

Marsac, F. (2008). Outlook of ocean climate variability in the west tropical Indian Ocean, 1997–2008. Paper IOTC-2008-WPTT-27 prepared for the Indian Ocean Tuna Commission Working Party on Tropical Tunas

McCarthy, J., Canziani, O., Leary, N., Dokken, D. and White, K (Eds.) (2001). Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge, UK: Cambridge University Press.

McClanahan. T.R., Cinner, J.E., Maina, J., Graham, N.A.J., Daw, T.M. and Stead S.M. (2008). Conservation action in a changing climate. Conservation Letters 2008; 1(2): 53–59.

McClanahan, T.R., Mwaguni, S. and Muthiga, N.A. (2005). Management of the Kenyan coast. Ocean & Coastal Management 48:901–931.

McClanahan, T.R. (2002). The near future of coral reefs. Environmental Conservation 29:460–483.

McClanahan, T.R. (1996). Oceanic Ecosystems and Pelagic Fisheries. In: McClanahan, T. R. and T. P. Young (eds). *East African Ecosystems and their Conservation.* Oxford University Press: New York, Oxford.

McClean, R.F., Tsyban, A., Burkett, V., Codignotto, J.O., Forbes, D.L., Mimura, N., Beamish, R.J. and. Ittekkot, V. (2001). Coastal zones and marine ecosystems. In Climate change 2001: *Impacts, Adaptation and Vulnerability*. Edited by J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White. Cambridge University Press, Cambridge, England pp. 343-379.

McGoodwin, J. (2001). Understanding the Cultures of Fishing Communities: A Key to Fisheries Management and Food Security. FAO Fisheries Technical Paper No.401. Rome: Food and Agriculture Organization.

McPhaden, M. J. and Zhang, D. (2002). Slow down of the meridional overturning circulation in the upper Pacific Ocean, Nature, 415, 603– 608.

McPhaden, M. J. (1999): Genesis and evolution of the 1997–1998 El Nino, Science, 283, 950–954.

Mendelsohn, R., Nordhaus, W.D. and Shaw, D. (1994) The impact of global warming on agriculture: a Ricardian analysis. American Economic Rev 84(4):753–771

Mendis, S., Mills, S. and Yantz, J. (2003). "Building Community Capacity to Adapt to Climate Change in Resource-based Communities." Prepared for the Canadian Forest Service.

Mikkelsen, B. (1995). Methods for development work and research: A guide for practitioners. Sage Publications, New Delhi, Thousand Oaks, London Milankovic, M., Canon of Insolation and the Ice-Age Problem (Kanon der Erdbestrahlung und seine Anwendung auf das Eiszeitenproblem), Belgrade, 1941 (Royal Serbian Academy of Mathematical and Natural Sciences, v. 33).

Miller, C. (1991). Handbook of Research Design and Social Measurement.Newborg: Park Gorge.

Mitlewski, B., Machado-Filho, F., Queiroz-Filho, E.S.P., Santana, A.C., Moreira, A.J.F., Mello, R.Q., Bonatto, M.P.O., Mota, S.Q.C. and Stevens, A.D. (1999).

Estudo de caso em Centro Comercial, Município de Alenquer, PA. In *Recursos pesqueiros do Médio Amazonas*: abordagem socioeconômica. Brasília: IBAMA. p. 251-320. (Série Estudos Pesca/Coleção Meio Ambiente, no. 21).

MoFD. (2008). National Oceans and Fisheries Policy, 2008

Mombasa County MTEF Budget Report 2012/13-2014/2015

Mora, C. and Ospína, A.F. (2001). Tolerance to high temperatures and potential impact of sea warming in reef fishes of Gorgona Island (tropical eastern Pacific). *Mar. Biol*.**139**, 756-769.

Morgans, J.F.C. (1962). Ecological aspects of demersal troplcal fishes off East Africa. Nature, Lond. 193: 86-87

Mortimore, M.J. and Adams, W.M. (2001). Farmer adaptation, change and 'crisis' in the Sahel Global Environmental Change-Human and Policy Dimensions, 11 (1) (2001), pp. 49–57.

Moss, D., Gypta, S. and Shah, V. (2005): "on the Margins in City: Adivasi Seasonal Labour Migration in Western India", Economic and Political weekly, 40 (28); 3025-38

Moyle, P. B. and Cech, Jr., J.J. (2004). Fishes: An Introduction to Ichthyology, 5th Ed.Prentice Hall, Upper Saddle River, NJ, 726 pages.

Mugenda, O.M. and Mugenda, A.G. (2003). Research Methods; Quantitative and Qualitative approach,Nairobi, Acts Press.

Murray, P.A. (2005). Climate Change, Marine Ecosystems and Fisheries: Some Possible Interactions in the Eastern Caribbean. Morne Fortune, Castries: OECS-ESDU. 52 pp.

Mutai, B.K. (2001). How to write Standard Dissertation: A systematic and Simplified Approach. New Dehli: Tally.

Mutai, C. C., Ward, M. N and Colman, A.W. (1998). Towards the prediction to the East Africa short rains based on sea surface temperature–atmosphere coupling. *Int. J. Climatol.*, 18, 975–997.

Mwana, O.C. (1979) Educational and Social Science Research Methods. Nairobi. Masola Publishers

Nagy, G. J., Bidegain, M., Caffera, R.M., Blixen, F., Ferrari, G., Lagomarsino, J.J., López, C.H., Norbis, W., Ponce, A., Presentado, M.C., Pshennikov, V., Sans, K. and Sención, G. (2006). *Assessing climate variability and change vulnerability for estuarine waters and coastal fisheries of the Rio de la Plata*. *AIACC Working Series Paper No. 22*. International START Secretariat, Washington, USA

Nagy, G., Severov, D., Pshennikov, V., Santos, M., Lagomarsino, J., Sans, K., and. Morozov, E. (2005). Rio de la Plata System: Relationship between river flow and frontal ariability. Advances in Space Research, Elsevier. (AIACC Project No. LA32).

Najam, A., Huq, S. and Sokona, Y. (2003).Climate Negotiations beyond Kyoto: Developing countries Concerns and Interests.

Nakamura, N., Kayanne, H., Iijima, H., McClanahan, T.R., Behera, S.K and. Yamagata, T. (2009). Mode shift in the Indian Ocean climate under global warming stress. Geophysical Research Letters 6:doi:10.1029/2009GL040590.

National Research Council (NRC), (2006). Surface Temperature Reconstructions For the Last 2,000 Years. National Academy Press, Washington, DC.

Neiland, A.E., Jaffry, S., Ladu, B.M.B., Sarch, M.T. and Madakan, S.P. (2000). Inland fisheries of North East Nigéria including the Upper River Benue, Lake Chad and the Nguru-Gashua wetlands I. Characterisation and analysis of planning suppositions. *Fisheries Research*, vol. 48, no. 3, p. 229-243.

Nellemann, C., Hain, S. and Alder, J. (2008). In Dead Water - Merging of climate change with pollution,over-harvest, and infestations in the world's fishing grounds. United Nations Environment Programme, GRID-Arendal Norway.

Nettleton, D. and Baran, E. (2003). *Fishery stakeholder groups and livelihood variation around the Tonle Sap Great Lake, Cambodia*. World Fish Center, Penang, Malaysia (mimeo.)

Netto, S L. (2006). *Pesca profissional versus pesca esportiva*: suas diferenças e semelhanças no Pantanal Matogrossense, Brasil. Cuiabá: Universidade Federal de Mato Grosso. 47 p. [Dissertação de Mestrado].

Ngware, N., Makalle, A. and Shemdoe, R.S. (2008). Understanding Gender Roles in Integrated Water Resource management in Tanzania: The Case of Usambara Mountains. In: Mukangara, F. and I. F. Shao, (eds.), Gender, Governance and Natural Resources in Rural Settings: Some Case Studies From Tanzania. Dar es Salaam University Press, 40(9): 46-78.

Nicholls, R. J., Wong, P.P., Burkett, V.R., Codignotto, J.O., Hay, J.E., McLean, R.F., Ragoonaden, S. and Woodroffe, C.D. (2007). Coastal systems and low-lying areas. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J.v. d. Linden & C.E. Hanson, eds. *Climate Change 2007: impacts, adaptation and vulnerability*,pp. 315–356.Contribution of working group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, Cambridge University Press.

Nicholson, S. F., Kim, E and Hoopingarner, J (1988): Atlas of African Rainfall and Its Interannual Variability. Dept. of Meteorology, The Florida State University, Tallahassee, FL, 237 pp.

Nicholson, S. F. and Kim, E. (1997): The relationship of the El Ninõ–Southern Oscillation to African rainfall. *Int. J. Climatol.*, **17,**117–135.

Ñiquen, M. and Bouchon, M. (2004). Impact of El Niño events on pelagic fisheries in Peruvianwaters. Deep Sea Research Part II: Topical Studies in Oceanography 51: 563-574

Norbis, W., Ponce, A., Severov, D.N., Saona, G., Verocai, V., Pshennikov, V., Silva, R., Sención G. and Nagy, G.J. (2005). Vulnerabilidad y Capacidad de Adaptación de la Pesca Artesanal del Río de la Plata a la Variabilidad Climática. In: El Cambio Climático en el Río de la Plata, Capítulo 18, 173-187. V. Barros, A. Menéndez, G.J.Nagy., Eds. Proyecto *Assessments of Impacts and Adaptation to Climate Change,* CONICET-UBA, Buenos Aires, Argentina.

North, D.C. (1990). Institutions, Institutional Change and Economic Performance Cambridge University Press, Cambridge.

Obasi, G.O.P. (2005). The impacts of ENSO in Africa. In Pak Sum Low (ed.) *Climate Change and Africa*, Cambridge University Press, 218-230, (2005).

Obura, D. (2005). Resilience and climate change: Lessons from coral reefs and bleaching in the Western Indian Ocean. Estuarine, Coastal and Shelf Science 63: 353–372.

Obura, D. O., Muthiga, N.A. and Mwaura, J.M. (2002). Participatory Monitoring of Artisanal Fishery in Kenya. In: Linden, O., D. Souter, D. Wilhemsson and D. Obura (eds). *Coral reef degradation in the Indian Ocean*– Status Report 2002. Kalmer, Sweden.

Ochiewo, J. (2004a) .*Changing Fisheries practices and their socio economic implications in South Coast Kenya. Ocean and Coastal Management,* 47:389-408.

Ochiewo, J. (2004b). *Sustainability of Marine Fisheries in Malindi Ungwana Bay in Kenya.* M.A. Economics dissertation submitted to Department of Economics , University of Nairobi.

O'Hare, J. Sweeney and R. L. Wilby (2005). *Weather, Climate and Climate Change: Human Perspectives,* Prentice Hall, Harlow, England.

Okemwa, E. N., Ruwa, R. K. and Mwandotto, B. A. J. (1997). Integrated coastal zone management in Kenya: initial experiences and progress. Ocean & Coastal Management 37(3):319347.

O'Reilly, C.M., Alin, S.R., Plisnier, P.D., Cohen, A.S., McKee, B.A. (2004). Nature 424:766–768.

Orodho, J. A. (2009). Elements of Education and Social Science Research Methods: 2nd Edition, Maseno. Kane 2 Publishers.

Orodho, J.A. (2005). Elements of Education and Social Science Research Methods. Nairobi, Masola Publishers.

Orr, J.C., Fabry, V.J., Aumont, O., Bopp, L., Doney, S.C., Feely, R.A., Gnanadesikan, A., Gruber, N. Ishida, A., Joos, F., Key, R.M., Lindsay, K., Maier-Reimer, E., Matear, R., Monfray, P., Mouchet, A., Najjar, R.G., Plattner, G-K., Rodgers, K.B., Sabine, C.L., Sarmiento, J.L., Schlitzer, R., Slater, R.D., Totterdell, I.J., Weirig, M-F., Yamanaka, Y. and Yool, A. (2005). Anthropogenic ocean acidification over the twenty first century and its impact on calcifying organisms. *Nature,* 437: 681–686.

Oso and Orien (2008). A general guide to writing proposals and reports. A hand book for beginning researchers 2nd Edition. March 2008, Makerere University. Printer Kampala Uganda.

Ostrom, E. (1999). Coping with tragedies of the commons. Annual Review of Political Science, 2: 493-535.

Ostrom, E. (1990). Governing the Commons: The Evolution of Collective Action. Cambridge University Press, Cambridge, UK.

Paavola, J. (2008). Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania. Environ Sci Policy 11:642–654.

Pachauri, R. K. & Reisinger, A. (2007). IPCC, 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 104. Geneva, Switzerland: IPCC, WMO/UNEP.

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes Global Environmental Change-Human and Policy Dimensions, 19 (3) , pp. 354–365.

Parsons, L. S. and Lear, W.H. (2001): Climate variability and marine ecosystem impacts: A North Atlantic perspective. *Progress in Oceanography,* Vol. 49, Pergamon, 167–188

Patz, J.A. (2000). Climate change and health: New research challenges. Ecosystem Health 6(1): 52–58.

Patz, J.A. and Kovats R.S (2002) Hotspots in climate change and human health. British Medical Journal 325: 1094-1098

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and Torres, F. (1998). Fishing down marine food webs. *Science,* 279(5352): 860–863.

Pelling, M. (2011). Adaptation to Climate Change: From Resilience to

Transformation Routledge, Abingdon, UK.

Perez, R. (2003). Adaptive Capacity: The Philippine Coastal Resources

Experience. In J. Smith, R. Stein and S. Huq (eds). Climate Change, Adaptive Capacity and Development. Imperial College Press, UK. pp. 217-240.

Perry, R.I., Ommer, R.E., Allison, E., Badjeck, M-C, Barange, M, Hamilton., L.,

Jarre, A., Quinones, R.A. and Sumaila, U.R. (2009). The human dimensions of marine ecosystem change: interactions between changes in marine ecosystems and human communities. In: Barange M, Field C, Harris R, Hofmann E, Perry I, Werner C (eds) Global Change and Marine Ecosystems. Oxford University Press, Oxford.

Peterson T.C. (2009). "State of the Climate in 2008," Special Supplement to the Bulletin of the American Meteorological Society, v. 90, no. 8, August 2009, pp. S17-S18.

Philander, S.G.H. (1990): *El Niño, La Niña, and the Southern Oscillation*. Academic Press, 293 pp.

Pielke, S. R. (2009). "Climate Change: The need to consider human forcings besides greenhouse gases," *Eos* 90:45, 413.

Plisnier, P.D., Serneels, S. and Lambin, E.F. (2000). Impact of ENSO on East African ecosystems: a multivariate analysis based on climate and remote sensing data. Global Ecology and Biogeography 9: 481-497.

Polsky, C., Neff, R. and Yarnal B. (2007). Building comparable global change vulnerability assessments: the vulnerability scoping diagram. Global Environ Chang 17:472–485. doi:10.1016/ j.gloenvcha.2007.01.005

Polyak, L. (2009). "History of Sea Ice in the Arctic," in Past Climate Variability and Change in the Arctic and at High Latitudes, U.S. Geological Survey, Climate Change Science Program Synthesis and Assessment Product 1.2,

Pratchett, M.S., Munday, P.L., Wilson, S.K., Graham, N.A.J., Cinner, J.E., Bellwood, D.R., Jones, G.P., Polunin, N.V.C.and McClanahan, T.R. (2008). Effects of climate induced coral bleaching on coral-reef fishes – ecological and economic consequences. Oceanography and Marine Biology: An Annual Review 46, 251–296.

Prachett, M.S., Gust, N., Goby, G. and Klanten, S.O. (2001). Consumption of coral propagules represents a significant trophic link between corals and reef fish. *Coral Reefs* 20, 13-17.

Prowse, M. and Scott, L. (2008). Assets and Adaptation: An Emerging Debate". IDS Bulletin 39 (4): 42 -52.

Quest Fish (2012). Quest_Fish project. Government of UK. Ramaswamy, V. (2006). "Anthropogenic and Natural Influences in the Evolution of Lower Stratospheric Cooling," Science 311, 1138-1141

Rakotondrafara, M.L. (2001). Occurrences in the southwest Indian Ocean, MSc Thesis, University of Hawaii, 93 pp.

Republic of Kenya (2008).The Draft National Environmental Policy (NEP)

Republic of Kenya (2004). National Policy on Disaster Management (Revised Draft) P 4 Nairobi, Kenya).

Republic of Kenya (2000). The Environment Management and Coordination Act, 1999. Government Printers, Nairobi, Kenya.

Robledo, C., Fischler, M. and Patino, A. (2004). Increasing the resilience of hillside communities in Bolivia. *Mt. Res. Dev.*, **24**, 14-18.

Rodriguez, A. and Smith, S. (1994). A comparison of Determinants of Urban, Rural and Farm poverty in Costa-Rica. World Development Vol. 22 pp 381-387

Rowe, D.P. (2001). Tele connections between the tropical Pacific and the Sahel. Quarterly Journal of the Royal Meteorological Society 127: 1683-1706.

Ruwa, R., Habib, G., Mukira, M., Okoth, G. and Mwatha, G. (2003*). Profile of Kenya Marine and fisheries-Country working Resource document*.GEF-South-West Indian Ocean.

Sabine, C.L. (2004), "The Oceanic Sink for Anthropogenic CO2," Science vol. 305 (16 July 2004), 367-371

Saji, N H. and Yamagata, T. (2003). Possible impacts of Indian Ocean dipole mode events on global climate. Clim Res, **25**: 151 – 169.

Saji, N.H., Goswami, B.N., Vinayachandran, P.N. and Yamagata, T. (1999). A dipole mode in the tropical Indian Ocean. Nature 401: 360–363.

Santer , B.D. (2003). "Contributions of Anthropogenic and Natural Forcing to Recent Tropopause Height Changes," Science vol. 301, 479-483.

Sarch, M-T and Allison, E.H. (2000) Fluctuating fisheries in Africa's inland waters: well adapted livelihoods, maladapted management. In: Proceedings of the 10th international conference of the institute of fisheries economics and trade, Corvallis, 9–14 July 2000

Schipper, E.L.F. (2009). Meeting at the crossroads? Exploring the linkages between climate change adaptation and disaster risk reduction Climate and Development, 1 (1) (2009), pp. 16–30.

Schmitt, K. and Kramer, D. (2010). Road development and market access on Nicaragua's Atlantic coast: Implications for household fishing and farming practices. Environmental conservation **36:** 289-300

Schreck, C.J. and Semazzi, F.H.M. (2004). Variability of the recent climate of eastern Africa, International Journal of Climatology, 24 (6): 681-701.

Scoones, I. (1998). Sustainable rural livelihoods: a framework for analysis. *IDS Working Paper*, No. 72, Institute of Development Studies, Sussex, U.K.

Shemdoe, R.S. (2011). Tracking Effective Indigenous Adaptation Strategies on Impacts of Climate Variability on Food Security and Health of Subsistence Farmers in Tanzania. African Technology Policy Studies (ATPS) Network working paper series No. 51. ISBN: 978- 9966-1552-0-7UNESCO. 2007.

Shemdoe, R.S, Kikula, I.S. and Van Damme, P. (2009). Traditional Tillage Systems as Drought Adaptation Strategies of Smallholder Farmers: The Case of Semi-arid Central Tanzania. Nat. Culture, 4(2): 191-207.

Shongwe, M.E., van Oldenborgh and van Aalst (2009). Projected changes in mean and extreme precipitation in Africa under global warming, Part II: East Africa. Nairobi, Kenya, 56 pp.

Singh, N. and Gilman, J (1999). Making livelihoods more sustainable. *International Social Science Journal* 51:539–545.

Sissoko, K., van Keulen, H., Verhagen, J., Tekken, V. and Battaglini, A. (2011). Agriculture, livelihoods and climate change in the West African Sahel. Reg Environ Chang 11:119–125.

Smit, B., Hovelsrud, G.K. and Wandel, J. (2008). CAVIAR: Community adaptation and vulnerability in Arctic regions. Occasional Paper No. 28. University of Guelph, Department of Geography, Guelph, Ontario, Canada. 23 pp.

Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16 (3), 282–292.

Smit, B. and Pilifosova, O. (2001). Adaptation to Climate Change in the Context of Sustainable Development and Equity Chapter 18 in Climate Change 2001: Impacts, Adaptation, and Vulnerability—Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Smit, B., Burton, I., Klein, R.J.T. and Wandel, J. (2000). "An anatomy of adaptation to climate change and variability." *Climatic Change* 45(1): 223-251.

Smith, M.D. (2010). Sustainability and global seafood. Science 2010; 327(5967): 784–6.

Sobel, J. (2002). *"Can We Trust Social Capital*". Journal of Economic Literature Vol. XL (March 2002), pp. 139.

Soon, W.W.-H. (2009). "Solar arctic-mediated climate variation on multidecadal to centennial timescales: Empirical evidence, mechanistic explanation, and testable consequences," *Physical Geography* 30:2, 144-148

Soon, W.W.-H. (2005). "Variable solar irradiance as a plausible agent for multidecadal variations in the Arctic-wide surface air temperature record of the past 130years," *Geophysical Research Letters* 32:10.1029/2005GL023429.

Spalding, M.D. and Jarvis, G.E. (2002). *The impact of the 1998 coral mortality on reef fish communities in the Seychelles. Mar. Pollut. Bull*. 44, 309-321.

Spencer, R.W. "Cloud and radiation budget changes associated with tropical intraseasonal oscillations," *Geophysical Research Letters* 34:L15707, doi: 10.1029/2007GL029698.

Sproul, N. (1998). Handbook for Research Methods: A guide for practitioners and students in science.

Stern, N. (2006). Stern Review on the Economics of Climate Change (Pre-Divisions Publication edition). Executive Summary H.M Treasury, London.

Steve, C. (2007). Global warming is not some conspiratorial hoax - Independent online Edition > Commentators". The Independent (London). 2007-01-29. Retrieved 2007-11-16

Stone, W. (2003). *"Towards building capacity and sustainable communities Bonding, bridging and linking with social capital"*. Bulletin no.4 S ring / summer 2003. Sumaila, U.R., Cheung WWL, Lam VWY, Pauly D, Herrick S. *(*2011). Climate change impacts on the biophysics and economics of world fisheries. Nature Climate Change1*:* 449–456

Strauss, S. and Orlove, B., (eds.) (2003). Weather, climate, culture. New York: Berg Publishers.

Strong, A., Goreau, T. and Hayes, R. (1998). Ocean hot spots and Coral Bleaching January-July 1998. Reef encounter 24:20-22

Sud, Y.C., Walker, G.K., and Lau, K.-M. (1999). "Mechanisms regulating deep moist convection and sea-surface temperatures in the tropics," *Geophysical Research Letters* 26:(8), 1019-1022.

Sumaila, U.R., Cheung, W.W.L., Lam, V.W.Y., Pauly D. and Herrick S. (2011). Climate change impacts on the biophysics and economics of world fisheries. Nature Clim Chang 1(9):449–456

Svensmark, H. and Friis-Christensen, E. (1997). "Variation of cosmic ray flux and global cloud coverage – A missing link in solar-climate relationships," Journal of Atmospheric and Solar-Terrestrial Physics59:1225-1232.

Tabachnick, B.G. and Fidell, L.S. (1996). Using multivariate statistics. Third edition New York: Harper Collins College.

The World Fish Centre (2008). Small-scale capture fisheries: a global overview with emphasis on developing countries: a preliminary report of the Big Numbers Project. Food and Agriculture Organization of the United Nations PROFISH World Bank and The World Fish Center, Penang, Malaysia.

Thomas, D.S.C. and Twyman, C. (2005*). Equity and Justice in Climate Change and adaptation among natural resource dependent societies*. Global Environmental Change.

Tierney, K.J., Lindell, M.K. and Perry, R.W. (2001). Facing the Unexpected: Disaster Preparedness and Response in the United States. Washington, D.C.: Joseph Henry Press.

Tologbonse, E.B., Auta, S.J., Bidoli, T.D., Jaliya, M.M., Onu, R.O. and Issa, F.O. (2010). Farmer's Perceptions of the Effects of Climate Change and Coping Strategies in Three Agro-Ecological Zonnes of Nigeria. *Journal of Agricultural Extension,* Vol. 14 (1), June. Pp. 144-156.

Tompkins, E.L. and Adger, W.N. **(**2004). Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society,* 9(2): 10.

Toya, H. and Skidmore, M. (2005). *Economic Development and the Impacts of Natural Disasters.* Working Paper 05-04. University of Wisconsin, Whitewater Wisconsin, USA

Trenberth, K.E. (2007). *The evolution of ENSO and global atmospheric temperatures.* Journal of Geophysical Research, 107, 4065, (2002).

Trotman A, Gordon R.M, Hutchinson S.D, Singh R, McRae-smith D. (2009). Policy responses to GEC impacts on food availability and affordability in the Caribbean community. Environmental Science and Policy 2009; 1294):529-41

Turner, B. L. I., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A. and A. Schiller, A (2003). "A framework for vulnerability analysis in sustainability science." *Proceedings, National Academy of Sciences of the United States of America* 100 (14): 8074-8079.

Tyler, N.J.C., Turi, J.M., Sundset, M.A., Strøm Bull, K., Sara, M.N., Reinert, E. and Oskal, N. (2007). Saami reindeer pastoralism under climate change: Applying a generalized framework for vulnerability studies to a sub-arctic social-ecological system. Global Environmental Change 17:191 – 206, doi: 10.1016/j. gloenvcha. 2006.06.001.

Tzanatos, E., Dimitriou, E., Papaharisis, L., Roussi, A., Somarakis, S. and Koutsikopoulos, C., (2006). Principal socio-economic characteristics of the Greek small-scale coastal fishermen. *Ocean and Coastal Management*, vol. 49, no.7-8, p. 511-527.

UNDP (2007). Human Development Report 2007/2008. *Fighting Climate Change: Human Solidarity in a Divided World*. New York: UNDP. 2009 (15).

UNDP (2006). Human Development Report 2006. Beyond Scarcity: Power, poverty and the global water crisis, United Nations Development Programme.

UNEP (2006a*). Marine and Coastal ecosystems and Human Well-being. A synthesis report based on the findings of the Millennium Ecosystem Assessment.* UNEP www.unep.org; MEA www.MAweb.org

UNEP (2006b). African Environmental Outlook 2: Our Environment, Our Wealth. United Nations Environmental Programme, Nairobi.542 pp.

UNEP (1994). The Impacts of Climate on Fisheries. UNEP, Nairobi, Kenya, 36. UNFCCC (2009), "Advance Report on Recommendations on Future Financing Options for Enhancing the Development, Deployment, Diffusion and Transfer of Technologies Under the Convention"). P. 17

UNFCCC (2009), "Advance Report on Recommendations on Future Financing Options for Enhancing the Development, Deployment, Diffusion and Transfer of Technologies Under the Convention"). P. 17

UNFCCC (2007). Climate Change Impact, Vulnerabilities and Adaptation in Developing Countries. UNFCCC Secretariat, Martin-Luther King-Straat 8 53175 Bonn, Germany.

UNFCCC Secretariat (2003). "Proceedings of the Special Event on Coastal Adaptation Strategies" Marrakech, Morocco, October 2003. United Nations Human Settlement Programme (UNHABITAT). (2010). *São Paulo a Tale of Two Cities.* United Nations Human Settlement Programme, Nairobi, Kenya.

UN-Habitat, (2008), The State of African Cities; A Framework for Addressing Urban Challenges in Africa, UN Habitat, Nairobi University press, Cambridge, UK and New York, NY, USA.

UN/ISDR (2004). Living with Risk – A global review of disaster reduction initiatives UK CIP (2003). Climate Adaptation: United Nations International Strategy for Disaster Reduction (UNISDR) (2002). *Living with Risk: a Global Review of Disaster Reduction Initiatives.* Preliminary version. United Nation Publications, Geneva, Switzerland.

Uphoff, N. and. Buck, L. (2006). Strengthening rural local institutional capacities for sustainable livelihoods and equitable development. Paper prepared for the Social Development Department of the World Bank.Mimeo.

Van Schayk, I.M. (2005). El Niño causes dramatic outbreak of Paederus dermatitis in east Africa. In Pak Sum Low (ed.) *Climate Change and Africa*, Cambridge University Press, 240-247.

Vilhjálmsson, H., Hoel, A.H., Agnarsson, S., Arnason, R., Carscadden, J.E., Eide, A. and Fluharty, D. (2005). Chapter 13: Fisheries and aquaculture. In: ACIA: Scientific Report. Cambridge: Cambridge University Press. 691 – 780.

Vincent, K. (2007). Uncertainty in adaptive capacity and the importanceof scale. Global Environ Chang 17:12–24.

Wakwabi, E., Abila, R.O. and Mbithi, M.L. (2003). *Kenya Fish Sub-sector: Fish Sector Development strategy for Kenya.* Consultancy Report for the International Trade Centre/ United Nations Conference on Trade And Development/ World Trade Organization Joint Integrated Technical Assistance Program to Least Developed and Other African Countries. Kenya Department of Fisheries/ Association of Fish Processors and Exporters of Kenya. Nairobi. (Final draft).

Walker, B.H, Holling, C.S., Carpenter, S.R. and Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society*9(2):5.

Wang X, Li C. Y. and Zhou, W (2006). Interdecadal variation of the relationship between Indian rainfall and SSTA modes in the Indian Ocean. *Int Jour. Climatol,* (2006), 26: 595 – 606.

Weart, S. (2011). "International Cooperation: Democracy and Policy Advice (1980s)". The Discovery of Global Warming. American Institute of Physics. Retrieved 9 July 2012

Webster, P. J., Moore, A.M., Loschning, J.P. and leben, R.R. (1999). Coupled ocean-atmosphere dynamics in the Indian Ocean during 1997-1998, *Nature*, 401: 356-360.

Wei, Y. P.; Chen; D.R.E., White, I.R., Edis, R.W. and Langford, J. (2009). Farmers' Perception of environmental degradation and their adoption of improved management practices in Alxa, China, Land degrade. Develop, Vol.

Westlund, L., Poulain, F., Bage, H.and Van Anrooy, R. (2007). Disaster response and risk management in the fisheries sector. Rome: FAO.

Whittingham, E., Campbell J. & Townsley P. (2003). Poverty & Reefs, Vol. 1. Paris: DFID-IMM-IOC/UNESCO, 260 pp.

Wilkinson, C. (2000). Status of Coral Reefs of the World: 2000. Australian Institute of Marine Science, Townsville, Australia.

Wilkinson, C., Lindén, O., Cesar, H., Hodgson, G., Rubens, J. and Strong, A.E. (1999). Ecological and socioeconomic impacts of 1998 coral mortality in the Indian Ocean: An ENSO impact and a warning of future change? Ambio 28, 188-196.

Williams, D.M. (1986). Temporal variation in the structure of reef slope fish communities (central Great Reef Barrier): Short term effects of Acanthaster planci infestation. *Mar. Ecol. Prog. Ser.* 28, 157-164.

Williamson, O. E. (2000). "The New Institutional Economics: Taking Stock, Looking Ahead." *Journal of Economic Literature*38: 595-613.

Wilson, S.K., Graham, N.A.J., Pratchett, M.S., Jones, G.P.and Polunin, N.V.C. (2006). Multiple disturbances and the global degradation of coral reefs: are reef fishes at risk or resilient? Global Change Biology 12, 2220–2234.

Wisner, B., Blaikie, P., Cannon, T. and Davis, I (2004*). At Risk: Natural Hazards, People's Vulnerability and Disasters.* Second edition. Routledge, London, UK.

WIO Fish, (2008). West Indian Ocean Fisheries Data base: a catalogue of small- scale fisheries.www.wiofish.org

World Bank (2005). Hazards of nature, risks to development: An IEG evaluation of World Bank Assistance for Natural Disasters (Washington, D.C.: World Bank)

World Bank (2004). *Saving Fish and Fishers*. Washington D.C

World Bank (2002). Poverty and Climate Change: Reducing the Vulnerability of the Poor. Discussion Document for COP 8 Prepared by Ten Partners Including the World Bank.

World Wide Fund for Nature (2006). Climate Change Impacts on East Africa. A Review of the Scientific Literature.

Yang, X. and Guo, F. (1999). "Gender Differences in Determinants of Temporary Labor Migration in China: A Multilevel Analysis." *International Migration Review* 33 (4): 923-953.

Young, O. (2002). The institutional dimensions of environmental change: fit, interplay, and scale. MIT Press, Cambridge, Massachusetts, USA.

Zhang, J., Fleming, J. and Goericke, R. (2012). Fishermen's perspectives on climate variability, *Marine Policy* 36 (2012) 466–472, 2011 Published by Elsevier Ltd.

Ziervogel G. and Calder R. (2003). Climate variability and rural livelihoods: assessing the impact of seasonal climate forecasts in Lesotho. Area

Zoellick, R.B. (2009). Climate Smart Future. The Nation Newspapers. Vintage Press Limited, Lagos, Nigeria.pp. 18.

APPENDICES: RESEARCH INSTRUMENTS

APPENDIX 1: FISHERS' QUESTIONNAIRE

Statement of Confidentiality
My name is Beatrice Akunga. I am a Kenyatta University Student carrying out research for my degree of Doctor of Philosophy in Environmental Studies .The information given through this questionnaire is confidential and purely for research purposes.

Enumerator……Date of interview……
Location……Sub-Location……
Village……..Name of landing site ……..……
Name of BMU if different from landing site……

I. GENERAL INFORMATION

a) Name of respondent ***(Optional)*** ……Gender: [ ] Male [ ] Female Age (yrs): [ ] below 18 [ ] 18-35 [ ] 36- 60. [ ] above 60
b) Birth Place…….
c) Marital status [ ] Married [ ] Single [ ] Divorced
d) Education background [ ] Primary [ ] Secondary [ ] Tertiary [ ] No formal education
e) How many years have you been a fisherman?
[ ] Less than 10 [ ] 10-20 yrs [ ] 20-30yrs [ ] more than 30 yrs

II. ACTIVITY DATA

Case: With boat activity:

f) No of crew in vessel…….
g) Are you a? [ ] Crew member [ ] vessel owner [ ] other specify …….....
h) Propulsion: [ ] Inboard engine [ ] Out board engine [ ] Paddles [ ]Sails [ ]foot fisher
i) Main gear type; ***(Multiple response- please tick the main gear type(s) you use)***

Main Gear Type used	**Main Gear Type used**	**Main Gear Type**	**Main Gear Type**	**Main Gear Type**	**Main Gear Type**
[ ] Diver	[ ] hand line	[ ] traps/ basket	[ ] Trolling lines	[ ] Prawn seine	[ ] spear gun
[ ] Gillnet	[ ] trammel nets	[ ] Scoop net	[ ] Ring nets	[ ] Beach seine	
[ ] Hook and line	[ ] trawl net	[ ] pointed sticks	[ ] harpoons	[ ] cast net	

[ ] other specify.....

10a). Have you suffered injuries during your fishing trips before? [ ] Yes [ ] |No

10b). If Yes, could it be weather related the cause of the injury? [ ] Yes [ ] |No

10c).If No, please mention the other major cause(s)

other.....

11). No hours/days dedicated to fishing activity[ ] less than 5 hrs [ ] 5-10 hours [ ] More than10 hrs

12). No days per week for fishing activity [ ] less than 2 days [ ] 3-5 days [ ] more than 5 days

13). Duration of the last fishing trip [ ] less than a day [ ] 1 day [ ] 2 to 3 days [ ] more than 3 days

14). If the trip lasted more than 1 day, what was the reason? .....

15) What is your potential radius of operation (Kms) [ ] 0-3 [ ] 4-6 [ ] 7-10 [ ] More than 10 [ ]

16) What document do you have as a fisherman ***(Multiple responses***)? [ ] fishing licence [ ] Boat licence [ ] none

17) Have you received capacity building courses in the last five years? [ ] Yes [ ] No

If the answer is yes, indicate what type: ***(Multiple responses***)

[ ] environmental awareness [ ] aquaculture [ ] business management

[ ] safety at sea [ ] leadership courses [ ] others please specify.....

III SOCIO -ECONOMIC INFORMATION

18a) Do you have a Life insurance [ ] Yes [ ] No

18b. Do you have Pension [ ] Yes [ ] No

19. Number of children in schooling age. [ ] none [ ] < 2 [ ] 2 -5 [ ] more than 5

20a) Estimated Monthly Family income in Kenya Shillings

[ ] below 5000 [ ] 5001-10,000 [ ] 10,001-15,000 [ ] 15,001-20.000

[ ] above 20,000

20b) Estimated Monthly family expenses in Kenya Shillings

[ ] below 2,500 [ ] 2,501-5,000 [ ] 5001-7,500 [ ] 7,501-10,000

[ ] above 10,000

21) Monthly Family incomes from fishing in Kenya Shillings

[ ] below 5,000 [ ] 5,001-10,000. [ ] 10,001-15,000

[ ] 15,001-20000 [ ] above 20,000

IV ECONOMIC ACTIVITY (NATURAL CAPITAL)

22).What are the main economic activities that sustain your family? Name them by order of importance.

a) Fishing [ ] b) Farming [ ] c) Formal employment [ ]

d) Other activities [

23a). Do the women in your house hold have any specific economic activity?

[ ] Yes [ ] No

23b). If yes, which ones? [ ] fish trader [ ] business [ ] causal worker [ ] other.....

d) <u>KIND OF CLIMATE VULNERABILITY AND TRENDS EXPERIENCED IN THE STUDY AREA AND EFFECT ON LIVELIHOODS</u>

1. What kind of climate shocks/stresses has been experienced by you and your household over the last 20 years? ***(Multiple responses)***

[ ] Violent rain (changes into the intensity of rainfall resulting in floods)

[ ] delayed and less rainfall [ ] increased temperatures [ ] decreased temperatures

[ ] increased strength of winds [ ] decreased strength of winds

[ ] less clearly defined seasons (rains sometimes arrive a month late or finish early; rains quickly give way to sun shine or dry periods during rainy seasons

[ ] Other please specify.....

2. What are the effects of this climate shocks on you and your household?

VP= Very positive. P= positive Ne=Neutral N= Negative VN= Very negative

Climate element	**Effect (positive-negative)**					**Changes observed and implications**
	VP 5.	**P4**	**Ne3**	**N2**	**VN1**	
a) Ocean temperature a) Increased temperature						
b) Decreased temp						
b) Wind changes in direction and strength						
c) Violent rain (e.g. El Nino)						
d) Delayed rainfall						
Other (Specify ……						
……						

3a. Which groups or households types are the most vulnerable to these shocks/stress and trends? [ ] Children [ ] women [ ] men [ ] old people [ ] other (Specify).....……. …….

3b Why (explain)

4a. Have you noticed shifts in kusi and kaskazi seasons? [ ] Yes [ ]No

4b. If Yes what are the differences in shifts with regards to the timing of seasons now and 10 or so years ago

Kusi Seasons[ ] seasons are longer [ ] seasons are shorter
[ ] seasons are the same [ ] no change

Kaskazi seasons [ ] seasons are longer [ ] seasons are shorter
[ ] seasons are the same [ ] no change

4c How can you compare your income during Kusi and Kaskazi seasons
[ ] Increases [ ] decreases [ ] do not know

4d How can you compare your income during kaskazi now and 10 or so years ago [ ] Increases [ ] decreases [ ]same [ ] do not know

4e. Please give reasons.....

4f. What happens when fish declines during kusi periods are you able to carry out alternative livelihood options? [ ] Yes [ ] No

4g. Please indicate which ones [ ] farming [ ] business [ ] livestock keeping [ ] aquaculture [ ] other

5a. Do you think fishing during El nino made you better off or worse off
[ ] Better [ ] worse [ ] do not know

5b How can you compare your income during El nino of 1997/8 compared to other years
[ ] Increased [ ] decreased [ ] No change [ ] don't know

5c. Please give reasons a)Increase
b) Decrease…….…….…….....

6a. Did you change gear from the normal gear you use during El Niño? Period of 1997/8
[ ] Yes [ ] No

6b. Did you stop working during El Niño? [ ] Yes [ ] No

6c. Did you change your normal activity? [ ] Yes [ ] No

6d. If changed activity (to what?)…….
…….....**.....**

7. How can you compare your income during the South East Monsoon winds as compared to the North East Monsoon winds [ ] Increasing [ ] decreasing [ ] no change [ ] Do not know
[ ] other (Specify).....

Financial capital

8. Do you have life insurance [ ] Yes [ ] No

9. Do you have pension [ ] Yes [ ] No

10a. Do you have access to loan facilities to help you carry out your fishing activities e.g. buying gears [ ] Yes [ ] No

10b.If yes, which institutions give you loans –financial institutions [ ] Formal [ ] Informal
[ ] No loan [ ] other (specify).....

10c. Did you ask for loan assistance during times of climatic crises e.g. El Nino? [ ] Yes [ ] No

10d. Did you get any assistance for your request? [ ] Yes [ ] No

10e. If no why didn't you ask for loans or what hindered you from getting assistance? ***(Multiple responses)***

[ ] No land title deeds to act as security [ ] No boats as security)

[ ] Don't own good house to act as security

[ ] other (Specify)

……

Physical Capital

11. Name the assets that you own [ ] Boats [ ] land [ ] livestock [ ] car [ ] Motor cycle [ ] Bicycle [ ] [ ] other (Specify).....

Landing site Facilities

i.	Do you have a cell phone?		Yes	No	1
ii.	Is there a banda at the landing site?		Yes	No	2
iii.	Is there a cold room?		Yes	No	3
iv.	If yes, does the cold room work?		Yes	No	4
v.	Does the landing site have any of the following fish processing facilities?				
	a. Drying racks/Oven		Yes	No	5
	b. Smoking kilns		Yes	No	6
	c. Others (specify)				7
vi.	Is there a fish store?		Yes	No	8
vii.	Is there a jetty/Slipway?		Yes	No	9
viii.	Does the landing site have mains electricity?		Yes	No	11
vix.	If "No" how far to the nearest electricity supply (km)				
	< 1	1 - 5	6 - 10	> 10	12
ix.	Is there a public toilet facility?		Yes	No	13
x.	Is there a potable water supply?		Yes	No	14
xi.	For how many years has this landing side had access to potable water?				15
xii.	Is the landing site accessible by all-weather road?		Yes	No	16
xiii.	If "No" how far to the nearest all-weather road (km)?				
	<1	1-5	6-10	>10	17
xiv.	Is there a net repair facility?		Yes	No	18
xv.	Is there a shop selling fishing gear within 2 km?		Yes	No	19
xvii.	Is there a boat repair facility?		Yes	No	20
xviii.	Is there an engine repair facility?		Yes	No	21.
xix.	Does fisheries staff serve the landing site?		Yes	No	22.
xx.	If Yes How Frequent? Daily Weekly Monthly		Quarterly		23.
xxi.	Is there a BMU owned office at this site?		Yes	No	24.
xxii.	In which year was the BMU office build?				25.
xxiii.	Is there a fenced area at this site for fish handling?		Yes	No	26.
xxiv.	Is the land at this site privately owned?		Yes	No	27.
xxv.	Do fish factory agents buy fish from the site?		Yes	No	28.
xxvi.	If yes, for which fish Exporting companies?				29.
xxvii.	Are fish landed at this site for:				
	< 5 months a year	> 5 months a year	All year-round		30

e) **DEGREE TO WHICH THE LOCAL FISHERY TARGETS FISHES DEPENDENT ON LIVE CORAL AND THE REEF MATRIX AND THE EFFECT OF SEA SURFACE TEMPERATURE ON THESE FISHES**.

Natural Capital

1. Please indicate **3 main** fishing zones you target and your target species for the zone. ***(Multiple responses)***

	Species targeted /Fishing Zones		Creek	Reef	Open Sea	Other (Specify)		
1	Rabbit fish (Tafi)							
2	Scavengers (Tangu)							
3	Snappers (Pali)							
4	Cavallajacks (Kolekole)							
5	Mullets (Mkizi)							
6	King fish (Nguru)							
7	Tuna (Jodari)							
8	Sharks (Papa)							
9	Prawns (Kamba)							
10	Lobsters (Kamba mawe)							
11	Octopus (Pweza)							
12	Crabs (Kaa)							
13	Grunter (Paramamba)							
14	Sardines (Simu)							
15	Tilapia							
16	Black skin (fute)							
17	Sail fish (suli suli)							
18	Marlin (Duaro)							
19	Catfish (fumi)							
20	Parrot fish (Pono)							

2. **Please tick Species target now and main 3 main gear type you use *(Multiple responses)***

	Species targeted Now/Main gear type use	Gill net Seine net	Prawn seine beach seine	Reef seine	Trawl nets	Cast nets	ring nets	trammel nets	Long line hooks	Hand lines	Traps/ basket	Scoop nets	Trolling lines	Spear gun/harp oons	Hooked sticks	Pointed sticks	Others
1	Rabbit fish (Tafi)																
2	Scavengers (Tangu)																
3	Snappers (Pali)																
4	Cavallajacks (Kolekole)																
5	Mullets (Mkizi)																
6	King fish (Nguru)																
7	Tuna (Jodari)																
8	Sharks (Papa)																
9	Prawns (Kamba)																
10	Lobsters (Kamba mawe)																
11	Octopus (Pweza)																
12	Crabs (Kaa)																
13	Grunter (Paramamba)																
14	Sardines (Simu)																
15	Tilapia																
16	Black skin (fute)																
17	Sail fish (suli suli)																
18	Marlin (Duaro)																
19	Catfish (fumi)																
20	Parrot fish (Pono)																

Species targeted during El Nino and Gear type use during El nino *(Multiple responses)*

	Species targeted i/Main gear type use	Gill net Seine net	Prawn seine beach seine	Reef seine	Trawl nets	Cast nets	ring nets	trammel nets	Long line hooks	Hand lines	Traps/ basket	Scoop nets	Trolling lines	Spear gun/harp oons	Hooked sticks	Pointed sticks	Others
1	Rabbit fish (Tafi)																
2	Scavengers (Tangu)																
3	Snappers (Pali)																
4	Cavallajacks (Kolekole)																
5	Mullets (Mkizi)																
6	King fish (Nguru)																
7	Tuna (Jodari)																
8	Sharks (Papa)																
9	Prawns (Kamba)																
10	Lobsters (Kamba mawe)																
11	Octopus (Pweza)																
12	Crabs (Kaa)																
13	Grunter (Paramamba)																
14	Sardines (Simu)																
15	Tilapia																
16	Black skin (fute)																
17	Sail fish (suli suli)																
18	Marlin (Duaro)																
19	Catfish (fumi)																
20	Parrot fish (Pono)																

2. Please indicate your total catch per day and the price/kg

Type of job	Gear	Catch	Quantity /day	Price / kg kshs
Crew member				
Boat owner				
Fish trader				
other				

3a. Do your target species depend on live coral and the reef matrix? [ ] Yes [ ] No

3b. If yes, what percentage of your catch depend on live coral and the reef matrix
10- 30% [ ] 30-50% [ ] 50-70%[ ] more than 70% [ ]

4a. What have been the trends of fish catches that depend on coral and reef matrix captured over the last 10 or so years?
[ ] Increasing [ ] Decreasing [ ] Do not know

4b. If decreased, (name 5 species)

Species	Species
1.	4.
2.	5.
3.	6.

4c. What in your opinion has been the ***two main***causes of the decrease in fish species captured?
[ ] Change in temperature [ ] Pollution [ ] Change in rainfall variability [ ] other (specify…….)

4d. If increased (name 5 species)

Species	Species
1.	4.
2.	5.
3.	6.

4e. What in your opinion has been the ***two main*** of the increase in fish species captured?
[ ] Change in temperature [ ] Pollution [ ] Change in rainfall variability [ ] other (specify……)

C. DETERMINE THE EXTENT TO WHICH THE SOCIO- ECONOMIC STATUS OF SMALL-SCALE FISHERS' AFFECTS THEIR COPING STRATEGIES AND THE EFFECTIVENESS OF THESE COPING STRATEGIES.

1. What do you do if uncertainties' due to climate variability e. g floods or increased rainfall persist? ***(Multiple responses)***
   [ ] Stay as fishers no matter what [ ] reluctant to move out [ ] Fishing is the employment of the last resort [ ] develop strategies to go with uncertainties'[ ] other ……

2. Have you changed your fishing gear over the last 10 or so years to deal with climate variability e.g. increased floods? [ ] Yes [ ] No

3. Please indicate with a tick the coping strategy you adopted during the 1997/8 El Nino and how effective it was

Climate Variability	**Coping Strategies**	**Effectiveness**			
Increased Rain fall / Floods		Low <5kg	Average 6-10 kg	High 10kg>	
	[ ] Use the same gear but fishing inshore				
	[ ] Changing gear- investing in modified gear and equipment e.g. boats -increasing the number of gear -increasing the efficiency of the gear				
	[ ] venturing further into sea (offshore)				
	increase no of crew (additional labour)				
	[ ] track changes in seasonal and spatial variations of fish stocks including going fishing early				
	[ ] adjust fishing targets i.e. reduce amount of fish caught				
	[ ] Increasing effort at sea (areas fished and spending more hours at sea)				
	[ ] Avoid fishing altogether (Seek alternative employment off water				
	[ ] Migrate to other areas with fish (changing fishing grounds)				
	[ ] getting credit/ loans to buy better equipment				
		Low 2kg	Average 3-5 kg	High 5kg>	
	[ ] Multiplicity (several income generating activities				
	[ ] Diversification within the fisheries sector e.g. use multiple gears or species				
	Other (specify.....)				

Wind	[ ] Increased financial capital (investing in boats with bigger engines and more fuel used to go further to open sea).			
	[ ] Avoid fishing during strong winds-loss of fishing days.			
	[ ] To track changes in seasonal and spatial variations including going fishing early.			
	[ ] Other (specify.....).			
Temperature variability	[ ] invest in boats with refrigeration [ ] Drying of fish to preserve [ ] Smoking of fish to preserve [ ] Other (specify.....)			

Change of fishing zone for fishing activity - Migration

4a. Have you moved since the beginning of your fishing career? [ ] Yes [ ] No

4b What have been the reasons for migrating[ ] heavy rainfall and resultant flooding [ ] other specify

4c. If yes, what areas have you visited for short term stays? (seasonal)
…….....

4d . What areas have you moved to (longer periods than a season or onetime event) since you started fishing?.....

4e. If you do not migrate give 3 main reasons why don't you change your fishing zone if other fishermen do it?
[ ] Family attachments [ ] Don't want conflicts [ ] No new opportunity [ ] species good here [ ] Did not want to [ ] costs of moving high [ ] Other (specify.....)

4f. Did you move based on your own decision, or did the captain or owner request you to move?
[ ] Own decision [ ] Owner [ ] Both

4g) What reason did you have to move there?
[ ] Kusi [ ] Kaskasi [ ] Both [ ] None

	If None above please give reasons
1.	
2.	
3.	

D: DETERMINE THE INSTITUTIONAL CAPACITIES THAT ARE IN PLACE TO COPE WITH CURRENT CLIMATE VARIABILITY AND FUTURE CLIMATE EXTREMES'.

Social Capital and Social safety nets

1. Are you a member of a local organization? [ ] Yes [ ] No If No

1.1. If yes, in what capacity [ ] Member [ ] Official

1.2 Organization type ***(multiple responses***). [ ] Religious [ ] Fishing organisation [ ] Credit organisation [ ] Other (specify.....)

1.3 Name of the organization to which you belong.....

2. Did your participation in a group help you to face El Niño events? [ ] Yes [ ] No [ ] Do not Know

3. In what ways did this social organisation assist you during times climatic crises e.g. floods /Elnino? ***(multiple responses***).
[ ] Credit facilities [ ] Provision of food [ ] Cash grants[ ] In –kind –equipment [ ] Other (specify.....)

4. Was the help effective? [ ] Yes [ ] No

5. If not, from whom would you propose to receive help from and what kind of help would you like during future extreme climate events?
……..

6. Have you received external help to support your household during times of climatic-related stresses e.g El Niño events? [ ] Yes [ ] No

6.1. If yes, what type of help did you receive and who gave you that help? ***(multiple responses***).
[ ] National govt [ ] Local authorities [ ] civil society (cooperatives, savings & loans) [ ] Private (private business, NGOs, charities) [ ] family [ ] other (specify.....)

6.2 Please indicate the name of agency and the nature of assistance / intervention you received from them you during times of climatic-related stresses. And indicates whether this assistance was/is effective**? Proposed livelihood support programs**

	Production support				**Market support**	**Financial support**		**Food aid**	**Training/ skill development and capacity building**	**Information gathering and dissemination**	**Resource mobilisation and allocation**	**Effective**	
Name of Agency	In –kind equipment (provide minor fishing equipment to improve catches gear and boats)	- govt provides reduced VAT on fishing equipment	- Govt financing repairs of fishing vessels	procurement of new technologically upgraded fishing vessels to replace those that are damaged during climatic hazards	i.e. market infrastructure (Transport and feeder roads, landing sites improved, electricity)	small and short term grants for working capital for micro entrepreneurs (fish processors and traders)	Subsidized micro credit for fishers (low interest rates)	(general distribution)		early warning systems about failure of rains or floods		**Yes**	**No**
Dept of social services													
Min of social welfare													
Dept of disaster preparedness													
Min of fisheries development													
Local Govt													
Min of education													
Min of health													
Dept of Youth													
Min of Roads													
NGO													
Microfinance institution													
Cooperative society													
KEMFRI													

7. Are there organizations/institutions that you think may be able to help you in the future? [ ] Yes [ ] No
   What kind of support would you
   like…….....

8. What is your the assessment of the current capacity of public institutions to support the community in dealing with more drastic climate conditions. In terms of Infrastructure (roads and landing sites, Electricity provision, construction of cold storage facilities, provision of early warning systems
   other……..……..……

Capacity	Effectiveness (Low)	Medium	High
Infrastructure (access roads			
Landing sites			
Electricity provision			
Cold storage facilities			
Provision of early warning systems			
Other (specify)			

9. How effectively is the meteorological department addressing climate variability e.g. real-time flow of information, early warning systems to the fisherman?
   a) Provide real time flow of information [ ]
   b) Provide early warning system to the fisherman [ ]
   c) Other [ ] d) Do not know [ ]
10. Is the access to knowledge and information and outreach on weather and climate forecasts from the Meteorological department to the fishers effective?
   a) Yes [ ] b) No [ ] c) Moderate [ ] d) do not know [ ]

E. ASSESS THE LOCAL PERCEPTIONS SMALL SCALE INSHORE FISHERS HAVE ON CLIMATE VARIABILITY IN RELATION TO IT BEING A KEY FACTOR THAT MAY HAVE DIRECT INFLUENCE ON FISH ABUNDANCE

1. What is your perception of **temperatur**e over the last 20 or so years?
   [ ] Increased temps [ ] Decreased temps [ ] Altered climate range [ ] No change [ ] Don't know
2. What is your perception of **rainfall** trends over the last 20 or so years?
   [ ] Increased rainfall [ ] decreased rainfall [ ] Changed timing of rains [ ] Frequency of droughts increased
   [ ] Frequency of droughts decreased [ ] other changes [ ] No change [ ] don't know
3. What is your perception of **wind** trends over the last 20 or so years?
   [ ] Increased speed of winds [ ] decreased speed of winds
   [ ] Changed timing of winds [ ] Frequency winds of increased
   [ ] Frequency of winds decreased [ ] No change [ ] don't know
4. Has Fish catches been increasing or decreasing over the last 10 or so years
   [ ] Increase [ ] decrease [ ] no difference in catches [ ] don't know
5. What do you attribute the increase or decrease of fish catch?
   If **Increased**
   [ ] Increased sea level rise [ ] Increased temperature [ ] Change in the direction of winds [ ] increased rainfall [ ] other
   If **Decreased-**
   [ ] Increased number of fishers [ ] Pollution [ ] Foreign fishers [ ] increased sea level rise [ ] increased temperature rise [ ] rain fall decrease [ ] decreased rainfall [ ] other
6. During Floods/ extreme events e.g. El Nino how has been your fish catch?
   [ ] catch increased [ ] catch reduced [ ] no difference [ ] do not know
   Name 5 species that decreased
   i)……ii)……iii)……..iv)……v)…….
   Name 5 species that increased)
   i)
   ……..ii)……iii)……..iv)……v)……

	Strongly agree(5)	**Agree (4)**	**Neutral(3)**	**Disagree(2)**	**Strongly disagree(1)**
7. In your opinion do you think that temperature variability has an influence on the abundance fish?					
8. In your opinion do you think rainfall variability has an influence on the abundance of fish?					
9. In your opinion do you think winds have an influence on the abundance of fish caught?					

10. How can you compare your income from fish catches over the years? Has it been increasing or decreasing?

Increasing	Decreasing	No change	Don't know

11. What are **2 main reasons that** can you attribute your **decrease** of income to?
    [ ] Increased population of fishers [ ] increased pollution [ ] Change in temperature variability [ ] Change in rainfall variability [ ] Do not know (specify……..)
12. What **2 main reasons that** can you attribute your **increase** of income to?
    [ ] Decreased population [ ] Decreased pollution
    [ ] Change in temperature variability [ ] Change in rainfall variability

----------END-----THANK YOU VERY MUCH----------

APPENDIX 2: INTERVIEW GUIDE FOR KEY INFORMANT (BEACH MANAGEMENT UNITS- CHAIRMAN) AND FOCUS GROUP DISCUSSIONS

No …….. Facilitator…….. Date…….

Statement of Confidentiality
My name is Beatrice Akunga. I am a Kenyatta University Student carrying out research for my degree of Doctor of Philosophy in Environmental Studies .The information given through this questionnaire is confidential and purely for research purposes.

Yours faithfully
Beatrice Akunga
Kenyatta University

Number of members in the focus group……..
Area……

Discussion Questions

1. How many active members does your association have? When was it created? What are its main goals/objectives/ projects

   Local perception of vulnerability

2. What are the climatic stresses or extreme events that the fishers' have had to face over the years? How have they affected their livelihoods?
3. Which groups or households types are the most vulnerable to these shocks and trends?

   Why (explain criteria)

4. What were the effects of the El Niño of 1998 to the activities of the members of your association?
5. Who in the community (i.e. which user group) responded the best to the El Niño event in 1998?
6. Who lost the most during the El Niño in 1998?
7. How have fishers' managed to (cope, or adapt) to such conditions at individual/ institutional level?……

8a. In terms of income what is the trend (increasing or decreasing) in the past 10 or so years? ……..

8b. Which factors explain this trend/ these changes?

9. What local /external aspects have constrained or facilitated their ability to deal with these climatic conditions?

   …….

APPENDIX 3: KEY INFORMANT'S INTERVIEW GUIDE (INSTITUTIONS)

No:…….. **Date……**

Statement of Confidentiality

My name is Beatrice Akunga. I am a Kenyatta University Student carrying out research for my degree of Doctor of Philosophy in Environmental Studies .The information given through this questionnaire is confidential and purely for research purposes.

Yours faithfully
Beatrice Akunga
Kenyatta University

Key informants A. Institutions (NGOs**)**

1. Name (optional)…….
2. Education back ground …….
3. Position in the organization…….
4. What are the main goals/objectives/projects of your organisation?
5. What type of services do you provide ……..
6. What type of assistance did you provide to fisherfolk during times of climatic stress e.g. El nino period of 1997/8
7. Was the assistance helpful? Y|N 4b How?
8. What are the main constraints limiting your activities
9. Do you have are linkages with other institutions?
10. Indicate the different livelihood support interventions your institution has offered during times of climatic stresses e.g Elnino, floods.

Name of Agency	Infrastructure (Market support)	Technical support (specify)	Micro finance Credit	Relief food	Training skills development	Health	income and employment a) food for work b) cash for work c) cash grants	Production support (provision of in kind equipment ie gears, boats	Information gathering and dissemination	Resource mobilisation and allocation	other
Dept of social services											
Min of social welfare											
Dept of disaster preparedness											
Min of fisheries development											
Local Govt											
Min of education											
Min of health											
Dept of Youth											
Min of Roads											
NGO											
Microfinance institution											
Cooperative society											
KEMFRI											

B. Government Institutions

1. What are some of the immediate and long term strategies that the government /institution is taking to deal with current vulnerability to recurrent climate hazards and future climate risks that may affect fishermen. Are these measures effective?
2. What is the government doing in terms of taking precautionary measures to prevent or minimize the adverse effects of climate change and mitigate its effects on small scale inshore fishers?
    a) Piloting adaptation and capacity building in support of policy setting, planning and adaptation practices
    b) Providing increased, sustainable and long term funding to meet increased needs for capacity building in climate issues
    c) Helping support and strengthen policies, knowledge and institutional capacity
    d) Development of national economic, legal institutional and regulatory framework integrating climate issues
3. What initiatives are being carried out to enhance local adaptive capacity? How can they be improved?
    a) Enhance local capability to predict and monitor climate impacts
    b) Increase the participation of stakeholders in adaptation efforts
    c) Increase communication between different stakeholders (government and local people)
    d) Mainstreaming climate change and adaptation and mitigation into development strategies and plans
4. What is your institution/ government doing to promote scientific, technological, socio economic and other research, systematic observation and development of data archives related to the climate system. Is this information disseminated to fishermen? How has the information facilitated coping mechanisms among inshore fishers?
5. What is your institution/government doing to promote education training and public awareness of fishermen in matters related to climate change and variability?

Thank you

APPENDIX 4: OBSERVATION RECORD SHEET

Name of Respondent: **Date**

Facilitator:

Name of Landing Site:

Please tick where applicable

Observations	**Yes**	**No**
Mangroves		
Sea wall		
Fishing ponds		
Landing Sites		
Cold storage facilities		
Landing Sites		
Modern Boats		
Gears	Specify type	

APPENDIX 5: CLIMATE DATA (SEA SURFACE TEMPERATURE, RAINFALL AND WIND DATA) FOR MOMBASA AND MALINDI FOR THE YEARS 1948-2012

	Sea Surface Temperature (°C)		Rainfall in mm	
Years	Mombasa	Malindi	Mombasa	Malindi
1948	25.7	24.9	790.4	766.6
1949	25.7	24.9	856.6	676.8
1950	25.6	24.6	922.5	735.5
1951	25.8	25.0	829.1	680.5
1952	25.9	24.9	969.3	760.4
1953	25.9	24.6	953.7	953.4
1954	25.4	24.8	880.0	767.5
1955	25.6	25.3	699.3	453.6
1956	25.7	24.7	983.4	775.8
1957	25.9	24.9	1175.1	902.5
1958	26.1	25.6	571.3	254.1
1959	26.2	25.0	906.2	591.3
1960	25.9	24.2	1118.3	805.4
1961	26.4	24.4	1370.0	995.7
1962	26.2	25.2	926.2	817.3
1963	26.0	24.6	973.6	721.6
1964	25.7	24.4	1166.5	1006.0
1965	25.6	24.8	970.2	836.0
1966	26.1	25.0	1182.1	966.7
1967	26.0	24.8	976.1	949.2
1968	25.8	24.5	1088.3	1035.4
1969	26.3	25.3	935.7	674.8
1970	26.2	25.0	1132.0	924.3
1971	25.6	24.9	752.7	589.0
1972	26.4	24.9	1094.1	874.4
1973	26.4	25.0	1130.8	915.6
1974	26.2	24.7	973.8	858.4
1975	26.0	24.3	1212.4	1175.4
1976	26.0	24.1	1100.3	1313.8
1977	26.3	24.2	1270.1	1750.2
1978	26.4	24.9	1236.3	1117.6
1979	26.2	24.8	1160.0	1420.7
1980	26.2	25.2	812.2	836.0
1981	26.1	24.4	1228.1	1389.6
1982	26.6	25.2	1189.8	1106.2
1983	26.7	25.6	692.7	729.5
1984	26.1	24.5	950.6	907.8

1985	26.3	24.6	1012.8	913.9
1986	26.4	24.6	994.0	949.9
1987	26.7	25.8	700.7	564.5
1988	26.7	25.0	925.4	885.2
1989	26.3	24.5	1107.9	915.6
1990	26.7	24.6	1062.1	1111.0
1991	26.5	25.4	833.3	769.3
1992	26.2	25.2	621.6	543.7
1993	26.4	24.9	878.7	737.0
1994	26.5	25.2	1005.5	701.5
1995	26.8	25.3	970.8	775.6
1996	26.5	25.2	810.6	631.8
1997	26.5	25.0	911.3	1033.5
1998	27.1	25.5	817.0	832.5
1999	26.4	25.5	576.5	403.3
2000	26.3	25.5	507.5	346.8
2001	26.5	25.7	526.6	349.6
2002	26.5	25.8	608.4	400.7
2003	26.5	26.3	300.1	187.6
2004	26.5	26.0	517.8	350.4
2005	26.5	26.0	377.1	226.6
2006	26.4	25.8	758.3	689.7
2007	26.6	26.0	612.9	654.0
2008	26.2	26.0	410.2	354.6
2009	26.7	26.4	375.9	227.6
2010	26.8	26.2	401.1	326.9
2011	26.8	25.9	475.3	432.4
2012	26.5	26.1	217.0	127.3

	U-Wind component		V-wind component		Wind Speed in m/s	
Years	Mombasa	Malindi	Mombasa	Malindi	Mombasa	Malindi
1948	-2.5	-1.7	3.1	3.6	5.5	5.1
1949	-2.4	-1.6	3.0	3.4	5.4	5.0
1950	-2.5	-1.5	2.9	3.3	5.4	5.0
1951	-2.5	-1.6	3.1	3.5	5.3	5.0
1952	-2.5	-1.8	2.9	3.5	5.6	5.2
1953	-2.4	-1.5	3.0	3.5	5.3	4.8
1954	-2.2	-1.6	3.5	3.9	5.4	5.2
1955	-2.8	-2.0	2.9	3.5	5.4	5.2
1956	-2.3	-1.5	3.4	3.8	5.1	4.9
1957	-2.5	-1.4	1.7	2.4	4.7	4.0
1958	-2.5	-1.5	2.3	2.8	5.4	4.6
1959	-2.5	-1.2	2.4	3.2	5.0	4.7
1960	-2.2	-0.8	3.3	3.5	5.1	4.6

1961	-1.9	-0.8	2.9	3.0	4.7	4.1
1962	-1.6	-1.3	2.4	3.0	4.8	4.6
1963	-1.8	-1.2	2.6	3.1	4.6	4.3
1964	-2.0	-1.2	3.1	3.3	5.3	4.7
1965	-2.4	-1.4	2.2	2.6	5.0	4.5
1966	-2.2	-1.3	2.6	2.9	4.6	4.3
1967	-2.5	-1.6	1.7	2.5	4.5	4.2
1968	-2.2	-1.2	2.2	2.7	4.5	4.1
1969	-2.2	-1.5	2.6	3.1	4.6	4.3
1970	-2.2	-1.4	2.6	3.1	4.5	4.3
1971	-2.8	-1.7	2.1	3.0	5.2	4.6
1972	-2.8	-1.6	2.2	2.9	4.9	4.3
1973	-2.5	-1.7	2.4	3.1	5.1	4.7
1974	-2.8	-1.7	2.1	2.8	4.7	4.4
1975	-2.3	-1.3	2.4	3.1	4.7	4.4
1976	-2.2	-1.1	2.4	3.1	4.4	4.0
1977	-1.9	-0.8	2.5	2.8	4.3	3.6
1978	-2.3	-1.3	2.1	2.7	4.2	3.9
1979	-2.0	-0.9	2.7	3.0	4.4	3.8
1980	-2.2	-1.3	2.0	2.7	4.4	3.9
1981	-2.3	-1.1	2.2	2.8	4.1	3.6
1982	-2.3	-1.2	2.0	2.7	4.5	4.0
1983	-2.7	-1.4	2.1	3.0	4.8	4.3
1984	-2.4	-1.3	2.3	2.9	4.9	4.3
1985	-2.5	-1.2	2.7	3.3	4.8	4.3
1986	-2.6	-1.4	2.7	3.3	5.0	4.5
1987	-2.8	-1.4	2.5	3.3	4.9	4.4
1988	-2.4	-1.1	2.6	3.4	4.7	4.3
1989	-2.4	-1.2	2.6	3.3	5.3	4.6
1990	-2.1	-0.9	3.0	3.4	4.5	4.1
1991	-2.5	-1.5	2.6	3.3	4.9	4.5
1992	-2.8	-1.6	2.5	3.4	5.0	4.6
1993	-2.8	-1.6	2.5	3.3	5.2	4.8
1994	-2.2	-1.2	2.9	3.3	4.9	4.6
1995	-2.4	-1.4	2.7	3.3	4.9	4.5
1996	-2.7	-1.8	2.8	3.6	5.2	4.9
1997	-2.3	-0.9	2.3	3.0	4.7	4.2
1998	-2.0	-0.9	2.7	3.6	4.5	4.2
1999	-2.6	-1.4	2.5	3.4	4.6	4.5
2000	-2.9	-1.7	2.1	3.4	5.0	4.8
2001	-2.7	-1.5	2.3	3.2	4.7	4.3
2002	-2.2	-1.3	2.4	3.2	4.5	4.3
2003	-2.5	-1.5	1.9	3.1	4.7	4.4
2004	-2.4	-1.5	2.5	3.4	4.6	4.4
2005	-2.9	-1.9	2.1	3.3	5.1	4.8

2006	-2.0	-0.7	2.9	3.4	4.5	4.2
2007	-2.3	-1.2	2.0	2.9	4.5	4.2
2008	-2.5	-1.4	2.1	3.0	4.7	4.4
2009	-2.5	-1.5	2.5	3.3	4.6	4.3
2010	-2.6	-1.4	2.7	3.6	4.8	4.5
2011	-2.4	-1.5	2.3	3.2	4.4	4.2
2012	-2.1	-1.4	2.5	3.6	4.5	4.5

APPENDIX 6: FISHERIES DATA FOR MOMBASA AND MALINDI FOR THE YEARS 1998-2010

MALINDI FISH DATA in kilograms

Years	Rabbit fish	Scavengers	Snapper	Parrot fish	Grunter	Sharks	Mullets	Barracuda
1998	38000	60000	33000	8000	2000	49000	10000	13000
1999	32000	62000	38000	10000	5000	33000	28000	16000
2000	41000	41000	18000	7000	3000	42000	54000	6000
2001	59000	50000	28000	20000	4000	82000	24000	13000
2002	31000	42129	31000	8121	3320	45941.1	25656	15000
2003	59584	49810.5	9772	19013	3314	94385.5	23902	16000
2004	63000	67000	27000	32000	4000	74000	41000	11000
2005	48000	36000	34000	21000	4668	100116	46290	13000
2006	35155	31724	27398	13529	7189	25878	44774	11331.5
2007	60082.6	50000	26578	25605	6842	25583	55949	27359.5
2008	68398	85692	53835	14645	7945	28393	28728	53583
2009	76000	47000	24000	18000	9000	28000	22000	16000
2010	102000	117000	51000	42000	14000	58000	25000	23000

MOMBASA FISH DATA in kilograms

Years	Rabbit fish	Scavengers	Snappers	Parrot fish	Grunter	Sharks	Mullets	Barracuda
1996	32000	42000	16000	42000	14000	18000	23000	3000
1997	31000	39000	9000	22000	11000	14000	16000	4000
1998	30000	39000	14000	29000	13000	14000	17000	4000
1999	30000	39000	18000	23000	18000	19000	19000	12000
2000	37191	44134	8951	33383	16127	14000	21153	13000
2001	45659	52954	16000	55000	16321	13967	21501	9233
2002	34943	37492	22000	39316	13102	15090	17094	10497
2003	29993	47000	9792	45906	16610	18920	18920	15053
2004	32138	62000	11090	45740	15280	19502	15882	12188
2005	35868	44953	15519	46494	18000	22723	17278	10732
2006	37346	45142	14375	28138	22000	25043	16249	22928
2007	59486	59946	35259	37553	27248	36869	15684	45876
2008	57839	41752	32609	28483	31598	56137	13817	51560
2009	63923	44292	37913	45305	38908	88184	12990	51426
2010	84000	64000	38000	48000	54000	84000	27000	59000