

**VULNERABILITY AND ADAPTATION OF ZANZIBAR EAST COAST COMMUNITIES
TO CLIMATE VARIABILITY AND CHANGE AND OTHER INTERACTING
STRESSORS**

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**A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS OF A PHD IN
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ABSTRACT

Climate variability and change as well as sea level rise poses significant challenges to livelihoods, water and food security in small island developing states (SIDSs) including the Zanzibar Islands. Thus, without planned strategic adaptation, the future projected changes in climate and sea level will intensify the vulnerability of these sensitive areas. This thesis is based on research conducted in two sites located in the north eastern parts of each island, namely Kiuyu Mbuyuni, Pemba Island and Matemwe, Unguja Island. The research focused firstly on assessing the vulnerability of these two coastal communities to climate variability and change and other stressors. This included investigation of (1) the perceptions of fishers, farmers and seaweed farmers regarding climate stressors and shocks and associated risks and impacts, (2) existing and possible future water and food security issues, and (3) household's access to important livelihood assets. This was followed by an exploration of the coping and adaptive responses of farmers, fishers and seaweed farmers to perceived shocks and stresses and some of the barriers to these responses. Lastly, an analysis of the implications of the findings for achieving sustainable coastal livelihoods and a resilient coastal community was undertaken.

The general picture that emerges is that local people along the east coasts of both islands are already vulnerable to a wide range of stressors. Although variability in rainfall is not a new phenomenon in these areas, increasing frequency of dry spells and coastal floods resulting from the influence of El Niño and La Niña events exert enormous pressures on local activities (fishing, farming and seaweed farming) which are the crux of the local economy. The main argument of the study is that the nature and characteristics of these activities are the main source of sensitivity amongst these communities and this creates high levels of vulnerability to climate shocks and trends. This vulnerability is evidenced by the reoccurrence of localised food shortages and the observed food and water insecurity. The study found that food insecurity is a result of unreliable rainfall, drought and seasonality changes. These interacted with other contextual factors such as poor soil, low purchasing power and the lack of livelihood diversification options.

In addition to exposure to these almost unavoidable risks from climate variability, the vulnerability of the local communities along the east coasts is also influenced by the low level of capital stocks and limited access to the assets that are important for coping and adaptation. Despite this, some households managed to overcome barriers and adapt in various ways both within the three main livelihood sectors (fishing, farming and seaweed farming) as well as through adopting options outside these sectors resulting in diversification of the livelihood portfolio. However, the study found that most of the strategies opted for by fishers, farmers and seaweed farmers were mainly spontaneous. Few planned adaptation measures supported by state authorities were observed across the sites, with the exception of the provision of motorised boats which were specifically meant to increase physical assets amongst fishers, reduce pressure in the marine conservation areas and prevent overfishing in-shore. Furthermore, numerous strategies that people adopted were discontinued when further barriers were encountered. Interestingly, some of the barriers that prevented households adapting were the same ones that forced households that had responded to abandon their adaptations. To increase resilience amongst east coast communities to current and future predicted changes in climate and sea level, the study argues that traditional livelihood activities (fishing, farming and seaweed farming) need to be better supported, and access to a range of livelihood assets improved. This may be achieved through increased access to local sources of water and facilitation of rainwater harvesting, expanding the livelihood options available to people and increasing climate change awareness, and access to sources of credit.

DECLARATION

I, **Makame Omar Makame** hereby declare that this thesis is my own original work. It has not been submitted for any degree or examination at any other University, and that the sources I have used have been fully acknowledged and referenced. This thesis is submitted for the Degree of Doctor of Philosophy (PhD) in Science at Rhodes University, South Africa.

Signature _____

Date_____

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CHAPTER 1

INTRODUCTION AND THEORETICAL CONTEXT

1.1 INTRODUCTION AND RESEARCH RATIONALE

1.1.1 Global climate change, small island developing states (SIDSs) and the need for adaptation

In its fourth assessment report (AR4), the Inter-governmental Panel for Climate Change (IPCC) defines climate change (CC) as a “change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer” (IPCC, 2007:30). Based on the IPCC, climate variability (CV) is mostly defined as “variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events” (Anwar *et al.* 2012). Scientists and major climate change governing boards such as the IPCC have reached the conclusion that climate change is real, happening and largely caused by anthropogenic actions and that it poses unprecedented risks and challenges to humanity (Hulme, 2009; NRC, 2010). Although anthropogenic climate change is mainly caused by greenhouse gases emitted by developed countries, related risks and impacts are and will disproportionately burden developing countries because of their low adaptive capacity and high levels of existing poverty and vulnerability (Paavola and Adger, 2005; IPCC, 2007). Regions already experiencing variability in weather patterns and trends are likely to become more vulnerable to further changes in the climate (IPCC, 2007; IPCC, 2013).

Globally, studies show that both physical and biological systems which act as ‘humanity sustainers’ are already being affected by new and increased climate risks such as droughts, floods, storm surges, desertification, sea level rise (SLR), shoreline change, sea water temperature (SST) and incidences of diseases (Mimura *et al.* 2007; Nicholls *et al.* 2007; Allison *et al.* 2009; Tschakert, 2007; Challinor *et al.* 2007; Pandey *et al.* 2003; Marin, 2010). For example, in both Asia and Africa the availability and accessibility of “green water” for farming and “blue water” for drinking will be tremendously decreased (IPCC, 2007). Similarly, output from rain-fed farming in Africa is predicted to decline by 50% by the year 2020 (Jones and Thornton, 2003; Jones and Thornton, 2009). Further, the recent IPCC special report on extreme events revealed that extreme events related to temperature, precipitation, cyclones and sea level rise are likely to increase in the 21st century (IPCC, 2011). However, the increase will not be uniform; some areas may experience a decline in intensity of these events (IPCC, 2011; IPCC, 2013).

SIDSs are in fact sensitive social-ecological systems and the observed variability and future changes in climate and associated extreme events such as coastal floods, declining rainfall and increasing temperatures particularly threaten the economy and livelihoods of people (Mimura *et al.* 2007). The major economic activities on these islands such as crop farming, livestock production, seaweed farming, fishing and tourism

are heavily influenced by the climate, and therefore vulnerable to even normal climate variability. A study by Mimura *et al.* (2007) shows that SIDSs, including Zanzibar, have characteristics which make them especially vulnerable to the effects of climate change (Box 1.1). These characteristics include biophysical, social and economic factors such as limited physical size, insufficient financial capacity, a small economy, high populations and a high dependency on natural resources. This demonstrates the fact that vulnerability to a specific impact of climate change (e.g. sea level rise, drought) will be most severe when and where these risks are felt together with non-climate stressors (Reid and Vogel, 2006; O'Brien and Leichenko, 2000; McDowell and Hess, 2012; Mubaya *et al.* 2012).

Box 1.1: Characteristics that underscore overall vulnerability of SIDSs to climate change, climate variability and sea level rise

Generally limited natural resources, with many already heavily stressed from unsustainable human activities.
A concentration of population, socio-economic activities, and infrastructure along the coastal zone.
High susceptibility to frequent and more intense tropical cyclones (hurricanes) and to associated storm surge, droughts, tsunamis and volcanic eruptions.
Dependence on freshwater supply for water resources that is highly sensitive to sea level changes.
Relative isolation and great distance to major markets, affecting competitiveness in trade.
Extreme openness of small economies and high sensitivity to external shocks.
Generally high population densities and in some cases high population growth rates.
Inadequate infrastructure in most sectors.
Limited physical size, effectively eliminating some adaptation options to climate change and sea level rise.
Insufficient financial, technical and institutional capacities, seriously limiting the capacity of SIDSs to mitigate and adapt to any adverse impacts of climate.

Adapted from UNFCCC (2005: 14)

Because the observed variability in climate and future changes threatens the survival of societies in developing countries and SIDSs in particular, the need to adapt is inescapable (Kwadijk *et al.* 2010). Even an immediate and dramatic cut in global greenhouse gas emissions would not fully prevent impacts (Kwadijk *et al.* 2010) since climate systems respond to changes in greenhouses gas levels with a time lag (UNEP and UNFCCC, 2003). Past and present emissions have already affected the climate system in ways that cannot easily be reversed in the near future. Though controlling emissions is vital, it must be accompanied by efforts to minimize the impacts triggered by unavoidable risks through efforts to adapt (Moser, 2010; UNEP and UNFCCC, 2003). It is within this context that Moser (2010) calls on academics and actors to address what some consider being the greatest challenge humanity has ever faced.

1.1.2 Perspectives on climate change and fisheries focusing on SIDSs

Coastal and marine ecosystems provide valuable services for humankind and are the suppliers of resources and products worth trillions of dollars each year (IPCC, 1998). Globally, about 55 million people obtain their livelihood and income directly from fisheries (FAO, 2012). About 7% of these people come from Africa, making it the second highest level of dependence in the world after Asia (FAO, 2012). However, if activities related to fisheries such as marketing, distribution, processing, packaging, making vessels,

making and repairing gear, among others are considered, it is estimated that the sector sustains the livelihoods of about 660-820 million people globally (FAO, 2012). According to FAO (2012) the number of people directly engaged in fishing and aquaculture has increased over time compared with those engaged in agriculture. However, fish farming, which is considered a valuable option for livelihood diversification and adaptation to fishery resources decline (see Chapter 7), is not common in Africa compared to other parts of the world. Only 1% of the world's fish farmers come from Africa, while 97% of fish farmers are found in Asia (FAO, 2012). In SIDSs, whether located in the Pacific, Atlantic or Indian Ocean, fishing is an important source of income and food for the majority of the population (Bell *et al.* 2009). Indeed, the contribution of fish to protein intake is found to be more than 25% in the poorest countries and it can exceed 90% in areas where the supply of other sources of animal protein is marginal (Bell *et al.* 2009). For example, on the island of Tuvalu (Pacific Ocean), fish consumption is lower in town (68.8 kg/person/year) compared with rural areas (147.4 kg/person/year).

Despite their importance for human survival, coastal and marine ecosystems are among the most threatened ecosystems on the globe because they are fragile and sensitive to both human and climate change pressures (Chapter 6; Bene *et al.* 2007). Sea level rise, increasing warming conditions, storms and sea surface temperature (SST) changes and associated El Niño Southern Oscillation (ENSO) events are affecting fisheries by influencing the distribution, abundance and productivity of fish stocks and by the deterioration of physical infrastructure (Chapter 6; FAO, 2012; Allison *et al.* 2009; Allison *et al.* 2005; Njock and Westlund, 2010; Badjeck *et al.* 2010; Lehodey *et al.* 2006; Jury *et al.* 2010; Miller, 2007; Yanez *et al.* 2001; Niquen and Bouchon, 2004) (see Chapter 5 for the definition of El Niño and La Niña). For instance, in South America the abundance of both large and small pelagic fishes was both positively and negatively affected during 1997/1998 ENSO events (Yanez *et al.* 2001; Niquen and Bouchon, 2004). Loukos *et al.* (2003), cited in Cruz *et al.* (2007), attributed a reduction in fish primary production in the tropical ocean of east and south-east Asia to increasing warming conditions, while in the Atlantic Ocean, temperature oscillation was also found to have a major impact on the productivity of various fish species and planktons (Parsons and Lear, 2001). In Lake Tanganyika, which is located between Tanzania, Zambia, Democratic Republic of Congo and Burundi, a combination of warming and a decrease in wind speed and their consequent impacts on the supply of nutrients was believed to have decreased primary productivity by 20% and fish yield by 30% (O'Reilly *et al.* 2003). Additionally, impacts related to human actions and ENSO events have been found to be a major driver for coral reef ecosystem depletions, which are crucial for fish breeding grounds and as nurseries (Obura, 2005; Ateweberhan and McClanahan, 2010; Barnett and Adger, 2003). For example, in the Caribbean, the analysis of coral reef surveys over three decades has revealed that coral cover across reefs has declined by 80% in just 30 years, partly due to climate change (Gardner *et al.* 2003 cited in Mimura *et al.* 2007).

Small island developing states are particularly vulnerable as they rely heavily on fisheries for their national and local economies. In examining food security in SIDSs in the Pacific, Barnett (2011) argued that future climate change is likely to impact unfavourably on both food production and the fisheries sector. In fact, artisanal fisheries in the developing world are characterised by their small scale nature, low technology and small vessels (Badjeck *et al.* 2010; Allison and Ellis, 2001; Chapters 3 and 6) which makes fisher folk particularly vulnerable to climate variability, poverty and food insecurity. In a study of 17 coastal communities in the Pacific, Kronen *et al.* (2010) found that the deterioration of fisheries resources resulted from both climate and non-climate stressors such as population increase, increasing demand and changing choices. In Senegal, conflict between artisanal and commercial fisheries around scarce resources was threatening not only the well-being of the fishers but also human security (DuBois and Zografos, 2012). Like any other SIDSs, coastal communities in Zanzibar are highly dependent on coastal and marine resources that are sensitive to current and future changes in climate. These changes are likely to interact adversely with human-induced factors (illegal fishing and lack of alternative sources of income, among others) to intensify their vulnerability.

1.1.3 Perspectives on climate change, water and agriculture focussing on SIDSs

Trends and seasonality of climate are known to partly influence the supply of water for households' basic needs and water production all over the globe in various ways (Arnell, 2004; Arnell, 1999). Variability and changes in precipitation, temperature and sea level changes impact the availability and accessibility of safe water for a wide range of uses. A study by WHO (1998), cited in Asare (2004) estimated that 1.2 billion people in 20 developing countries live without access to safe water for household needs. Since there is a relationship between water, food security and poverty (UNEP, 2011), the observed variability of rainfall, temperature and increasing frequency of extreme events (IPCC, 2011; Boko *et al.* 2007), play a huge role in explaining global food prices, local food insecurity and poverty in the developing world (Wang, 2010; UNEP, 2011; Ericksen, 2008; Barnett, 2011; Chapter 4).

A large body of literature has noted a decline in the production of rice, maize, wheat and livestock in many parts of the world due to increasing water stress attributed partly to increasing temperature, increasing frequency of El Niño events and a reduction in the number of rainy days (Wijeratne, 1996, Aggarwal *et al.* 2010, Jin *et al.* 2001 cited in Cruz *et al.* 2007). Apart from water stress, climate change is also associated with the increased incidence of pests and diseases affecting crops, animals and humans (Boko *et al.* 2007; Rosenzweig *et al.* 2007). In Latin America, findings show that El Niño and La Niña events, coupled with diseases such as 'cancrosis' in citrus and 'fusarium' in wheat, have tremendously affected production in Mexico, Brazil and Argentina (Magrin *et al.* 2007). Similarly, local food production in Africa has been affected by climate change, with many countries already experiencing scarce rainfall and variable temperatures which affect both the growing season and crop and animal yields (Boko *et al.* 2007; Jones and

Thornton, 2003). The predominantly rain-fed small scale farming systems of Africa (Chikozho, 2010), as well as livestock keeping, are confronted with both declining rainfall and other constraints such as poor soil fertility, pests, crop and livestock diseases, human diseases and a lack of access to inputs and improved seeds (Boko *et al.* 2007; Reid and Vogel, 2006; McDowell and Hess, 2012, Mubaya *et al.* 2012). The future situation is not promising either; climate change models predict some difficulties in the production of major crops such as maize and wheat (Jones and Thornton, 2003; Jones and Thornton, 2009). For instance, a study by Jones and Thornton (2003) forecast a decline of 10% in maize production in sub-Saharan Africa and Latin America by the year 2055. In their opinion, this reduction will have significant impacts on 130 million livestock keepers in mixed systems of sub-Saharan Africa.

Small island developing states are particularly vulnerable to climate variability and change regarding availability and accessibility of quality water for farming, household needs and other development sectors such as tourism as they lack permanent water bodies such as lakes and rivers and have a low capacity to perform desalination (Chapter 4). In such states, declining rainfall is not only affecting the dominant rain-fed small scale farming, it also decelerates the recharge rate of water lenses which are the major source of fresh water for non-farm uses (Kuruppu and Liverman, 2011; Chapter 4). Additionally, underground water lenses in many SIDSs, particularly atoll islands such as Kiribati, Maldives, Marshall Islands, Tokelau and Tuvalu, are prone to salt water incursion due to sea level rise (Barnett and Adger, 2003; Kuruppu, 2009; Kuruppu and Liverman, 2011); something that is also occurring in Zanzibar. Moreover, major characteristics of SIDSs (see Box 1.1) enhance the vulnerability of the agricultural sector to climate change and associated extreme events (Barnett and Adger, 2003; Mimura *et al.* 2007). Crop farming and livestock keeping is already competing with other land uses on a limited land resource all over SIDSs (Ghina, 2003) and some studies suggest that the predicted sea level rise could lead to a further reduction in size and loss of land surface in many of these islands (see Mimura *et al.* 2007). Given these characteristics, it appears that future projections related to extreme events (IPCC, 2011; IPCC, 2013), climate trends and sea level rise (see Chapter 5; Mimura *et al.* 2007; Arnell, 2004; Arnell, 1999) are likely to intensify food security, water stress and scarcity, and severely affect the economies of these islands.

1.1.4 Climate change and vulnerability in Zanzibar

Zanzibar, which consists of two sister islands called Unguja and Pemba, is one of the poorest small island developing states in the tropical Indian Ocean. Like any other SIDSs, Zanzibar's economy is based on activities which are sensitive to present and future changes in climate such as farming, seaweed farming, fisheries, and tourism (Allison *et al.* 2009; Allison *et al.* 2005; Boko *et al.* 2007; Mimura *et al.* 2007; Gössling and Hall, 2006). Subsistence farming, small scale seaweed farming and artisanal fisheries form the mainstay of the coastal communitys' livelihoods across the islands (see Crona *et al.* 2010; Feidi, 2005).

Additionally, these communities are characterised by a high dependence on marine resources to meet their nutritional needs (Feidi, 2005).

The small scale artisanal fishery in Zanzibar is a multi-species fishery based on delicate fisheries ecosystems such coral reefs (Mkenda and Folmer, 2001; Feidi, 2005) which are being subjected to climate change and human pressure (Chapter 6). Similarly, seaweed farming, which operates within the intertidal zone, is prone to temperature variability (Sheikh *et al.* 2012), sand deposition and competition with other uses of the intertidal zone such as bathing areas for tourists and fishing (see Chapter 5 and 6). Farming is completely rain-fed and characterised by low inputs and in the case of the study areas it is practiced on nutrient poor coral rag soils (see Chapter 6). With regard to tourism, although it does not directly employ many local coastal residents, it can positively impact local people's well-being through increasing the market for their fishery products and handcrafts (see Chapter 3; Wallevik and Jiddawi, 1999). But again, tourism is also vulnerable to climate variability and change (Gössling and Hall, 2006).

Throughout its history, Zanzibar has experienced periods of intense storms and highly variable temperatures and rainfall which threatened the commercial farming of cloves and coconut and fishing activities (Spinage, 2012; Chapter 5). For the past two decades Zanzibar has experienced events like minor earthquakes, the boxing day Indian Ocean tsunami on Sunday, 26th December 2004, a high frequency of dry spells and localised food shortages (Said, 2011; Walsh, 2009), stronger winds and heat waves than previously recorded (Watkis *et al.* 2012), and coral reef bleaching attributed to the El Niño event of 1997/1998 (Payet and Obura, 2004). Other events have included coastal floods in urban Unguja in 2007 (Mustelin *et al.* 2010), coastal floods in arable land in Pemba in 2010-2011 (Sultan, 2011), the highest temperature ever recorded (39.4°C) in February 2007, and extreme rainfall, such as the event in April 2005, where 474 mm were recorded in just 24 hours at Zanzibar airport weather station (Mustelin *et al.* 2010). The last time an extreme rainfall event like this was recorded was in 1942 (Mustelin *et al.* 2010). Several El Niño (1997/1998) and La Niña (1999/2000) events and associated floods and droughts have also hit Zanzibar in recent years and caused a significant impact on the rural economic sectors. Additionally, studies show that the general rainfall trend indicates declining rainfall particularly along the east coast in both islands (Salum 2009; Kombo, 2011; Watkiss *et al.* 2012). Acknowledging these examples of weather-related events, one could easily argue that the climate in Zanzibar is changing and thus threatening the livelihoods of coastal communities.

Analysis of past and future sea surface temperature (SST) along the coast of East Africa has predicted further coral reef bleaching within the 21st century (Jury *et al.* 2010). However, little has been written to establish the linkages between ENSO events and fisheries in Zanzibar. A study by Jury *et al.* (2010) along the east African coast, including Zanzibar, showed that fish abundance is influenced by warming and

humidity along the coast. Globally, these events have been found to have impacts on fisheries resources in various ways (see Chapter 6 and section 1.1.2). Tourism, which is a backbone of the Zanzibar economy, is also vulnerable to increasing beach erosion and seasonal variability. Beach erosion is one of the most prevalent environmental problems in Zanzibar (Salum, 2009). It has become a major socio-economic and environmental concern to a large number of countries in the western Indian Ocean (WIO) region as well, where it poses serious problems for tourism and fishing infrastructure, livelihoods and the environment (Kairu and Nyandwi, 2000). Although the exact causes (e.g. climate change, wave actions, sand mining and sea walls) of beach erosion are debatable, climate change hazards such as sea level rise and increasing intensity of winds may heighten the problem. Furthermore, the undefined onset of the rainy season and variability in temperature may also affect the tourism industry in the future (Gössling and Hall, 2006; Gössling *et al.* 2006). In examining the perceptions of tourists visiting Zanzibar regarding the importance of climate for travel decisions, Gössling *et al.* (2006) found that the predicted changes in climate in the future may influence the decision of travellers to come to Zanzibar.

Rain-fed agriculture and livestock production which along with fishing forms the basis of food security in Zanzibar, has been affected firstly by the increasing frequency of dry spells partly associated with ENSO events (see Chapter 5), and secondly by coastal floods on arable land (Sultan, 2011) connected with recent fluctuations in sea level (Chapter 5). The east coasts of both islands, where Kiuyu Mbuyuni, Pemba and Matemwe, Unguja (study sites) are located, traditionally receive unreliable rainfall compared with the central corridors and west coasts (see Chapter 5; Walsh, 2009) and are thus more vulnerable. For the past two decades the recorded frequency of dry spells and the general decline of rainfall, particularly in the short rainy season, have negatively interacted with poor soil quality and low access to capital assets to cause an increased frequency of localised food shortages along the east coasts (Said, 2011; Walsh, 2009; Chapter 4). Further declines in rainfall and variability in temperature may put these already vulnerable farming systems in the east coasts of both islands at further risk (Chapter 6).

Future scenarios of climate change predict further changes in rainfall, temperature, sea level and winds that threaten the survival of coastal communities in Zanzibar. For instance, a study by McDonald *et al.* (2005) indicated that by the end of the century (2080-2100) there were likely to be more frequent and intense tropical storms in the southern Indian Ocean. Similarly, the IPCC's third assessment report estimated that global mean sea level would rise between 9 and 88 cm from 1990 to 2100 (Houghton *et al.* 2001). At the regional and local scale, however, future changes in sea level are more uncertain because of regional climate change effects on sea level and geological processes that influence land uplift or subsidence. But, the study by Brown *et al.* (2011) revealed a high probability that sea level could increase flooding, particularly on the coasts of east Africa, which includes Zanzibar.

Though traditionally there has been some resilience in the face of climate variability (Orlove, 2005; Adger *et al.* 2009), these new challenges need collective and collaborative responses, therefore understanding that vulnerabilities and adaptation of coastal communities in Zanzibar to global, regional and local changes and drivers of vulnerability is important, especially now that the nation is on a course towards policy formulation related to climate change adaptation. Despite an ever-increasing number of vulnerability studies worldwide, relatively few studies have been conducted in Zanzibar. Those that have been undertaken have focussed mainly on climate change impacts related to sea level rise, beach erosion, agriculture, tourism and the national economy (Table 1.1).

Table 1.1: Studies undertaken in Zanzibar related to climate change

Author	Focus area
Gössling and Hall (2006) and Gössling <i>et al.</i> (2006)	Likely impact of climate change on tourism sector.
Walsh (2009)	Use of wild and cultivated plants as famine foods in Pemba Island.
Salum (2009)	Climate change and beach erosion in the south east coast of Zanzibar.
Mustelin <i>et al.</i> (2009)	Assessment of practical measures to tackle climate change with an emphasis on coastal and beach erosion.
Mustelin <i>et al.</i> (2010)	Current and future vulnerability in coastal Zanzibar.
Kombo (2011)	Assessment of climate variability in relation to water availability in villages surrounding Jozani-Chwaka Bay National Park.
Reid (2012)	Assessment of unpredictability of rainfall and increasing temperature on agriculture in the south east coast of Unguja.
Watkiss <i>et al.</i> (2012)	The economics of climate change in Zanzibar.

Most of these studies only consider climate risks and fail to acknowledge the characteristics of societies, politics and institutions that create sensitivity to climate change in the first place. None have holistically analysed access to assets or capital stocks (livelihood building blocks) in understanding vulnerability and adaptive capacity. Similarly, none has simultaneously considered all the important livelihood activities (fishing, seaweed farming and agriculture) that shape well-being in Zanzibar coastal areas, nor looked at climate impacts within the context of other stressors that affect these livelihood activities. Scheuer *et al.* (2011) and O’Brean *et al.* (2004) believe that to understand the vulnerability of a society, assessment should seek to understand both actual risks of climate change and societal vulnerability. Societal vulnerability in this context implies the social capacity to cope and adapt, and includes the social characteristics that make individuals, households or societies sensitive to the impacts of climate change and other linked stressors (Adger and Kelly, 1999; Blaikie *et al.* 1994). For instance, Blaikie *et al.* (1994) argue that poverty and local institutions that result in inequities in access to assets create local sensitivity that makes communities vulnerable to disasters. Other livelihood commentators argue that capital stock in households and households’ access to these assets plays a central role in explaining vulnerability of rural communities to climate change in developing countries. This is because these assets influence utilisation of

resources, economic dynamics, networks, adaptive capacity and well-being of the societies (McDowell *et al.* 2010; McDowell and Hess, 2012).

This study therefore, examines vulnerability as a starting point (examining social factors that construct vulnerability and access to assets that influence vulnerability and adaptation) and as an end point (understanding climate change risks through perceptions and observed data). Thus, to build coastal communities resilient to climate change, knowledge is needed of livelihood activities, capital stocks and access to these (as influenced by institutions and power relations) in order to assess the causes of sensitivity, people's adaptive capacity and the prospects for future adaptation. It is impossible to design measures to reduce vulnerability of coastal communities to climate change without having a holistic understanding of the many factors that make people vulnerable. Further, knowledge of how local people cope and adapt to the impacts of climate variability and change and other linked stressors, and the barriers that hamper both their decisions and ability to adapt is also important. This will aid in understanding firstly, the factors that may prevent autonomous responses to various types of change, and secondly, the potential barriers that planned interventions can be expected to confront. Such understanding provides the insights needed to develop mechanisms to overcome these barriers, which are often far from the usual technical approaches to adaptation. Finally, as communities at risk are the ones who are expected to cope and adapt, knowledge of how local people perceive variability and change in climate and the associated risks and impacts for their livelihoods is needed, because perceptions of risk may influence decisions for adaptation (see Vedwan, 2006; Vedwan and Rhoades, 2001; Chapter 5 and 6).

1.1.5 Thesis aim and objectives

The goal of this study was to build a comprehensive and holistic understanding of the current vulnerabilities, adaptive strategies and options available to coastal communities when dealing with climate variability and change through in-depth, place-based research, and thus gain insights into the vulnerability of these communities to future changes in climate and sea level.

I achieved this through addressing three broad objectives which included:

1. To assess the existing vulnerability of households in two communities on the east coasts of the two major islands of Zanzibar.
2. To investigate the perceptions and responses of fishers, farmers and seaweed farmers in these communities to climate variability and change and associated risks.
3. To analyse the implications of the study's findings for achieving sustainable coastal livelihoods and a resilient coastal community.

The key research questions that guided this study were:

1. What assets do households have access to and how does this influence their vulnerability?
2. What is the current vulnerability context of the two communities, with a focus on water and food security, and what factors influence this vulnerability?
3. What are the perceptions of farmers (crop and livestock), fishers and seaweed farmers regarding changes in climate and sea level and how do these relate to observed meteorological data?
4. What risks have farmers, fishers and seaweed farmers faced in relation to their livelihoods?
5. What coping and adaptation strategies have been employed by farmers, fishers and seaweed farmers in response to perceived changes in climate and associated risks to their livelihoods?
6. How are these influenced by other interacting stressors and what are the barriers that hinder responses?
7. What do the findings mean for building sustainable livelihoods and resilient coastal communities to the predicted changes in climate and sea level?

1.1.6 Thesis structure

The thesis consists of eight Chapters organised into three main Parts: (1) the background and introduction part which comprises two Chapters (Chapter 1 and 2); (2) the empirical Chapters of which there are five Chapters (Chapter 3-7); and (3) the synthesis and conclusion (Chapter 8).

Chapter 1 introduces the study objectives as well as provides the theoretical background to the study. It provides definitions of key concepts and presents the conceptual frameworks used to understand vulnerability and adaptation among communities in the study areas to variability and change in climate and sea level. Chapter 2 discusses the methods used for data collection and provides a description of the study sites on both islands. This description includes information on weather and climate, water resources, geomorphology and soils, population and settlement, economic activities and ecosystem dependency.

Chapter 3 is the first of the results Chapters. It focuses on the livelihood activities and portfolios of the households surveyed, their stocks of capital and access to this capital, allowing an understanding of the sources of vulnerability and adaptation amongst coastal communities. Chapter 4 discusses food and water security in the areas. This Chapter provides a broad understanding of current sensitivity and vulnerability of the coastal communities. Chapters 5 and 6 present the perceptions of farmers, fishers and seaweed farmers related to variability and change in rainfall, temperature, wind and sea level and the risks associated with any changes, as well as other stresses in their livelihood activities. The major task of these Chapters is to understand vulnerability as a starting point as well as the degree to which coastal communities and their activities are exposed and sensitive to variability in climate and sea level rise, as well as other associated stressors.

Chapter 7 explores the coping and adaptation strategies employed in fishing, seaweed farming and agriculture in response to variability and change in climate and other interacting stressors. It also discusses the barriers that hinder local people in their efforts to cope and adapt to climate variability and change both within their respective livelihood sectors, but also more broadly in terms of livelihood diversification. Lastly, the Chapter examines the discontinuance of previously adopted adaptation strategies.

Chapter 8 is the final Chapter. It is a synthesis of the findings from Chapter 3 to 7 and presents the implications of the results for relevant adaptation policies and programmes that aim to improve the well-being of the coastal communities and build local resilience to future shocks and risks related to climate.

1.2 THEORETICAL CONTEXT AND CONCEPTUAL FRAMEWORKS

1.2.1 Theoretical framing: Complex social-ecological systems

This study is framed within a social-ecological systems (SESs) paradigm because changes in one component of a system will affect other components, either positively or negatively. For example, increasing biophysical exposure to climate change hazards is likely to undermine the resilience of the ecological system which, in turn, affects livelihood systems and thus increases vulnerability (Dolan and Walker, 2006). Social-ecological systems (SESs) can be referred to as a give-and-take relationship between natural systems and society (see Berkes and Folke, 1998; Gallopin, 2006; Folke *et al.* 2002; Janseen and Ostrom, 2006). Budgeck (2008:19) defined SESs as “social systems in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non-human biological units at multiple temporal and spatial scales”. Biophysical and non-human biological units may include coral reefs, mangroves, the continental shelf, grazing lands, forests and coral rag areas among others, while the social component comprises a wide range of users and actors such as individuals and organised groups, as well as traditional knowledge systems and local institutions that govern the linkages between the two (see Resilience Alliance, 2007). Figure 1.1, modified from Resilience Alliance (2007) and de la Torre-Castro (2006), shows the complex interactions between various components within the system in the context of a marine SES.

Ecosystems, whether semi-arid or marine, are decisive in supporting human well-being and survival (Reid *et al.* 2005). Fischlin *et al.* (2007) for example, categorised the functions and services of any ecosystem as supporting, provisioning, regulating, and cultural. SESs can be specified for any scale from the local coastal community and its surrounding environment (as in the case Kiuyu Mbuyuni in Pemba Island and Matemwe, in Unguja Island), to the global scale constituted by the whole of mankind and the ecosphere (Gallopin, 2006; Janssen *et al.* 2007). SESs constantly undergo change resulting from interactions within the system or from abnormal natural phenomena such as natural hazards. SIDSs are thus among the delicate SESs as they are associated with sensitive resources and their population relies heavily on these resources.

In examining the robustness of social-ecological systems to spatial and temporal variability, Janseen *et al.* (2007) found variations in resilience and adaptive capacity among the studied SESs. Some have a higher resilience to disturbances than others. As frequency of disturbance may erode resilience in the long run, Janseen *et al.* (2007) argue that even those SESs that have a history of resilience are likely to be vulnerable to new disturbances. Similarly, Adger (2006) argues that a SES that is already delicate will experience huge impacts from climate change, both ecologically and socially.

Furthermore, humanity is a major force in global change and shapes ecosystem dynamics from the local environment to the biosphere (Peterson, 2000; Folke, 2006). The realisation that nature and society are intricately linked motivated the need to study the whole SES in understanding resilience, adaptive capacity and vulnerability to climate variability and change and non-climate stressors (see Gallopin, 2006; Resilience Alliance, 2007). Thus, it is critical to consider the linkages between nature and society in studying vulnerability and adaptation to climate change and disaster impacts (Gallopin, 2006; Wisner *et al.* 2004; Tyler *et al.* 2007; Olsson *et al.* 2006; Mermet, 2008) as well as in understanding the drivers of change and ecosystems degradation (de la Torre-Castro, 2006; Janssen *et al.* 2007; Folke, 2006; Ostrom, 2007; Young *et al.* 2006; Hughes *et al.* 2005).

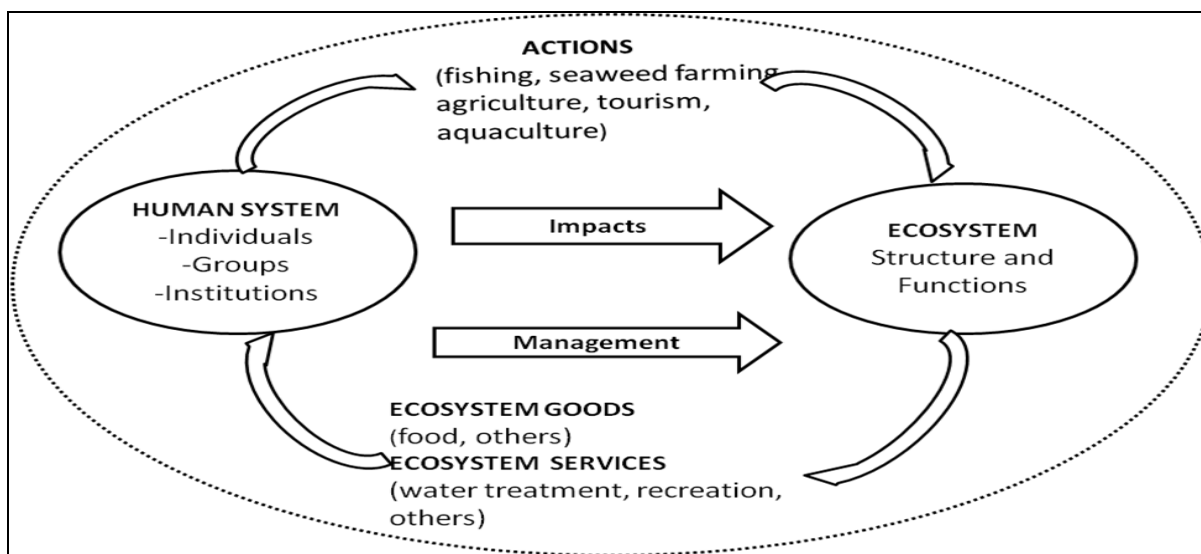


Figure 1.1: Coastal and marine social-ecological systems modified from Resilience Alliance (2007) and de la Torre-Castro (2006)

In their short communication to introduce papers related to marine SESs, Perry and Ommer (2010) argue that the marine SES is complex and, despite significant achievement towards studying coastal and marine SESs under global change so far, many issues still need further study to understand fully how marine SESs operate and they call upon natural scientists, social scientists, and humanists to work together. These issues include multi-stakeholder participation and development of flexible livelihood and governance strategies, among others. This complexity is clearly articulated in the following examples. A study by Crona *et al.*

(2010) in Zanzibar and Kenya found that, although the linkages between fishers and middlemen increase fisher's access to market and fishing assets, middlemen may reduce the fish price and thus impact both the fishers and fishery resources in the long run. So they argue that to benefit all the actors and for the health of the natural systems, the relationship between middlemen and fishers should be regulated. In Brazil, Kalikoski *et al.* (2010) showed that a combination of climate variability, lack of public policy specifically on climate variability and fisheries and little or no support for fishers, have intensified the vulnerability of both fishers and lagoon health. Since humans and nature constitute linked systems (de la Torre-Castro, 2006; Perry and Ommer, 2010), the above case studies demonstrate the fact that what is happening in one system may affect the other and the dynamisms within coupled human-environment relationships potentially lead to stressors other than climate change risks. To underscore this complexity, this study understands that vulnerability of Zanzibar communities along the east coast is not solely a result of climate variability, but rather a combination of both climate and non-climate factors.

1.2.2 Sustainable Livelihood Framework (SLF)

1.2.2.1 Description of the framework

A livelihood, according to Ellis (1998) cited in (Masanjala, 2007:1033), “encompasses income, as well as social institutions, gender relations and property rights required to support and sustain a certain standard of living” (also see Chapter 3). Indeed, a livelihood is an outcome of the utilisation of assets and entitlements ranging from natural, like mangrove ecosystems and grazing land, to social and public services. However, for a livelihood to be sustainable, it is expected to persist and survive through shocks and stressors of various origins without compromising future needs (Chamber and Conway, 1992; Scoones, 1998).

The Sustainable Livelihood Framework (SLF) (Figure 1.2) is not expected to present reality in local places, but it offers an analytical framework to unlock the complexity in human-environment relationships in understanding sources of vulnerability and interventions to reduce these (Farrington *et al.* 1999). In this context, a large body of literature in vulnerability and adaptation studies also views the SLF as an important analytical tool to study the sensitivity of society or households and their capacity to bounce back from shocks and risks (see Reid and Vogel, 2006; Badjeck, 2008). Figure 1.2, which represents the SLF, shows that the livelihood outcome in the household (more income, increased well-being, reduced vulnerability) is the result of the interaction of four dimensions that are intricately linked. These include livelihood assets; policies, institutions and processes; livelihood strategies; and the vulnerability context. This framework assumes that capital assets (natural, physical, social, human and financial, see Box 3.1 in Chapter 3 for their description) interact with policies, institutions and processes resulting in a wide range of livelihood strategies to choose from (farming, seaweed farming, fishing, small business, middlemen, tourism), and leading to favourable livelihood outcomes in the households (see Figure 1.2). Policies, institutions and processes, as shown in the Figure 1.2 occur at various scales (Adato and Meinzen-Dick, 2002) and

influence access to the capital assets and determine livelihood choices (Farrington *et al.* 1999). A study by Jones and Boyd (2011) in western Nepal, for example, showed that social and cultural ways of life and gender relationships affect access to important assets needed by women and other discriminated sections of the society for coping with climate change (see section 1.2.4.3). In Zimbabwe, women were found to be constrained to planting local maize varieties that can be obtained from neighbours or through networks as they have low access to credit and cash needed to buy improved varieties and fertilizers (Adato and Meinzen-Dick, 2002).

Further, the framework assumes that the five types of capital assets which are considered as livelihood building blocks (see Figure 1.2), and the resulting livelihoods are exposed to a vulnerability context which includes shocks, trends and seasonality. Policies, institutions and processes not only influence access to and choices of livelihood strategies, they may also influence the vulnerability context (Figure 1.2). In this regard, Masanjala (2007) shows how the sustainability of household livelihoods is also determined by the capacity to overcome this vulnerability resulting from climate change and non-climate factors such as policies, institutions and processes operating at various levels. In the context of coastal and marine livelihood strategies, seasonality involves seasons in farming, seaweed farming and fishing, rainfall and dry seasons, trends (e.g. population increase, decreasing catch, decreasing and increasing rainfall, temperature, winds, rising and falling prices of fish and food) and shocks (e.g. fuel price hike, increasing input prices for seaweed farming and fisheries, and shocks at household levels such as death and illness) (Allison and Horemans, 2006). Apart from negative impacts, the vulnerability context may also offer positive opportunities that could influence sustainability of the chosen livelihood strategies (Adato and Meinzen-Dick, 2002). Ideally, the model suggests that resulting livelihood strategies from the interactions as shown in Figure 1.2 are likely to reduce vulnerability of the communities as long as they are resilient to the vulnerability context. Therefore, the ability of the people to graduate from poverty or vulnerability is controlled by, or depends on the connectedness of the components within the framework.

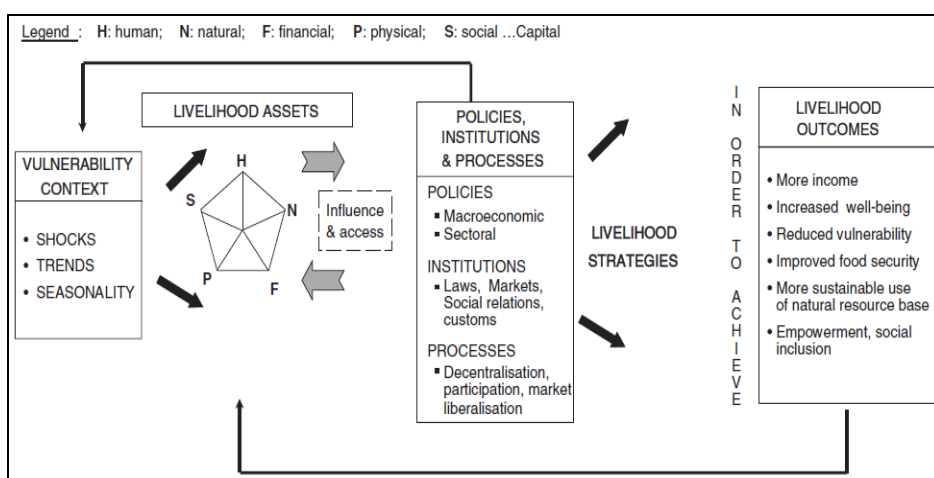


Figure 1.2: Rural livelihood framework, adapted from Allison and Horemans (2006:759)

1.2.2.2 Vulnerability context of natural resource based communities

As noted previously, vulnerability of a society is not only a function of external factors such as climate variability, but also internal characteristics of the society such as gender relations, religious and local beliefs, and access to assets, among others. This study, for example, is based on the assumption that the stock of capital assets and access to these among households partly defines the vulnerability and adaptation of coastal communities in Zanzibar. Thus, the livelihood assets and vulnerability context dimensions of the SLF (Figure 1.2) are important in this study (see Chapter 3). In the highlands of Bolivia, farmers were unable to cope with climate change and other linked stressors as they lacked access to land and education that could allow them to diversify their livelihood activities out of farming (McDowell and Hess, 2012). A great deal of poverty literature, particularly that originating from the World Bank, argues that a wide range of social capital (e.g. bonding, bridging and networks) can help to improve well-being and help people to graduate from poverty (Woolcock and Narayan, 2000; Narayan and Pritchett, 1999). Chapter 3 provides examples and discussion related to the interrelationship between livelihoods and assets and how this influences vulnerability.

Capital stocks and access to livelihood assets are necessary for adaptation, but at the same time climate change and other linked stressors can impact on these assets (Allison and Horemans, 2006; Allison and Seeley, 2004; Allison and Ellis, 2001; Reid and Vogel, 2006; Torell *et al.* 2006; Chapter 6) and make communities even more sensitive to these stressors. Since these capitals stocks are intricately linked, the exposure of one capital asset may constrain access to other capital assets. For example, the destruction of settlements, fishing vessels and gear, and the death of livestock triggered by climate events may reduce saving in the process of recovery and thus affect a household's future adaptation. A study by Aiken *et al.* (1992) cited in Badjeck *et al.* (2010) showed that fishers in Jamaica lost 90% of their fish traps during Hurricane Gilbert, resulting in a loss of revenue and high cost of repairs.

Furthermore, variability in rainfall can increase or reduce run-off, impacting natural capital through contributing to dry land salinisation and soil erosion, which affects crop production, livestock keeping and food security (Rosenzweig and Hillel, 1995 and Power *et al.* 2006 cited in Anwar *et al.* 2012). Additionally, temperature and precipitation variability and the frequency and severity of extreme events like droughts, floods, and wind storms can affect the quality and amount of pasture, while warming conditions reduce livestock's appetites and thus their weight and may sometimes cause death (Adams *et al.* 1998; Jones and Thornton, 2003; Jones and Thornton, 2009; Kurukulasuriya *et al.* 2006). The resulting reduction in the weight of the livestock reduces value at the market and ultimately disrupts the financial capital of the households (see Chapter 6). With regard to fishery resources, climate variability and change affect fisheries resources through various pathways (see Chapter 6). A study by Suna *et al.* (2005) cited in Badjeck (2008) revealed that capture of a type of mackerel in the area between Taiwan and Japan

experienced a dramatic decline following El Niño events of 1997/1998. Decreasing fish catch and distribution, as well as agriculture failure associated with trends and seasonality in climate can cause protein shortages and associated effects such as malnutrition, especially for a rural community with few sources of animal protein with impacts on human capital (McMichael *et al.* 2006; Haines *et al.* 2006).

Non-climate stressors, such as HIV/AIDS or illness related to climate sensitive diseases such as malaria and cholera (Hay *et al.* 2002; McMichael, 1999), can significantly affect stocks and access to capital in households (Figure 1.3). Figure 1.3 shows that illness can decrease availability of labour, result in loss of knowledge regarding natural resources management due to death, and accelerate the rate of resource extraction due to demand for cash for medical expenses. HIV/AIDS is perhaps the biggest challenge of our time as it affects so many dimensions of human life, including the human lifecycle (Barnett, 2006). Fishers are vulnerable to risks largely influenced by mobility, fisheries trade, life style and the use of drugs and alcohol (Allison and Seeley, 2004; FAO, nd). In rural Africa, including Zanzibar, and in other developing countries where most of the population is engaged in natural resource-based activities (Ellis, 2000; Owusu *et al.* 2011; Salayo *et al.* 2012), illness, injury or death, particularly of the heads of the households, has significant implications for access to assets, welfare and food security in the households. In Tanzania in 1997, 20% of deaths among adults were caused by HIV/AIDS, malaria caused 12% of deaths, and 10% and 5% of deaths were caused by diarrhoea and pulmonary tuberculosis respectively (Ministry of Health, 1997 cited in Paavola, 2008). It was estimated that 90% of global malaria cases occur in Africa (WHO, 1999). According to Rosenzweig *et al.* (2007), the incidence of malaria has increased since the 1970s at some sites in East Africa and it has been found that temperature and rainfall variability can be important determinants of the transmission of vector-borne diseases like malaria (Githeko and Ndegwa, 2001; Yanda *et al.* 2009). Thus malaria is likely to increase and spread as variability in temperature and rainfall influenced the growth of vectors like mosquitos (McMichael and Githeko, 2001). Tanser *et al.* (2003) projected an increase of a 5-7% by 2100 globally. Apart from malaria, poor sanitation and low access to safe, quality water in rural communities are also increasing sensitivity to waterborne diseases all over the developing world and thus affecting human capital which is required if households are going to adapt (Badjeck *et al.* 2010).

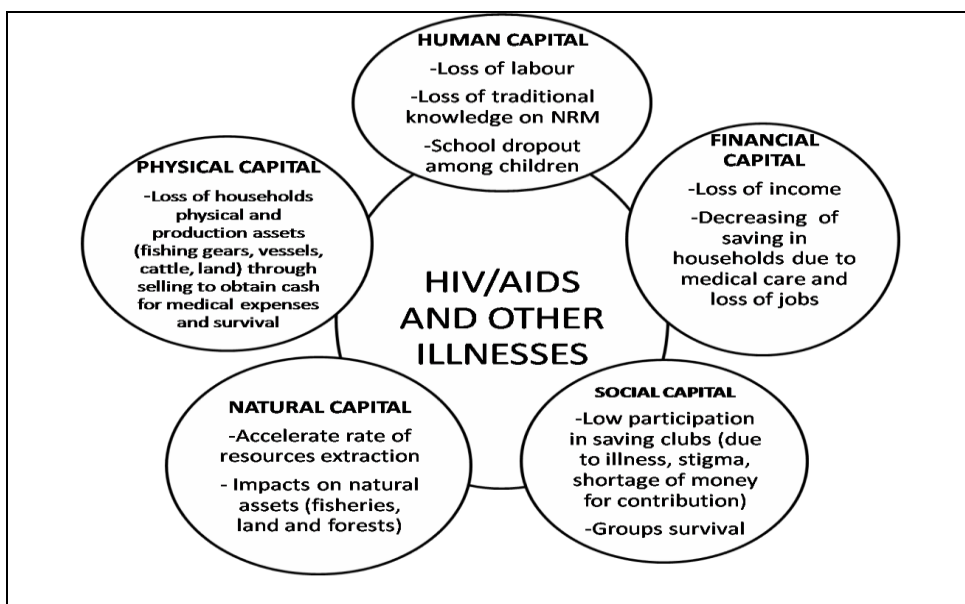


Figure 1.3: Impact of HIV/AIDS and other illnesses on livelihood capital (Torell *et al.* 2006; FAO, nd; Allison and Horemans, 2006; Reid and Vogel, 2006; Barnett and Whiteside, 2002)

1.2.3 Overall integrative conceptual framework for this study

Figure 1.4 shows the linkages and relationship between the various dimensions of vulnerability (exposure, sensitivity and adaptive capacity). This framework was modified from Donald and Walker (2004) and Ospina and Heeks (2012) and based on the IPCC definition of vulnerability as being a “function of the character, magnitude, and rate of climate variations to which a systems is exposed, its sensitivity, and its adaptive capacity” (McCarthy *et al.* 2001:995).

The framework in Figure 1.4 shows that the vulnerability of the coastal communities (C) is a function of exposure to stressors, trends, seasonality, drought and floods and other linked stressors (poverty, poor soils, variability of economy) (A) and sensitivity and adaptive capacity of the coastal marine social-ecological system (SES) (B). These different aspects of vulnerability are dealt with in Chapters 3 - 6 (see section 1.1.6). The framework also shows that the motivation and decision of an individual farmer, fisher and seaweed farmer, or household to respond (E) is determined by the extent to which they can manage to overcome barriers of various kinds (D). Successful adaptation is likely to improve sustainable livelihoods, and increase resilience and adaptive capacity, which in turn are likely to reduce vulnerability. On the other hand, responses such as doing nothing, maladaptation such as illegal fishing and short-term strategies that are later discontinued may further increase vulnerability (C). Discontinued adaptations are adaptation strategies abandoned by individuals or households after being previously adopted. The discontinuance of certain coping or adaptation strategies is influenced by several factors, including costs and unanticipated outcomes of the adopted option. This aspect of the framework is covered in Chapter 7. In the following sections, I briefly explain each of these components with further details provided in the introductions to each of the results chapters.

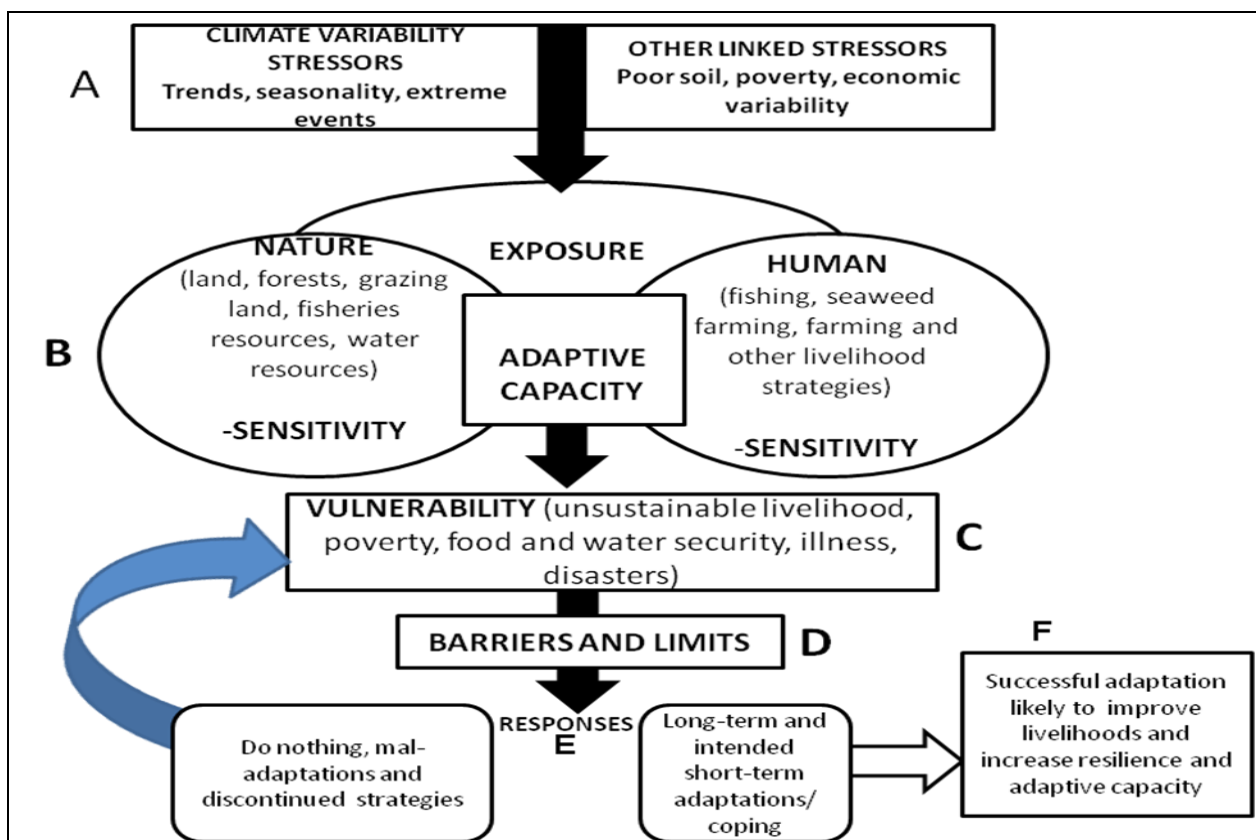


Figure 1.4: An integrated framework, modified from Dolan and Walker (2006) and Ospina and Heeks (2012)

1.2.4 Key Concepts central to this thesis

1.2.4.1 Vulnerability

Vulnerability has been conceptualized in many different ways in different research traditions and thus there are different methodological approaches for tackling it (Gallopín, 2006; Fussler, 2007; Adger, 2006; Brooks, 2003; Dolan and Walker, 2006). Badjeck (2008) identified five different schools of thought, each with their own definitions of vulnerability; these included social constructivist theory, political economy, political ecology, natural hazards and climate change literature. However, the most frequently applied definitions come from hazard and climate change literature. From these two disciplines (natural hazards and climate change), Dolan and Walker (2006) classified three broad categories of vulnerability as follows: one that characterizes vulnerability in terms of exposure to hazardous events and how this affects people and structures; a second that views vulnerability as a human relationship, not a physical one; and a third that integrates both the physical event and the underlying causal characteristics of populations that lead to risk exposure and limited capacity to respond. Based on the third category, Blaikie *et al.* (1994:9) defined vulnerability as “characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of natural hazards” (also see Wisner *et al.* 2004). While hazards (e.g. drought, hurricanes, wild-fires, tsunamis) are unavoidable, social-economic characteristics of the social system are the ones that construct vulnerability (Blaikie *et al.* 1994).

Indeed, “the existence of competing conceptualizations and terminologies of vulnerability has become particularly problematic in climate change research” (Fussel, 2007:156). This is attributed to the cross-cutting nature of climate change impacts ranging from ecological resilience to human health. In this study, the IPCC definition is used (section 1.2.3) because it provides room to understand the external risks, shocks and stressors that nature and society are subjected to (exposure). The IPCC definition also provides for understanding the internal side of vulnerability, for example the capacity of households to resist shocks and recover from them (sensitivity and adaptive capacity).

Exposure refers to the magnitude and frequency of stressors (e.g. rainfall, temperature and wind variability, sea level change and other socio-economic stressors) that come into contact with a system (Adger, 2006; McCarthy *et al.* 2001; Gallopin, 2006; Fussel and Klein, 2005). According to Gallopin (2006), different components of a system are unevenly exposed to stressors; for example poor households, which in most cases occupy marginal land, are more exposed to floods than affluent households that occupy high land. Thus, the intensity of exposure varies within a social system; this can be attributed by the variations on socio-economic factors within the households.

Sensitivity refers to the extent to which a social-ecological system can absorb impacts originating from stressors of whatever nature without much change in the state of the system (McCarthy *et al.* 2001; Adger, 2006; Gallopin, 2006). Since this study is based on the social system of the SES, the sensitivity of a fisher, farmer, seaweed farmer or household refers to the state of susceptibility to stressors both climate and non-climate (Adger, 2006). For instance, a household’s overdependence on natural resources and rain-fed farming may well be sources of sensitivity; similarly, exportation of raw seaweed to the world market may also be a major source of sensitivity in the sector. On the other hand, *adaptive capacity* which is also known as the capacity to respond and sometimes as adjustment refers to the “ability of a system to evolve in order to accommodate environmental hazards or policy change and to expand the range of variability with which it can cope” (Adger, 2006:270) (also see McCarthy *et al.* 2001; Smit and Wandel, 2006). Adaptive capacity is defined differently and used in a different context by Carpenter *et al.* (2001). They see adaptive capacity as a component of resilience that reflects learning aspects of a system’s behaviour in response to stressors, whereas Walker *et al.* (2004) define adaptability as the collective capacity of the SES to manage resilience.

Regarding individuals and households, adaptive capacity refers to their ability to respond and assimilate the stressors through utilisation of capabilities and capital stocks. For example, vulnerability of the farmers to drought will depend on how well they respond and are able to bounce back during and after the drought. The capacity to respond in this regard depends on how much they have diversified their livelihood portfolio or how best they can call upon their social capital (networks, bonding and bridging) in order to cope with crises. As the study focuses on social components of SES, the foregoing discussions suggest that sensitivity

and adaptive capacity of coastal communities are the starting point of vulnerability which is socially constructed. For instance, stocks of and access to livelihood capital such as human, social, financial, natural and physical at household or at individual level influences both sensitivity to risks and adaptive capacity (see section 1.2.2.1). Indeed, determinants that constitute adaptive capacity in social systems vary within the realm of vulnerability studies. MacKendrick and Parkins (2004) considered policy learning and adaptation to changing conditions by key political, social and economic institutions as essential to build adaptive capacity, as institutions can contribute to reducing vulnerability and to adaptation efforts. Furthermore, Johnston and Williamson (2007) identified flexibility and efficiency of institutions and policy, distribution and availability of financial resources, technological capacity and human capital as determinants of adaptive capacity. Adger *et al.* (2004) and Williamson *et al.* (2005) have added determinants such as knowledge and awareness of potential impacts, social networks, trust, isolation, infrastructure quality and perception of climate risk as factors which strengthen the ability to adapt (also see Chapter 3 and 5). Therefore, I argue that vulnerability of coastal communities in local places is influenced by external factors (exposure) and internal factors that make societies sensitive to risks and unable to adapt (see Chapter 3, 6, and 7).

1.2.4.2 Risks and stressors

Like vulnerability, risks and stressors have been used extensively in the climate change and hazards literature, with similar or different meanings based on the spatial scale, magnitude and context. This list can be extended to other concepts such as crises, disturbances, threats and hazards. The IPCC, in a recent special report on extreme events, defines risks as:

“the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.” (IPCC, 2011:32)

The word ‘likelihood’ in many definitions of risks is a typical trait of risk which is characterised by uncertainty in distribution of the events and their interactions within societies and nature (Alwang *et al.* 2001). The uncertainty of climate change risks is also said to influence perceptions of local people (see Chapter 5 and 6). Stressors on the other hand, can be defined as those circumstances that originate from both climate variability and change and socio-economic dimensions. McDowell and Hess (2012:343) define stressors as “those events, trends (e.g. drought, dry spells, increasing frequency storms, cyclones, coastal floods, floods and diseases), policies, and processes that deplete resource stores or systematically alter resource access”. Although risks and stressors can be used interchangeably, these two definitions highlight that stressors are used mainly when the risk of climate change becomes a reality. A large body of literature in climate change has recently argued that the compounding effects of climate change and non-

climate stressors are the real concern, rather than climate change impacts alone (Reid and Vogel, 2006; O'Brien *et al.* 2004, Marin, 2010; Boko *et al.* 2007; Chapter 6). In this study multiple stressors have been used as a concept referring to a combination of both climate and non-climate stressors.

1.2.4.3 Coping and adaptation

The introductory part of this Chapter highlighted that adaptation to climate variability and future changes in all sectors that shape human survival are needed and important (Leary *et al.* 2009; IPCC, 2007). Coping and adaptation have been defined and used extensively in climate change and hazards literature (see for example Smit and Wandel, 2006; Leary *et al.* 2009; Thornton and Manasfi, 2010; Adgers *et al.* 2009; Brooks, 2003; Wisner *et al.* 2004). In the context of this study, adaptation is mostly defined as adjustments in human systems in response to actual or expected climate stimuli or their effect, which moderates, harms, or exploits beneficial opportunities (Gallopín, 2006:300 also see Brooks, 2003; Leary *et al.* 2009). Adaptation, according to Gallopín (2006), is a specific action aimed at modifying sensitivity and resilience of both ecological and human systems in the face of shocks and stressors. Adaptation occurs at various scales, ranging from individual (fishers, farmers and seaweed farmers) and household to district and national levels. It can be top-down/planned (e.g. programmes and activities implemented by local people that are initiated by government agencies or international NGOs) or bottom-up/autonomous (Grafton, 2005). Adaptation can also be reactive or anticipatory and involve tactical or strategic responses (see Chapter 7 for a detailed description of these types of adaptation). Box 1.2, adapted from UNFCCC (2005), shows examples of planned adaptation options in various economic sectors in SIDSs.

A large body of literature has also tried to understand vulnerability and adaptation at the household level, in relation to the various assets in the Sustainable Livelihoods Framework (Badjeck, 2008; Below *et al.* 2012; Adger, 2003; Ebi and Semenza, 2008). For instance, using the Activity-based Adaptation Index (AAI), Below *et al.* (2012) found that enhancing linkages between farmers and extension services (human capital) and strengthening social capital and micro-credit (financial capital) would improve adaptation in the two communities of the Morogoro region in Tanzania. Similarly, Adger (2003) argues that sustainability of adaptation within social systems (e.g. coastal communities in Zanzibar) will only be attained through collective action and the strengthening of social capital. Additionally, using a community-based adaptation approach, Ebi and Semenza (2008) show that social capital, through organised neighbourhood groups and connections across multiple actors in relation to interventions, may be effective in adapting to the health impacts of climate variability and change (see Chapter 3 and 7 for more discussions and examples).

Box 1.2: Examples of adaptation measures for small island developing states (SIDSs)

Agriculture – management and infrastructure development (Mauritius).
Water resources – more efficient management of both demand and supply; improved monitoring and forecasting systems for floods and droughts (Seychelles); desalination of sea water (Federated States of Micronesia, Malta).
Human settlement and infrastructure – hazard mapping; improved forecasting and early warning systems; insurance provision (Antigua and Barbuda).
Public health – development of a health surveillance and forecast system; strengthening of data collection and reporting systems; vaccination campaigns and health education (Saint Kitts and Nevis).
Tourism – protection of essential facilities and infrastructure as part of the Integrated Coastal Zone Management strategy (Barbados, Grenada, Jamaica, Saint Lucia and Singapore).
Coastal zone – integrated, sustainable coastal zone resource management (Dominica).

Adapted from UNFCCC (2005:25)

Since adaptation is mostly based on the individual making a decision and changing his or her behaviour (e.g. among farmers and fishers), a considerable number of studies have recently picked up the idea of psychology and cognitive factors as important in understanding adaptation (Frank *et al.* 2011; Grothmann and Patt, 2005; Adger *et al.* 2009; Blennow and Persson, 2009; Gifford, 2011). Grothmann and Patt (2005) used a “Model of Private Proactive Adaptation to Climate Change” (MPPACC) to understand adaptation in two case studies and found perceptions and cognition significantly influenced the decision to adapt. Building from MPPACC, Frank *et al.* (2011) believe that perception of risk, which is central to the MPPACC, is shaped by social identity and is fundamental in influencing motivation for adaptation within social systems. For Frank *et al.* (2011), ‘social identity’ is a kind of knowledge of risks validated through interactions of peers and social learning. Furthermore, in understanding farmers’ motivations for taking measures to adapt in Sweden, Blennow and Persson (2009) found that variations in the motivation to adapt were extensively influenced by variability in beliefs about climate change (cognitive) and adaptive capacities.

Distinction is made between adaptation and coping strategies. Coping normally refers to short-term, temporal strategies under constrained conditions, whereas adaptation includes long-term strategies aimed at reducing impacts related to both current and future changes in climate (McDowell *et al.* 2010). Adger (1996) cited in Eriksen *et al.* (2005:288) contrast coping with adaptation as follows: “coping refers to the actions and activities that take place within existing structures, such as production systems, whereas adaptation frequently involves changing the framework within which coping takes place”. For Eriksen *et al.* (2005) coping and adaptation are intricately linked. Indeed, reactive actions which have only a short-term capacity to overturn vulnerability may be called coping strategies. For example, food aid, or eating unfamiliar food during dry spells, drought or floods are examples of coping, while the development of water harvesting techniques during the long-rain season in order to respond to declining rainfall in the short-rain and winter seasons can be termed as adaptation strategies (see Chapter 7 for more examples).

Despite the fact that adaptation is desperately needed in the developing world, now more than ever because of the increased magnitude and frequency of extreme events and shocks, adaptation is facing a number of challenges at all levels. In some situations, people or institutions have the means to adapt, but fail to be motivated or decide to adapt. People or institutions may decide not to adapt, may partially adapt (Leary *et al.* 2009) or may discontinue a valid adaptation option. IPCC (2007) in its AR4 recognises the knowledge gap in understanding the societal limits to adaptation. This acknowledgement has aroused the interest of researchers from a wide range of disciplines, from geographers to cognitive scientists, to start thinking about limits and barriers to adaptation (examples of studies in this new discourse include Hulme *et al.* 2007; Adger *et al.* 2009; Jones, 2010; Moser and Ekstrom, 2010; Nielsen and Reenberg, 2010; Jantarasami *et al.* 2010; Jones and Boyd, 2011; Gifford, 2011) (see Chapter 7 for a definition of limits and barriers).

In their paper “*Are there social limits to adaptation?*” Adger *et al.* (2009) challenge the previous understanding of limits which mainly focus on ecological, physical, economic and technological dimensions. They argue that societal limits to responding to climate change are constructed in four dimensions: (1) ethics, (2) risks, (3) knowledge, and (4) culture. *Ethics* as a limit to adaptation refers to the value attached by an individual or society to resources at risk (Adger *et al.* 2009). *Knowledge* refers to the knowledge gap regarding future climate. This means that the uncertainty of future climate, particularly among the African farmers and fishers may act as a limit to adaptation. Apart from other obstacles, Conway and Schipper (2011) also identify uncertainty of climate as a major obstacle that holds back the decision of the farmers in Ethiopia to adapt (also see Leary *et al.* 2009; Blennow and Persson, 2009).

Regarding *risk*, Adger *et al.* (2009) argue that individual and social factors such as age, perception of risk, habit, social status and age, among others, influence decision-making at individual and group levels, and may also constrain motivation to respond. For example, individual farmers or fishers who perceive and believe in risk are more likely to be motivated to adapt (see Blennow and Persson, 2009; Leary *et al.* 2009). *Culture* refers to the social-cultural value attached to place, resources and actions. A farmer or a fisher may decide not to adopt a prospective adaptation option if perceived to not be aligned with their culture (see Chapter 7 for examples). Building on previous works, including Adger *et al.* (2009), an adaptation cognitive study by Grothmann and Patt (2005), and the traditional understanding of adaptation, Jones (2010) and Jones and Boyd (2011) classified limits and barriers into three main categories (see Chapter 7). These include human and informational, social and natural barriers. Like Adger *et al.* (2009), Jones and Boyd (2011) also believe that social barriers are particularly responsible for holding back people’s motivation to adapt. Jones and Boyd (2011) argue that social factors restrict some people in poor communities from accessing the important livelihood assets needed for adaptation. Lower caste people were also discriminated against in terms of receiving aid during crises such as floods. Furthermore, gender

inequality was found to be a barrier for women which prevented them from acquiring assets and information that could help them to adapt to stressors such as floods (also see Table 1.2).

Table 1.2 Illustrative examples of social barriers to adaptation

Social barrier	Examples
Cognitive behaviour	-Belief that uncertainty is too great to warrant taking adaptation action now. -Unwilling to accept the risks associated with implementing adaptation action. -Change not yet seen as a problem: temptation to wait for the impact to be felt before reacting. -Reluctance to accept outside aid and assistance.
Normative behaviour	-Adopting historic and cultural response actions in relation to climatic stimuli that may be inappropriate in the context of future environmental change, or potentially maladaptive in the longer term. -Unwillingness to deviate from traditional practices and adopt more appropriate and sustainable strategies.
Institutional structure and governance	-Institutional inequalities and social discrimination restrict access and entitlement to key resources and assets needed to adapt. -Political and social marginalisation and discrimination. -Lack of institutional flexibility.

Adapted from Jones and Boyd (2011:1264)

1.3 CONCLUSIONS

This Chapter provides a broad description of the impacts of climate variability and change, interacting with other stressors, on coastal livelihoods in Zanzibar at various scales. Several studies have shown some evidence that justifies the existence of climate variability and change in the islands. Extreme heat waves, the heaviest rainfall ever recorded, changes in the incidence of El Niño and La Niña, coastal floods in both islands, dry spells especially along the east coasts of both islands (where study areas are located) have all been recorded over the past two decades. Although some of these events are not new in Zanzibar, their increasing frequencies raise the concern amongst both local people and the authorities. This highlights the fact that Zanzibar islands, like many SIDSs, are vulnerable to climate change and disasters especially as they are already affected by a large number of development challenges. The main economic activities such as fishing, tourism and farming are particularly sensitive to risk-related trends and changes, as well as seasonality and shocks related to climate variability and extremes.

The discussion in section 1.2 provides a deeper understanding of the frameworks that shaped and guided this study. The framework I used recognises that human activity and the environment are intricately linked and should be treated together, although this study focuses specifically on the social/human side of the coastal SES. Both the social and ecological components of the SES are exposed to a wide range of stressors including risks related to climate variability and change. However the impact of the stressors on human vulnerability is highly determined by people's capacity to withstand and absorb shocks. This in turn is influenced by various factors including capital stocks (natural, human, financial, social and physical) and

access to these. These assets not only assist in overcoming poverty and vulnerability, they can create wealth within the households. However, these capital stocks themselves are sensitive to both climate and other linked stressors (Figure 1.3). For example, various forms of food insecurity and poverty may be the result of stressors on the ecosystems or natural capital that forms the basis of livelihood activities such as fishing and farming. Given the changing context and the evidence of more extreme climate events, adaptation is essential to ensure sustainable rural livelihoods. However, the decisions and motivations to adapt are not only constrained by capital stocks and access to these, but also by a wide range of social and cognitive barriers that may act together to limit adaptation.

CHAPTER 2

STUDY AREA AND METHODS

2.1 OVERVIEW

This Chapter provides a description of the study areas and methods employed in this study, starting with an overview of the location of the study areas and the rationale for their selection. This is followed by a description of the important biophysical, demographic and socio-economic characteristics of the two study areas, including geomorphology and soils, water resources, weather and climate, settlement and population, and coastal livelihoods. With regard to the methods employed in this study, I begin with a general discussion of the primary and secondary data collected and follow this with a detailed description of the various quantitative and qualitative data collection tools employed.

2.2 STUDY AREA

2.2.1 Study site selection

Zanzibar consists of two major islands, Unguja and Pemba which are located between latitudes 4° and 6°S and between longitudes 39° and 40°E, some 40 km off the coast of mainland Tanzania (Figure 2.1 and 2.2). Unguja is a capital of Zanzibar and it is sometimes informally known as Zanzibar, but Zanzibar actually consists of several islands. The distance from Unguja and Pemba is about 50 km and both islands are surrounded by more than 30 smaller islands and islets including Latham island/Fungu Kizimkazi, only some of which are inhabited (Heguye, 1993). Unguja is 1,658 sq. km in size, and Pemba about 985 sq. km (Mohd, 1997; Heguye, 1993; Hassan, 2007). The study was conducted in two sites located in the north-east of each island, namely Kiuyu Mbuyuni in Pemba (Figure 2.1) and Matemwe in Unguja (Figure 2.3). The selection of these two sites was not meant for comparison, but rather to provide representation of both the major islands that make up Zanzibar (although some comparisons are indeed made in interpreting the results).

The selection of the study sites involved two steps. Firstly, two districts (Micheweni district, Pemba, in which Kiuyu Mbuyuni is located and North 'A' district, Unguja, in which Matemwe is located) were purposely selected; the reasons for their selection are numerous. Both experience high unreliability and variability in rainfall along their east coasts, and this variability is usually accompanied by localised food shortages, especially in Pemba Island (Walsh, 2009). These districts are also categorised as the poorest compared with other districts on their respective islands (RGZ, 2009). Further, local people in these districts rely heavily on ecosystem-based livelihood activities that are influenced or controlled by the climate. These characteristics were important for the selection of the sites since one of the key objectives of this study was to examine the vulnerability of communities in areas that are highly sensitive to climate variability and change. Secondly, two shehia (wards), Kiuyu Mbuyuni from Micheweni district, Pemba and

Matemwe from North 'A', Unguja, were randomly selected from the shehia that are located along the east coasts of the selected districts; each shehia is composed of several villages.

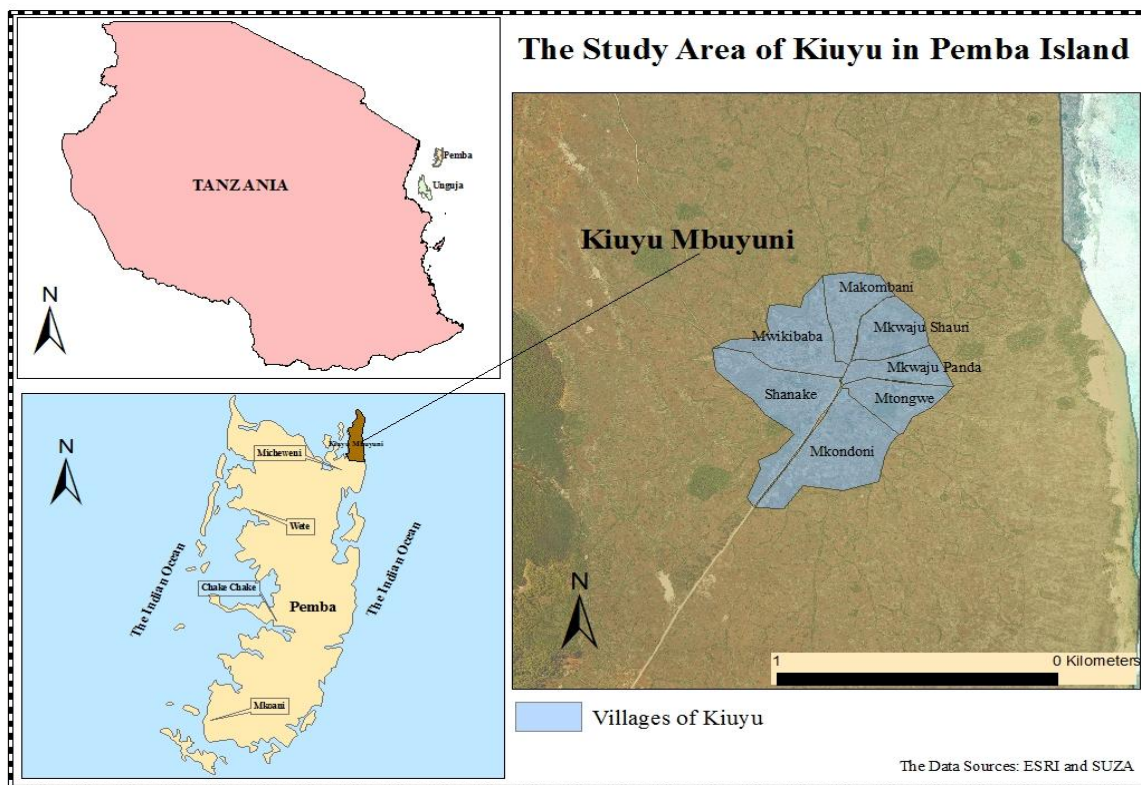


Figure 2.1: Location of the study site in Pemba Island

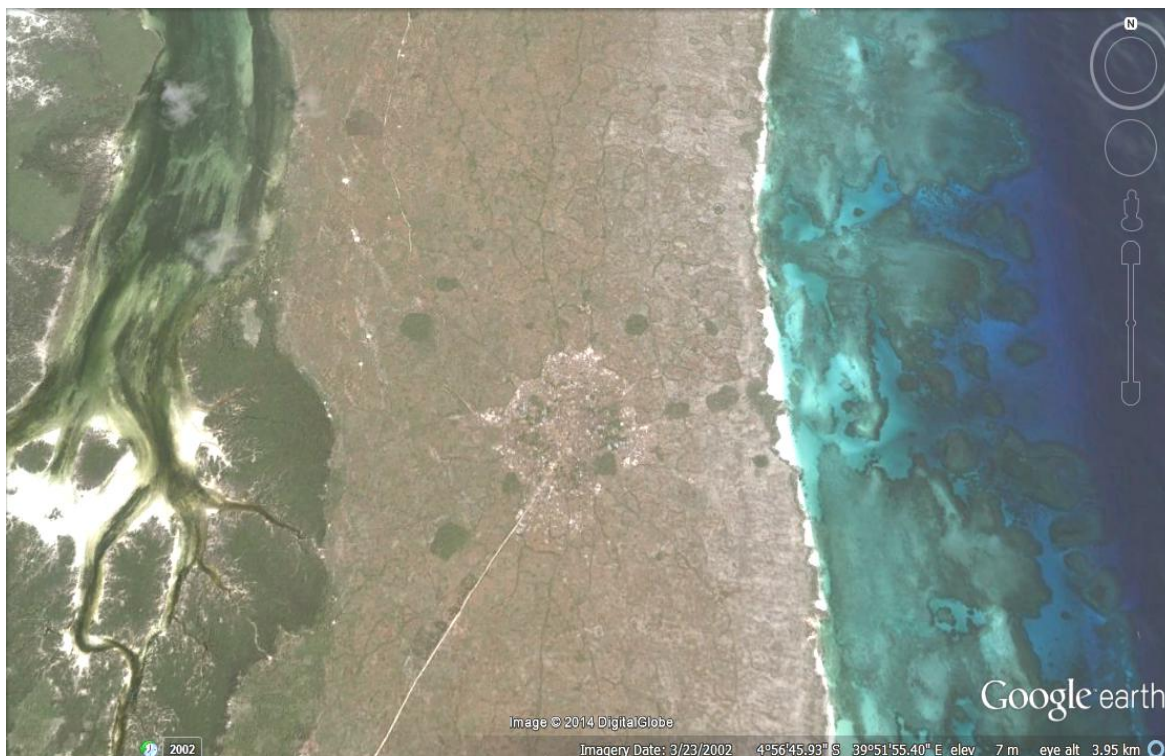


Figure 2.2: Google earth high resolution satellite image of Kiuyu Mbuyuni, Pemba

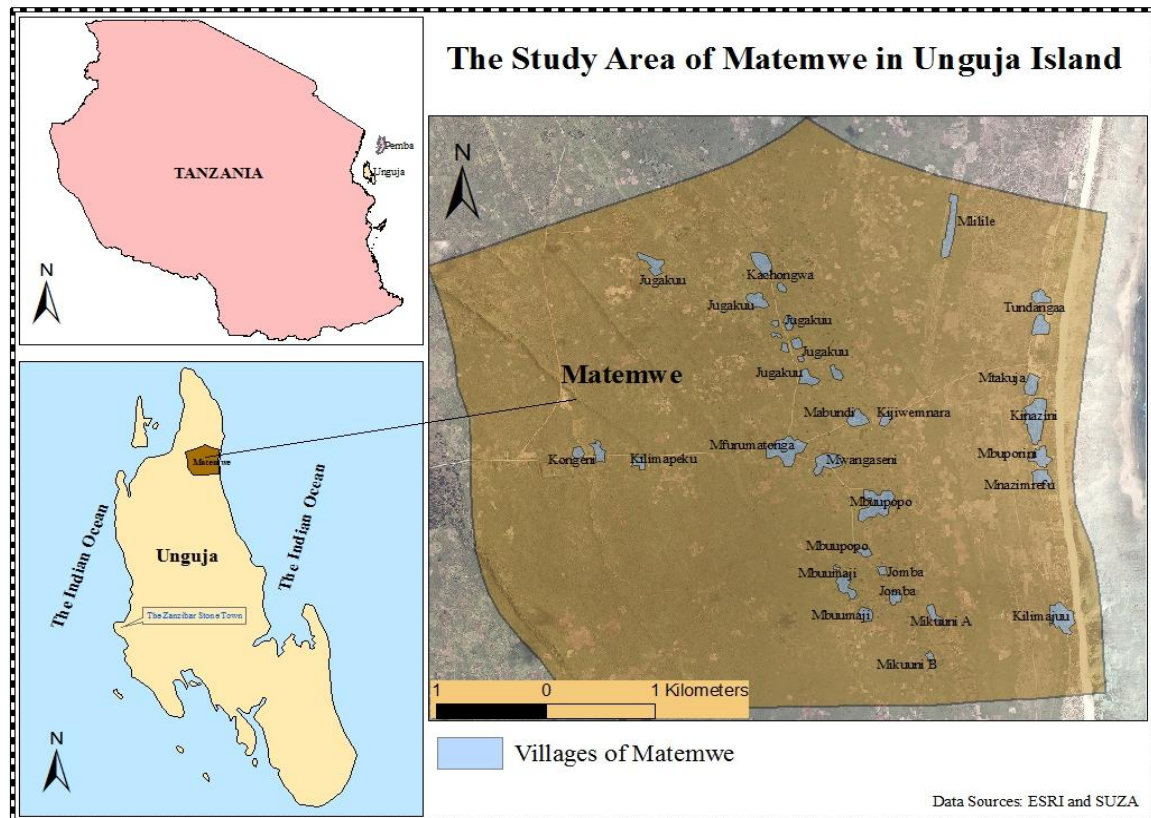


Figure 2.3: Location of the study site in Unguja Island

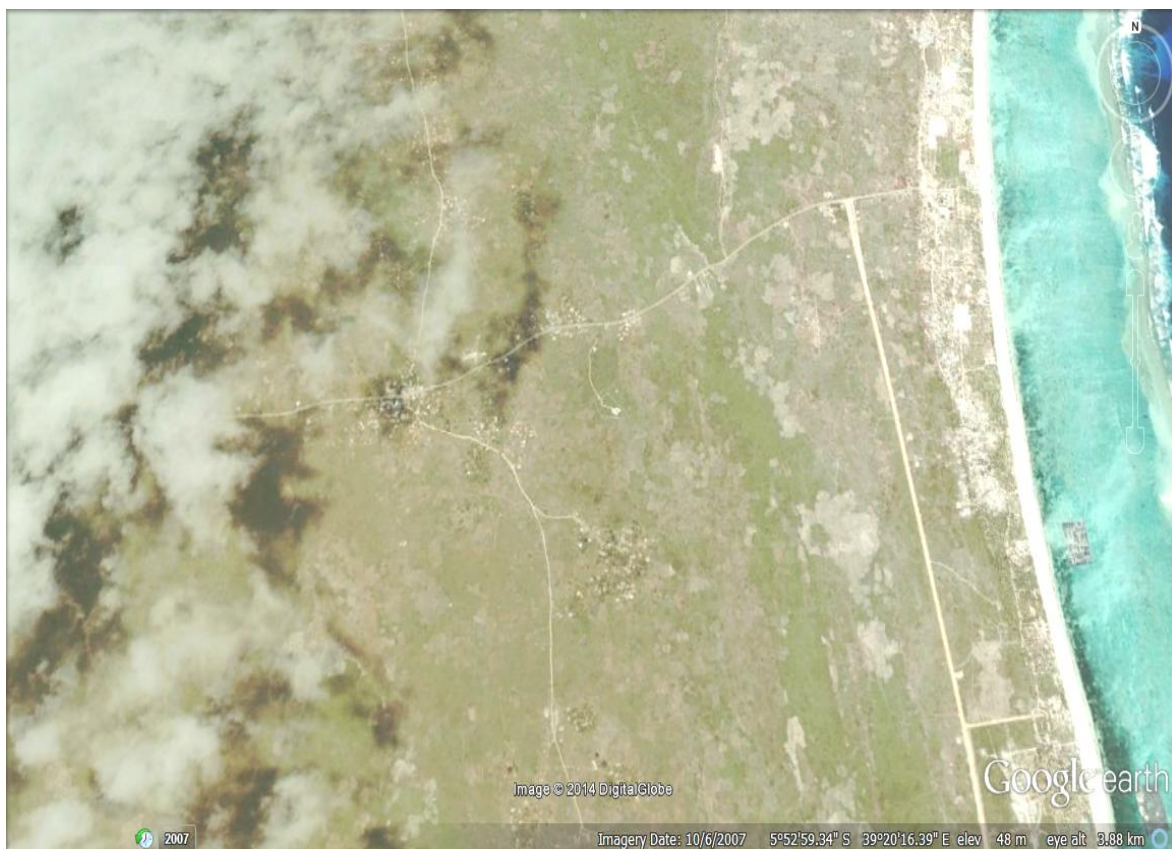


Figure 2.4: Google earth high resolution satellite image of Matemwe, Unguja

2.2.2 Geology, geomorphology, flora and fauna and soils

Pemba is a simple fault block raised higher than Unguja, and it is thought to have been disconnected from the mainland coast earlier than Unguja (RGZ, 2005) some 10 million years ago. It is believed that Pemba emerged from the sea during the Miocene geological age when Unguja was still submerged (Ingrams, 1960). Thus, Unguja is a younger island and believed to have been formed recently during the Ice Age less than 0.5 million years ago (RGZ, 2005). Geologically, Pemba and Unguja Islands are composed of lower Miocene rocks overlain by Pliocene and Quaternary formations (RGZ, 2005). Geomorphologically, the coast of both islands is similar to other East African coasts (Arthurton *et al.* 1999; Muzuka *et al.* 2004), “characterised by largely intertidal fringing platforms commonly extending more than one kilometre” (Arthurton *et al.* 1999:635). This platform is particularly important socio-economically as it supports crucial livelihoods activities such as coconut fibre making, seaweed farming, shellfish collection and fishing. It is also ecologically vital, providing habitat for a variety of marine animals and plants (Arthurton *et al.* 1999). Despite this vitality, the fringing platforms and associated features such as beaches are under the threat of shoreline change and inundation. For example, the low elevation of Zanzibar coastal platforms compared with the mainland (Muzuka *et al.* 2004) potentially make them more vulnerable to the predicted changes in global sea level and weather patterns. The Holocene beach sand plains along the Zanzibar coast are also likely to become vulnerable to marine erosion (Arthurton *et al.* 1999).

According to Ingrams (1960), both islands were densely forested during the Holocene geological age. This study categorised native vegetation in Zanzibar into five main zones. These included mangrove forests and swamps which are mainly located along the west coast in both islands; and beaches and rocks which support species like casuarinas and screw pine and scrub bushes. Other zones included bush savannah and the intensity forest zone (Ingrams, 1960). The intensity forest zone consisted of tropical forest which now forms a part of reserved forest in Jozani-Chwaka Bay National Park in Unguja and Ngezi Forest Reserve in Pemba. Zanzibar’s forests support various animal species, including slender mongoose, vervet monkey, gazelle and black pig in Pemba, and red colobus monkey, Zanzibar duiker, giant elephant shrew and squirrel in Unguja. *The red colobus* monkey, mainly found in Jozani-Chwaka Bay National Park, is an endemic species that attracts a considerable number of tourists to the area.

With regard to soil, studies show that the soil cover in both islands varies between west and east. In the west and central corridors, the soil is much deeper and very fertile (Mohd, 1997). As a result, most of the clove, coconut and rubber plantations are found in these areas (Walsh, 2009). However, in the east, where the study sites are located, the soil is shallow with many coral outcrops and is covered with bushy vegetation up to 4.5 metres in height (RGZ, 2005; Mohd, 1997; Sheriff and Ferguson, 1991). The coral rag areas, locally known as ‘*Makaani*’ in Pemba and ‘*Uwanda*’ or ‘*Maweni*’ in Unguja, cover some 17% of Pemba Island, while in Unguja they cover as much as 59% of the land (Owen, 1993; Mohd, 1997; Heguye,

1993). Generally, coral rag soils are less fertile than the soils in the west of the islands and they are easily exhausted under little pressure. Thus, shifting cultivation has been the main method of farming in these areas (Singer, 1996). There is some contrary evidence regarding the nutrient content of these soils. Klein (2008) found that coral rag soils are richer in nutrients than the deep soils in both islands, but other characteristics of coral rag soils, such as thinness and low water retention capacity, coupled with unreliability of rainfall, make these soils less suitable for agriculture than the deep soils in the west where the rainfall is higher and more reliable. As identified earlier, shifting cultivation is very common in the coral rag areas together with livestock keeping. However, due to increasing population (see section 2.2.5) and emerging new land uses like tourism and development infrastructure (see Chapter 6), the fallow period for shifting cultivation has changed from nine years to between two and four years (Kombo, 1994). Because of the infertile nature of these soils, large parts of the land in the east in both islands was left out of the land distribution process after the Zanzibar revolution of January 12th, 1964 (Singer, 1996).

2.2.3 Water resources

Like many SIDSs, Zanzibar obtains most of its water for household needs through extraction from underground aquifers, the richness of which varies between islands. Underground water is also used for irrigation, but this is small scale (RGZ, 2012c). The major source of water for farming is rainfall. In the east coasts, as mentioned earlier, rainfall is unreliable compared with the central and western segments (Walsh, 2009). East coast villages in both islands are endowed with a network of coral caves that contain water (Hansson, 2010). These caves, together with local wells and piped water supplied from distant sources, complement each other in meeting daily household needs (Hansson, 2010). The geohydrology of Pemba forms discontinuous perched aquifers, which fail seasonally (RGZ, 2005), whereas the Unguja aquifers are considered to be rich in water (Halcrow, 1994). Figure 2.5 shows the water lens structure for a typical oceanic island, highlighting how the depth of the underground aquifers decline as distance increases from the centre of the island to the periphery. Similarly, the underlying saline water layer is closer to the aquifers at the margins than at the central points (Figure 2.5). The study sites are located in areas with marginal aquifers that could be prone to salt water intrusion resulting from high water extraction as demand increases (e.g. because of increasing population, the need for irrigation, and tourism development) or sea levels rise. Furthermore, studies show that rainfall is a very important source of water for the recharge of underground water lenses (Halcrow, 1994; Hansson, 2010) and thus sensitive to climate change. However, the degree to which water lenses are recharged through rainwater varies between islands. For example, a study by Halcrow (1994) shows that rainfall recharge in Unguja is higher than Pemba, largely attributable to high run-off because of the hilly nature of Pemba (Halcrow, 1994).

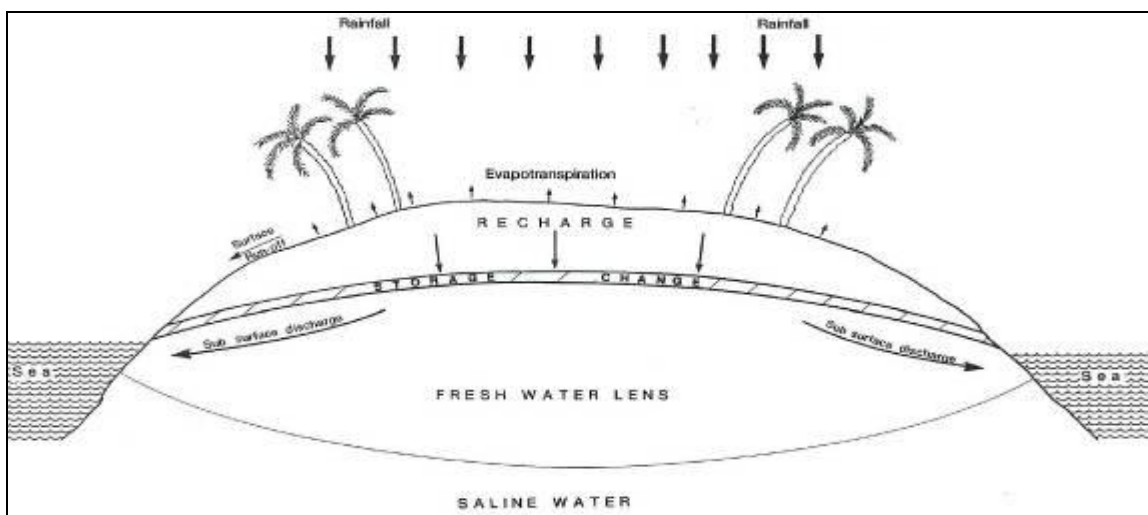


Figure 2.5: Hydrological cycle in Oceanic Islands (Source: Halcrow, 1994)

With regard to surface water resources, like other SIDSs, Zanzibar lacks big rivers and lakes that could be used for farming and household needs. However, it is endowed with both perennial and ephemeral streams, and where available, these are mostly used for small scale rice farming (RGZ, 2012b). Figure 2.6 show that Pemba has a relatively higher density of streams than Unguja. The volume and the flow of these streams are influenced by the availability of rainfall in both the long-rain season (*masika*) and the short-rain season (*vuli*) (see section 2.2.4). Therefore, both the flow and volume in these streams is reduced drastically during the dry season with most of them drying up. In most cases, these streams end up in the Indian Ocean, but some of them disappear into the coral limestone. In the study areas, surface streams are almost absent (see Figure 2.6)

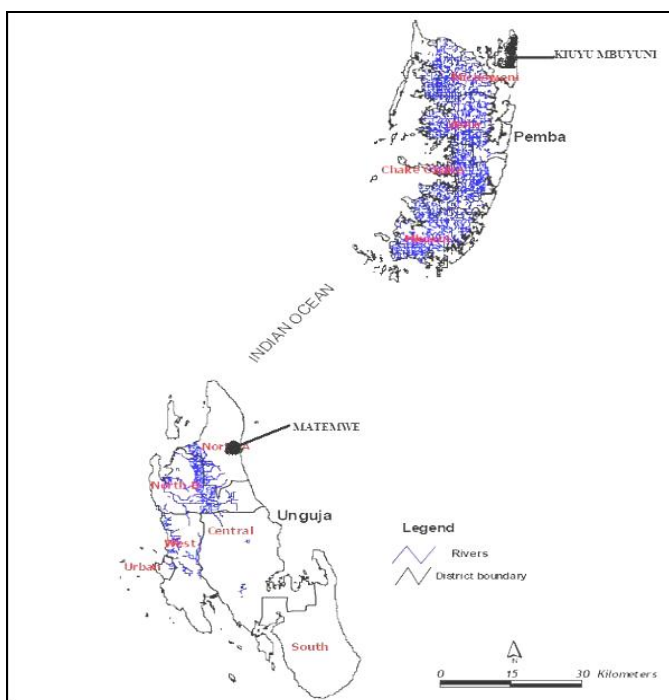


Figure: 2.6: Streams in Zanzibar (source: RGZ, 2007)

2.2.4 Weather and climate

The climate in Zanzibar is typically insular: being tropical and humid. Zanzibar experiences four main seasons in a year: summer, known locally as *kiangazi* (January-March); the long rainy season/*masika* (March-May); winter, known locally as *mchoo* in Pemba and *pupwe* in Unguja (June-August/September), and the short rainy season/*vuli* (October-December). Rainfall occurs in all four seasons, but most is received in the long rainy season followed by the short rainy season, winter and summer. Across Zanzibar, heavy rains associated with showers and thunderstorms during March and May sometimes produce heavy flooding, which can force people out of their homes. The annual average rainfall along the east of both islands is around 1 400 mm, in contrast to the central and west segments which receive up to 2 000 mm per annum (Walsh, 2009). For example, Table 2.1 shows that, although there is little variation between east and west regarding rainfall received during *masika*, a large difference can be seen during *vuli* season. In fact, apart from experiencing low rainfall compared with the west coast, rainfall is also much more unreliable along the east coast (Walsh, 2009) (see Chapter 5).

Table 2.1: Difference in rainfall received during *masika* and *vuli* between the east and west coast of Unguja

Angaza

Long rainy season (March-May)					Short rainy season (Oct-Dec)			
East Coast (Paje weather station)								
years	March	April	May	Avg (mm)	October	Nov.	Dec	Avg (mm)
2006	121	542	222	295	30	108	261	133
2007	202	207	424	278	2	170	6	59
2008	79	467	47	198	21	10	8	13
2009	28	213	51	97	27	14	91	44
2010	83	158	114	118	6	15	8	10
West Coast (Zanzibar airport weather station)								
2006	243	343	185	257	96	259	363	239
2007	388	272	527	396	113	214	527	285
2008	125	584	116	275	90	243	64	132
2009	154	202	112	156	62	195	140	132
2010	223	253	194	223	87	169	102	119

Source of data: (TMA Zanzibar office)

With regard to temperature, Zanzibar experiences a mean monthly maximum temperature of 28-32°C and a minimum of 18-22°C (Owen, 1993). The highest temperatures occur during summer/*kiangazi* (January-March) with a mean maximum of 32°C (Figure 2.7) and the lowest during winter (June-August/September) with a mean minimum of 20°C (Figure 2.8). Both Figures 2.7 and 2.8 shows similar patterns in which temperature peaks in February-March and is at its lowest in July-August before it starts rising again in October.

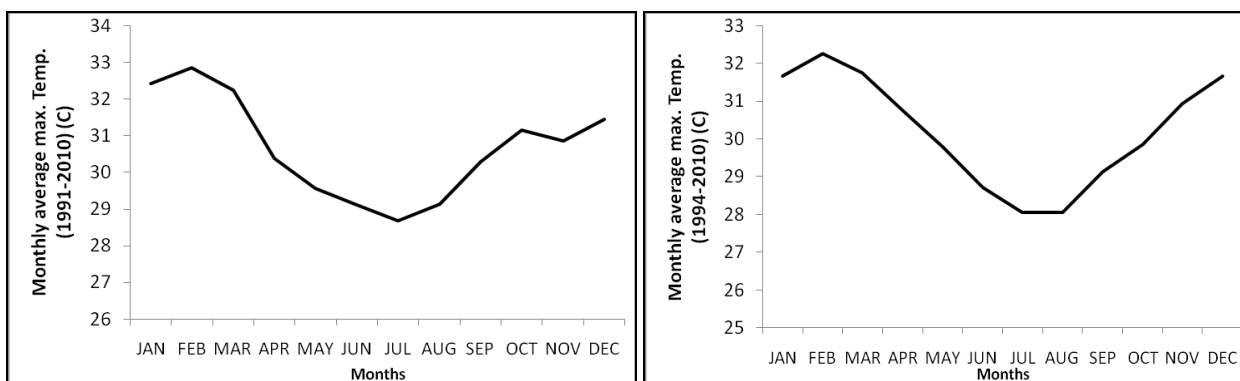


Figure 2.7: Monthly average maximum temperature left (Unguja) and right (Pemba) (Source of data: TMA Zanzibar office).

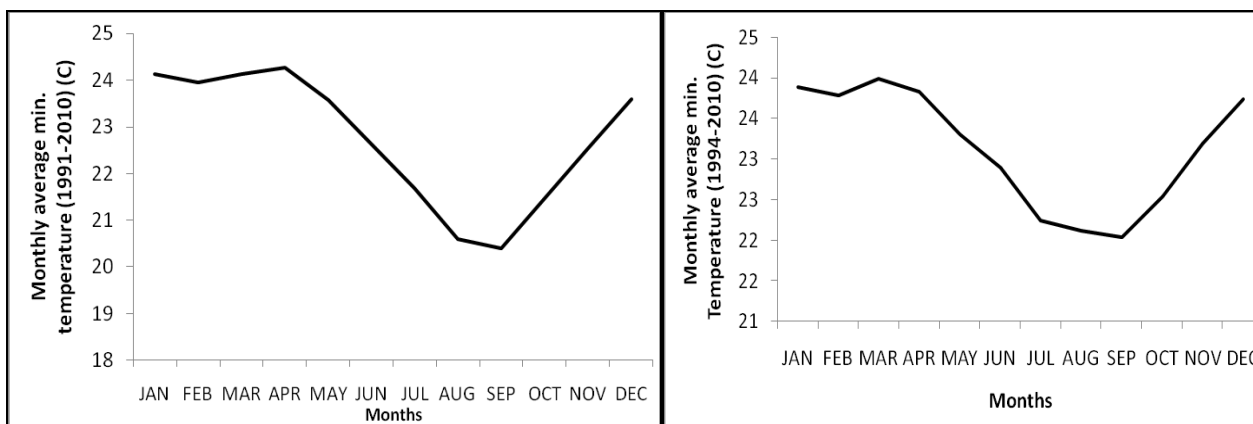


Figure 2.8: Monthly average minimum temperature left (Unguja) and right (Pemba) (Source of data: TMA Zanzibar office).

In terms of winds patterns, Zanzibar experiences two main windy seasons characterised by north-easterly and south-easterly winds with calm periods in between. Cyclones and storms also occur in Zanzibar, but on a smaller scale. The north-easterly winds, locally known as *kaskazi*, blow towards the coast of both islands during December-March, occurring in the same period that the islands experience warm conditions (summer). The south-easterly winds, or *kusi*, blow away from the shore during June-September, during the same period in which the islands are experiencing colder weather (winter). Wind patterns in Zanzibar are thus highly influenced by the differential of heat between the southern and northern hemisphere, attributed to the movement of the sun and pressure pockets. These wind patterns are separated by two calm periods locally know as *leleji* in April-May and October-November.

Climate is important for the well-being of the coastal community in Zanzibar in multiple ways as it influences the growth of crops and pasture, the survival of livestock, the distribution of fishery resources, the ease with which fishers can go to sea, and the growth of seaweed. For example, normal seasons provide suitable conditions for growing crops and pasture. Wind patterns and resultant weather conditions can influence the abundance, size composition, fish migrations and recruitment and food supply for fish (Feidi,

2005). Similarly, south-easterly winds and associated cool conditions (June-September) provide ideal weather conditions for the growth of seaweed, more so than the north-easterly winds, associated with warm conditions (December-March). Indeed, normality of the climate in Zanzibar is crucial for the development of important activities practiced in the coastal villages such as fishing, farming and seaweed farming. However, climate has started to show deviations from the long-term 'normal' (see Chapter 1; Mustelin *et al.* 2010; Watkis *et al.* 2012) and therefore is threatening the sustainability of these activities, which are already exposed to other types of environmental change related to soil fertility in the case of farming, and fishery resources depletion in the case of fishing.

2.2.5 Culture, politics and economics: The historical context of Zanzibar

Zanzibar was a major player in the history of eastern Africa and great lakes region (Sheriff, 1991:1). During this period Zanzibar emerged as a commercial empire based on the twin foundation of commerce and cloves plantations (Sheriff, 2001). Zanzibar was then under the Sultan of Muscat and Oman who started to rule in the 18th century and promoted clove plantations. Zanzibar was an entry point and hub that linked east and central Africa with the outside world, especially the Middle East, India and other parts of Asia. These trade interactions dated back as early as 1 century AD. However, the prosperity of Zanzibar started to decline in the latter parts of the 19th century. According to Sheriff (2001), this decline was associated with many factors. These included the diversion of trade to new colonies done by colonial powers (German and British) who ruled mainland countries, obliteration of the slave trade and slavery; and the great depression of the 1930s. After a hurricane in 1840 which uprooted a large percentage of clove plantations in Unguja, Pemba Island became a focal point for clove and clove trade, before and after the revolution of 1964 (Sheriff, 2001). These cloves were and still remain an important part of Zanzibar's economy. However, due to the unreliability of the world market and the emergence of other producers in the Far East, Zanzibar sought to diversify its economy by introducing tourism in the late 1980s, utilizing its rich history and culture, and abundant natural beauty to attract visitors.

For centuries goods of various types, and slaves, were transported between the islands and in the broader region using dhows driven by the monsoon winds. This movement resulted in complex interactions and integration between the local community, Arabs and other immigrants and because of this interaction, three major ethnic groups emerged (*Watumbatu*, *Wahadimu* and *Wapemba*). The *watumbatu* which are considered to be real natives of Unguja Island occupied a small islet north of Unguja called Tumbatu. They are now widely dispersed in northern Unguja. The *Wahadimu* inhabited the southern part of Unguja and the *Wapemba* occupied the whole of Pemba Island including Kiuyu Mbuyuni (study site). When Zanzibar was declared a British protectorate in 1890, it witnessed the formation of associations based on ethnic lines encouraged by the British rulers. These associations transformed themselves to political parties in the early 1950s, fighting for independence in the latter stage. Many historians believe this deep political division

along ethnic lines was responsible for the deadly unrest in pre-independence elections (1963) and during the revolution (1964). According to Sheriff (2001) the recurrences of political unrest in recent years particularly during national elections of 1995, 2000 and 2005 has to be re-examined.

The political unrest after the 2000 general election was particularly intense in Pemba Island and generated more than 1000 refugees who fled to Mombasa in Kenya. Within this number were youth and some adults from Kiuyu Mbuyuni. Low development in Pemba compared with Unguja make the island a strong supporter of opposition in Zanzibar. Despite the reconciliation which led to the formation of a Government of National Unity (GNU) which included opposition parties after the 2010 general election, Zanzibar is still polarised along party lines and that has created a division within communities. This situation is likely to affect the social capital within the communities as some groups are still struggling to maintain their position in a polarised nation. Indeed, the history of Zanzibar according to Ingrams (1967:19) “is long and complicated, the customs of the people are coloured, to a large extent by external influences, as throughout the centuries the Zanzibaris have absorbed the manner of various civilisations that have been imposed upon them”.

2.2.6 Settlement, population and socio-economic characteristics of the study areas

The two sites exhibit different settlement patterns. Kiuyu Mbuyuni, Pemba has a nucleated settlement pattern located at the centre of the area (Figures 2.1 and 2.2). According to people’s narratives during group discussions as part of this study, the first people who migrated into this area settled along the shore originally using saline water from caves as their main source of water. This prompted them to look for a spot where they could get fresh water and thus they settled at the centre of this piece of land which projects into the Indian Ocean (see Figures 2.1 and 2.2). Matemwe, Unguja, by contrast, displays a scattered settlement pattern (Figure 2.3 and 2.4) and this affects the provision of services such as water and electricity. Unlike Kiuyu Mbuyuni, in Matemwe, local people have settled along the shore ever since they first arrived in the area. However, since the introduction of tourism to Zanzibar, local people in Matemwe are no longer able to settle close to the shore as tourism and the desire of rich people from town to live along the beach has increased the value of coastal land significantly. In both sites, houses have shown massive transformations over time from huts with thatch roofs and maize/millet cobs in most of the walls to a dominance of iron roofs with stones and bricks in most of the walls. Currently, in Matemwe some people are shifting from iron roofs to locally-made tiles to cope with the impact of salt-laden on-shore winds on iron roofs (see Chapter 3). This transformation was mainly evident after the revolution of Zanzibar in 1964 onwards and has also been highlighted in the household budget survey (HBS) (RGZ, 2012a).

With regard to population, Kiuyu Mbuyuni had a total of 6416 residents, of which 3089 are male and 3327 are female, with an average household size of 5.3 persons (URT, 2013), while Matemwe, Unguja has 5014

residents of whom 2502 are male and 2512 are female, with an average household size of 5.0 persons (URT, 2013). The population in Kiuyu Mbuyuni is equal to 6.2% of the total population (103,816) of Micheweni district, whereas the population in Matemwe is 4.7% of the North 'A' total population (105,780). Like many other islands, Zanzibar is considered as having a very high population density. Persons per square kilometre has increased from 149 persons in 1967 to 530 in 2012, while the total population jumped from 354,815 in 1967 to 1,303,569 in 2012 (Table 2.2). Inter-census increases range between 2.7% and 3.1% (Table 2.2). The overall increase in population in Zanzibar means increasing pressure on limited resources, such as land and marine resources, upon which the livelihoods of the majority rely. Increasing demand for land for housing to satisfy a growing population is likely to increase pressure on grazing and crop land, while the demand for fishery products will further degrade the delicate marine ecosystems. In fact, if the speed of this increase remains unchecked and is coupled with rural poverty, Zanzibar is likely to experience serious conflicts over resources.

Table 2.2: Population of Zanzibar since 1967

Years	1967	1978	1988	2002	2012
Population	354,815	476,111	640,685	984,625	1,303,569
Population density	149	201	201	400	530
Inter-census population increase					
Years	1967-1978	1978-1988	1988-2002	2002-2012	
Inter-census increase (%)	2.7	3.0	3.1	2.8	

Sources: Population and Housing Census

According to the Household Budget Survey (HBS) 2009/2010 (RGZ, 2012a), Zanzibar has a very young population. About 46% and 39.5% of the population in rural and urban areas respectively is under 15 years of age (study sites located in the rural areas). Only 4.7% of the rural and 3.3% of the urban population is above 60 years of age. This highlights the fact that Zanzibar is experiencing high fertility rates with low life expectancy. Further, the mean age dependency ratio was higher at 1.2 in Micheweni district, Pemba (where Kiuyu Mbuyuni is located) and than in North 'A' district, Unguja (where Matemwe is located) which had a ratio of 1.13. Both are higher than in other districts of their respective islands. In addition, 19.1% of the households in North 'A' and 18.3% in Micheweni are headed by females. Since fishing is mainly practiced by men and is considered the main source of income; female-headed households are thus likely to suffer from both poverty, and livelihood and food insecurity.

With regard to poverty, HBS 2009/2010 showed that 75% of the population in Mcheweni and 48% in North 'A' are below the basic needs poverty line. A study by Ruitenbeek *et al.* (2005) found that 85% of the coastal population in Tanzania lives on less than USD 1/day; this is close to the findings of HBS 2009/2010. The survey found that the mean annual per capita income in Zanzibar was Tshs. 483,520 (USD

302). However, per capita income is higher than this in urban areas and lower in rural areas. Additionally, increasing education and livelihood diversification increased household income (RGZ, 2012a). As for food security, 28% and 7% of the population in Mcheweni and North 'A' respectively, live below the food poverty line.

According to HBS 2009/2010, 62.1% of the population in Mcheweni and 64.7% in North 'A' are illiterate. This will impede access to jobs outside fishing and farming. Furthermore, illnesses are also a problem, especially malaria, diarrhoea and pneumonia. The HBS shows that 16.6% of the rural population are reported to have had malaria. As for diarrhoea and pneumonia, 8.5% and 1.8% of the rural population have reported these illnesses respectively. The small percentage of people who suffered from malaria in this survey period (2009/2010) might be linked with an ongoing malaria project that is fighting malaria through household fumigation and the distribution of treated nets. Other household characteristics linked with human health include the availability of a latrine in the households; about 63.7% of the household in Mcheweni and 32.5% in North 'A' had no toilet (RGZ, 2012a).

2.2.7 Coastal livelihoods and ecosystems dependency

Zanzibar is endowed with coastal and marine resources such as beaches, coral reefs, crop and grazing land, mangroves and other forests, sea grass, seaweed farms, fishery resources, salt marshes and collectable seafood that form the foundation of livelihood activities and which are important for coastal well-being and the nation at large. Fishing and agriculture are traditional livelihood activities in rural areas, but people's livelihood portfolios have changed over the last two decades. Livelihood activities such as seaweed farming and activities related to tourism (e.g. hand crafts) have started to play a role in the rural economy (Eklund and Petterson, 1992; Wallevik and Jiddawi 1999; Msuya, 2011). The introduction of seaweed farming, which is mainly practiced by women, has increased their income and their role in the household economy (Eklund and Petterson, 1992). While employment opportunities in the tourism industry remain out of reach for the majority, including women (Salum, 2009), it has opened up a market for goods produced by women such as handcrafted products (Wallevik and Jiddawi, 1999). Table 2.3, adapted from the HBS report, shows a wide range of livelihood activities practiced in both rural and urban areas ranging from selling crops and fish products to other casual earning activities. During the period 2009/2010, as shown in Table 2.3, 18.8% of the rural households earned money from selling food crops, while 2.3% and 0.8% respectively, sold cash crops such as cloves and livestock products. About 13.3% of households in rural areas earned income through fishing. Only 18% and 4.9% depended on wages and salaries and small businesses respectively. Since casual earning activities are not reliable, it can be argued that rural communities rely heavily on natural resources for their well-being. This has significant implications for ecosystem health and resilience as population density continues to increase (see Table 2.2).

Table 2.3: Percentage distribution of households by main source of cash income by area

Main source of income	Rural		Urban		Total	
	2004/05	2009/10	2004/05	2009/10	2004/05	2009/10
Sales of food crops	13.2	18.8	1.9	2.1	9.0	11.9
Sales of livestock	0.7	0.3	0.1	0.1	0.5	0.2
Sales of livestock product	0.8	1.5	0.1	0.1	0.5	0.9
Sales of cash crops	6.1	2.3	0.6	0.9	4.1	1.7
Business	7.6	4.9	12.3	11.7	9.3	7.7
Wages or salaries in cash	15.4	18.0	41.4	47.5	25.0	30.2
Other casual cash earning	23.7	24.9	28.9	24.0	25.6	24.5
Cash remittances	13.0	11.5	9.4	9.3	11.7	10.6
Fishing	14.7	13.3	2.1	0.7	10.1	8.1
Selling charcoal	0.5	0.1	0.2	0.2	0.4	0.2
Selling firewood	1.1	0.7	0.4	0.2	0.8	0.5
Other	2.6	2.9	1.8	2.3	2.3	2.7
Total Percent	100	100	100	100	100	100
Number of Households	120,626	136,059	70,053	96,452	190,679	232,511

Adapted from RGZ (2012a) Household Budget Survey 2009/2010

Households in Zanzibar coastal areas are characterised by livelihood diversification to cope with poverty (Jayaweera, 2010). The Household Budget Survey (2009/2010) showed that households in Zanzibar are engaged in between one and eight livelihood activities. However, with the high rate of illiteracy and limited opportunities outside farming and fishing (Jayaweera, 2010), households in rural areas mainly diversify within ecosystem-based activities (e.g. fishing, farming including livestock and seaweed farming). Thus, their vulnerability to poverty is likely to increase as these activities are known to be sensitive to climate change. However, income related to wages or salaries is also important in the rural areas of Zanzibar. For example, Table 2.3 shows that 18% of the rural population also obtained income from wages and salaries in cash. Fishing, seaweed farming, farming and livestock keeping are not only important for the rural well-being but they are fundamental for the national economy (Feidi, 2005; Lange and Jiddawi, 2009). For example, at national level, fishing alone contributes 6% to the GDP (Lange and Jiddawi, 2009), while seaweed farming contributes about 0.4% (Lange and Jiddawi, 2009), agriculture contributes 30.8% with 4.5% contributed by livestock (Economic survey 2009 cited in RGZ, 2012c).

2.3 METHODS EMPLOYED IN THIS STUDY

Both primary and secondary data were used in this study to address the aims and objectives presented in Chapter 1. To avoid repetition, in this section an overview of the methods employed in the study is provided while more detailed aspects of data collection and analysis are described in each of the results chapters.

2.3.1 Primary data

Primary data involved both quantitative and qualitative data collection. Although a large part of the study was informed by quantitative data, the use of combined methods is known to help to increase the comprehensiveness of the enquiry for the problem under study (Creswell, 1994) and provides a means to test the validity of the data obtained across methods (Jick, 1979). This is known as triangulation. Quantitative data were obtained by administering four different questionnaires at household and individual level, while qualitative data were obtained from a wide range of Participatory Learning and Action (PLA) techniques (e.g. historical timelines, participatory risk mapping and vulnerability matrices), storytelling, interviews and observations. The following sections briefly discuss these methods and more detailed descriptions are provided in the methods sections of each of the results chapters (i.e. Chapters 3-7).

2.3.1.1 Quantitative methods

Two types of structured surveys were used in the study: a household survey and perception surveys specifically targeted at farmers, fishers and seaweed farmers. The data obtained from the household survey are analysed and reported in Chapters 3 and 4, while data obtained through the perception surveys are used as the basis for Chapters 5, 6 and 7. The household survey was administered to 200 households, 100 from each site (Kiuyu Mbuyuni, Pemba and Matemwe, Unguja). These were selected from the list of households in the local leader's registry. In Kiuyu Mbuyuni, Pemba, with 1 543 households, a household was selected after every 15 households in the list, whilst in Matemwe, Unguja, with 1 337, households, a household for interviewing was selected after every 13 households. Due to the small number of households in both the study sites, this sample size was assumed to be representative of the population under study. The survey targeted the head of the households as respondents; in their absence any important decision-makers in the households were considered for interview. With regard to the fisher's perception survey, 98 fishers were interviewed, of whom 50 were from Kiuyu Mbuyuni and 48 from Matemwe. For the farmer's survey, a total of 98 farmers were interviewed, 49 farmers from each shehia/ward, while the seaweed perception survey involved 100 seaweed farmers, 50 from each study site. The fact that these surveys were age-biased, targeting respondents of 25 years of age and above, and since there was no list of people participating in these livelihood activities at the local leaders' offices, I used a snowball sampling approach to select respondents amongst fishers, seaweed farmers and farmers. Snowball or chain sampling is a non-probabilistic method used when the desired sample characteristics (e.g. age) are rare. This sampling relies on referral from first subjects to generate additional subjects with desired characteristics. The targeted age groups were expected to possess significant experience in the activities and be in a good position to recall trends and seasonality of temperature, rainfall, winds and sea level for the past 10 or 20 years.

The household questionnaire was designed to collect information on livelihood activities, livelihood diversity, capital stocks and access to livelihood capital (see Chapter 3) as well as information regarding the

various components of food and water security (see Chapter 6). The perceptions surveys collected information on the existing context of the activities, perceptions of climate variability and change (rainfall, temperature, winds) and sea level change, and perceptions of risks related to climate variability and other interacting stressors (see Chapter 5 and 6). Other data collected related to adaptation strategies in response to impacts of climate change and other stressors and barriers to adaptation (Chapter 7). The method sections of these chapters explain how the data were analysed.

2.3.1.2 Qualitative methods

With regard to workshops (historical timeline, vulnerability matrix and participatory risk mapping), 15 participants were purposively selected with the help of local leaders to participate in each workshop in each study site. Based on the knowledge and awareness of the issues to be raised, we drew men, women, local leaders and people from NGOs. The workshops were age-biased; only participants of 25 years of age and above were selected because all workshops involved understanding trends over time. In each study site, each workshop was administered separately. Each workshop consisted of new participants, but five participants in each study site participated in all workshops. Because of their active participation and knowledge, these five participants were included in the other workshops after the first one.

2.3.1.2.1 Historical timeline

An historical timeline is a simple PLA tool that seeks to identify events; both climate and non-climate, that happened in the community over a particular time period (Daze *et al.* 2009; Murshed and Aburquez, 2004). Participants were asked to draw a table with two columns, the first column was to record the period in which the event took place (year), and the second column contained a list of the events (see Appendix I). The participants were also guided to discuss the implications of these identified events on the livelihoods and well-being of the communities. The main objectives of the workshop were (1) to learn about significant events that have occurred in the community that could be used to explain local people's sensitivity to a wide range of stressors; (2) to learn about the frequency of climate events (e.g. drought, floods and storms) in both sites and (3) to "make people aware of trends and changes over time regarding these events" (Daze *et al.* 2009:37). The information obtained through these workshops was used to triangulate findings, particularly in Chapter 5, on perceptions of fishers, farmers and seaweed farmers of the variability and change in climate and sea level.

2.3.1.2.2 Participatory risk mapping

Two workshops for participatory risk mapping were also conducted, one in each site (Appendix II). Participants were assisted to draw a visual map to represent their villages and their resources such as land, local water resources and other features. The main purpose was to explore local peoples' spatial perceptions regarding the suitability of land for farming and the risks faced by their natural resources (e.g. land, forest

and water resources) due to climate variability and change, and other drivers. Although the entire east coast is said to be covered by coral soils which are not good for farming (see section 2.2.2), participants in these workshops classified their land into various suitability zones based on their experiences (see Appendix II). Further, they identified areas affected by pests and diseases of crops and livestock and also identified water resources (e.g. local wells and coral caves) with high salinity content, those with low salinity and those affected by dry seasons or dry spells. The information obtained from this participatory risk mapping was used to triangulate findings in Chapter 4 and Chapter 6.

2.3.1.2.3 Vulnerability matrix

The vulnerability matrix workshop was complex and long as participants needed to agree on the extent of vulnerability of selected resources attributed to particular climate or non-climate risks, and then rank these risks. However, this workshop was important for learning as it facilitated dialogue and discussion (Murshed and Aburquez, 2004). Two exercises were undertaken; the first involved filling in the matrix with impact scores and the second involved risk ranking based on the perceived impacts on community resources and livelihoods. The impact score in the exercise ranged from 0 (no impact) to 3 (significant impact) (see Appendix III) and was adopted from Daze *et al.* (2009). The matrix shown in Appendix III was prepared in advance with a short list of risks on the horizontal axis and resources on the vertical axis. The objectives of this exercise were to determine which resources and associated livelihood activities were most at risk from a certain stressor and to learn peoples' perceptions regarding the impact of these risks through ranking. The information obtained in these workshops (Appendix III) was used to triangulate the findings obtained through surveys in Chapter 6.

2.3.1.2.4 Storytelling

Telling a story comes naturally to humans as we have used this method to convey knowledge ever since we have been able to communicate. Six people, three from each site, were purposively identified during the workshops for storytelling. Storytellers were guided to narrate their life story through issues like how they grew up, how they made a living, the knowledge and practices involved in their livelihood activities, risks faced throughout history and how they adapted to those risks. The stories or narratives obtained present a picture of societal sensitivity to stressors and the ability of the people to adapt (see Chapter 6). The method, while largely informing Chapter 6, also shed light on the survey results obtained for Chapter 3 and 4 on existing vulnerability context, and on local people's adaptation to climate change and the barriers to adaptation (Chapter 7).

2.3.1.2.5 Focus group discussions

According to Kombo and Tromp (2006), focus group discussions, if well facilitated, can produce valuable information and are good for identifying and exploring beliefs and ideas or opinions in a community. Two

group discussions were administered in this study, one in each study site. Each group involved 20 participants; these were heterogeneous as participants were drawn from different social groups and societies. They included both male and female residents, local leaders and members of local authority structures, and members from NGOs. The objectives of the group discussions were threefold: firstly, to discuss the history of the villages and associated transformations over time; secondly, to discuss livelihoods and to rank livelihood activities based on their perceived importance and the number of people employed; and thirdly, to identify stressors that affect these livelihood activities, both climate and non-climate. The information obtained from the first objective was used to inform the settlement section in this Chapter (see section 2.2.5). The information obtained under the second and third objectives served to triangulate the findings in Chapter 5 (see Appendix IV).

2.3.1.2.6 Participatory observation and water resources inventory

Observation entails the systematic recording of events, behaviours and artefacts in social settings (Kombo and Tromp, 2006). This was the first activity carried out before any data collection in order to obtain an overview of the study sites. In this method, I accompanied some members in the study villages on transect walks to observe and record events, how they practiced their livelihood activities (e.g. farming, livestock and seaweed farming) and to visit fishing landing sites (see Plate 2.1). The observation also involved informal discussions and conversations with people at their farms, seaweed plots and at the landing sites. These helped to expand my knowledge of how the various livelihood activities are practiced, but more importantly, these conversations helped me to facilitate the discussions for the vulnerability matrix and participatory risk mapping. With regard to the water resources inventory, these methods are described in the methods section of Chapter 4.

2.3.1.2.7 Key informant interviews

The last method of data collection was key informant interviews intended to validate the information collected through the surveys and PLA workshops. The interviews were semi-structured, based mainly on the key issues that had emerged during field work. Four key informants were interviewed from each district where the study sites are located. The interviews covered planning, fisheries and marine resources, and livestock and crop farming. Interviews on climate variability and sea level rise were also conducted with key informants from the Tanzania Meteorological Agency (TMA), Zanzibar office and from the Institute of Marine Science at the University of Dar es Salaam. The information obtained in these sessions was used to triangulate the findings obtained from other methods.

2.3.2 Secondary sources of data

With regard to secondary data, apart from reviewing important documents related to the study, I also collected and analysed the observed data for temperature, rainfall, and sea surface temperature (SST), to

understand their trends and seasonality. Rainfall and temperature data were purchased from the Tanzania Meteorological Agency (TMA), Zanzibar office. Sea level data were downloaded from the University of Hawaii's Sea Level Centre (UHSLC). The centre obtained data directly from Zanzibar through the wave gauge installed at the shore of Stone Town in Unguja Island. Sea surface temperature data were obtained from <http://poet.jpl.nasa.gov/> a website run by NASA (see method section in Chapter 5 on the analysis of these data).

CHAPTER 3

UNDERSTANDING THE VULNERABILITY OF EAST COAST HOUSEHOLDS FROM AN ASSETS PERSPECTIVE

3.1 INTRODUCTION

3.1.1 Overview

This Chapter examines the ‘internal’ characteristics that make the two study communities vulnerable, not only to climate change risks but also to other linked stressors. The sustainable livelihoods framework (SLF) is used as a lens to examine both livelihood activities and diversity amongst households and their stocks and access to livelihood capital, focussing on social, financial, human and physical capital. Both the assets and livelihood information provides insights regarding how local people are likely to be sensitive to climate variability and change in concert with other pressures on livelihoods and whether and how they might bounce back from shocks and risks related to both climate and other linked stressors.

The Chapter starts with an introduction to rural livelihoods and the role of capital stocks and access to these in explaining vulnerability and resilience. This is followed by a presentation of the mix of methods used to gather livelihoods and assets data. The results and discussion focuses firstly on the livelihood activities in which households are engaged and their primary sources of income, and secondly on the various types of assets held by households and the community. What these findings mean in terms of vulnerability and adaptive capacity is discussed in relation to the literature. The conclusion summarises the key findings and suggests what is needed to improve access to livelihood assets and decrease vulnerability in Zanzibar.

3.1.2 General background

As defined in Chapter 1, a livelihood constitutes peoples’ capabilities and their means of living, which includes food, income and assets, both tangible (resources) and intangible (claims and access) (Chambers and Conway, 1992). A sustainable livelihood is defined as “the ability of a livelihood to be able to cope and recover from stresses and shocks” (Scoones, 1998:6), without compromising the quality of the assets for future needs (Chambers and Conway, 1992; Ashley and Carney, 1999). Building on this understanding of livelihood, various studies have found that overdependence on natural resources coupled with low access to these resources and limited access to other assets were responsible for poverty and the slow pace of development in developing countries (Barrett *et al.*, 2001a; Barrett *et al.* 2001b; Owusu *et al.* 2011; Cephas and Bernard, 2012). However, pursuing lucrative activities outside farming or fishing, migration and agriculture/fishing intensification or extensification in order to sustain households’ livelihoods is not an easy course for every decision unit (individual or household). The ability of a decision unit to expand existing livelihood strategies or to pursue new ones for sustainability depends on the tangible and intangible assets that a unit possesses (Scoones, 1998).

In examining multiple stressors on livelihoods in the Bolivian highlands, McDowell and Hess (2012) contend that the failure of local people to cope and adapt to multiple stressors, including climate variability, was largely influenced by limited access to assets, ranging from natural (low access to arable land) to human capital (education). Similarly, both disaster and climate change studies in recent years suggest that the vulnerability of communities is socially constructed (Chapter 1; Blaikie *et al.* 1994; Adger and Kelly, 1999; Brooks *et al.* 2005; Adger *et al.* 2006). Thus, vulnerability can be defined as the exposure and sensitivity of communities to multiple stressors, and poor adaptive capacity attributable to social determinants that limit access to assets (McDowell and Hess, 2012). This definition tallies with the sustainable livelihood outcomes presented by Scoones (1998) in the sustainable rural livelihood framework. The framework contends that access to capital assets would lead to positive changes in rural livelihoods, and thus reduce poverty, improve well-being capabilities and enhance resilience.

Because capital assets (see Box 3.1) play a crucial role in influencing vulnerability and adaptation on the one hand, and poverty and well-being of the rural community on the other, the sustainable livelihood approach which involves the analysis of this capital has been in the centre of various development programmes designed to reduce vulnerability by increasing access to those assets (Chapter 1). Studies in Bangladesh, Nepal, Paraguay, Cameroon, Tanzania, and Nigeria found that poverty declines with increased access to various forms of capitals, particularly social and financial capital (Molinas, 1998; Narayan and Pritchett, 1999; Mayoux, 2001; Rankin, 2002; Islam *et al.* 2011; Islam and Yew, 2012; Kazi and Leonard, 2012; Nkpoyen and Eteng, 2012). In Cameroon, for example, increased access to financial capital through saving and soft credit groups has tremendously increased land ownership among rural women (Mayoux, 2001), which is crucial to increasing sustainability for future adaptation. Similarly, in the Yala local government area of the cross-river state, Nigeria, micro-lending among women helped to reduce the severity of poverty as it increased self-employment and savings (Nkpoyen and Eteng, 2012). Low levels of saving, attributed to the low level of returns from livelihood activities, is a major source of vulnerability among the poor as savings act as an asset for recovery after shocks such as droughts.

The various capital assets are intricately linked, so that access to one of these capitals may facilitate access to another capital asset. For example, access to schooling (human capital) may not only facilitate access to financial capital but it can also help to raise trust (social capital) levels within communities (Lanzi, 2007; Dinda, 2008). Further, schooling enhances the ability of people to discuss, debate, negotiate and add their voices in planning issues that directly affect the well-being of the household and community as a whole (Sen, 1997). In addition cooperative groups and saving groups may both facilitate social cohesion networks, and the accumulation of financial capital for future investment (Molinas, 1998; Narayan and Pritchett, 1999; Mayoux, 2001). However, according to Bird *et al.* (2000) cited in Islam *et al.* (2011), access to a single capital asset, say human capital, may not ensure the desirable output towards more sustainable

livelihoods. Rather, a combination of all important capital assets as defined in the sustainable livelihood framework is usually required (see Box 3.1; Scoones, 1998; Ellis, 2000).

Box 3.1: Capital assets

1. Natural capital: the natural resource stocks (soil, water, fisheries, forest) from which livelihood strategies derive. Natural capital is crucial for current and future adaptation options, especially for SIDSs.
2. Financial capital: the capital base (cash, credit/debt, saving and other economic assets) which is essential for diversification, intensification and extensification of rural livelihood activities.
3. Human capital: the skills, knowledge, health, physical capabilities important to pursue different livelihood strategies successfully.
4. Social capital: informal norms that promote cooperation between two or more people (social relations), networks, associations and affiliations. Social relations provide safety nets that can be immediately drawn on from friends, neighbours and family members during times of crisis. This is also called bonding capital. Social capital can also be framed within decision-making processes, participation in local institutions and organisation.
5. Physical capital: basic infrastructure (houses) which act as a guarantor in order to access financial capital. Production equipment and technologies (fishing vessels, boat engines, refrigeration, tractors, motorbikes, cell phones), which help to modernise livelihood strategies for a better outcome; livestock and poultry which act as a safety net to call upon during a crisis.

Sources: Scoones (1998), Fukuyama (2000), Woolcock and Narayan (2000)

Social capital is considered as those social norms that promote cooperation between people, making up voluntary associations and social networks (Putnam, 2000; Fukuyama, 2000). It is increasingly viewed as an important capital that may ensure sustainable natural resources use and desirable social, political and economic outcomes. Indeed, in rural households, social capital may facilitate access to other important assets (natural, physical and financial) needed for sustainability. Ballet *et al.* (2007) for example, argue that social capital is an import resource to call upon to solve the free-rider problem amongst common property resource systems like fisheries, because social capital promotes collective action among the resource users. Grafton (2005) and Islam *et al.* (2011) obtained similar findings in Bangladesh and Sekhar (2007) in Chilika Lake in India. Since coping and adaptation responses to climate change must be implemented by resource users themselves, collective action, through networks and social organisations was found to be an important ingredient for adaptation (Adger, 2003). Because social capital has multiplier effects, it seen as a central component in various development programmes designed to reduce rural poverty and vulnerability and to increase sustainability (Woolcock and Narayan, 2000; Narayan and Pritchett, 1999; Mayoux, 2001; Bebbington *et al.* 2007). According to Fukuyama (2000), social capital is an important component of the modern economy and democracy and it is embedded within modern traditions (see also Putnam, 2000).

Zanzibar coastal communities are extremely poor (Walsh, 2009) and various barriers challenge their attempt to graduate from poverty and thus increase their resilience to more frequent droughts and other forms of climate change (see Chapter 7). The findings in Chapter 7 reveal that most of these barriers were related to the limited access to capital assets which in turn affects the livelihood options available to people.

For instance, securing capital for non-farming or fishing activities has remained out of reach for the majority of people not only in coastal Zanzibar, but also in large parts of the Tanzania mainland (see Ellis and Mdoe, 2003). Building on sustainable livelihood thinking, local NGOs, international organisations and the government of Zanzibar have, for the last decade at least, played a major role in improving access to capital assets through training, forming organisations, saving groups and social linkages (Issa, 2012). Drawing on McDowell and Hess's (2012) idea that vulnerability is, in part the result of lack of access to potential capital assets and hence limited livelihood options, this Chapter examines the livelihood activities households engage in, the current status of capital stocks in these households and access to the various livelihood capitals, as a way of understanding how vulnerable Zanzibar coastal communities are to the variability in climate and sea level rise currently observed, and to projected future changes and other linked stressors (see 3.1.1).

3.2 METHODS

The Chapter combines data from several complementary sources. A large part of the data however, were obtained through a household survey administered to 200 households, 100 from each site (see Chapter 2 for a detailed description of how households and respondents were selected for interview). Other sources of data used included interviews with local leaders, NGOs and beneficiaries of the Presidential Fund to promote small businesses. PLA (mainly group discussions and the production of a participatory vulnerability matrix) was used to triangulate the findings from the household survey. The household survey was designed to obtain information on the nature and role of livelihood activities amongst east coast households and to gain insights regarding access to and amount of household stocks of four major capital assets, namely human, physical, financial and social capital. Other than access to private farming plots, this chapter does not include access to public or communal natural capital such as grazing land, forests and marine resources. This is covered in Chapter 6 (see section 6.3.1, 6.3.4 and 6.3.7). The sections of the questionnaire and the analysis of the data collected are outlined below.

a. Livelihood activities

The analysis of livelihood activities was intended to provide insights into how many coastal households rely on livelihood activities that are sensitive to climate variability and change. Under the livelihood section of the interview schedule, respondents were first asked to identify the livelihood activities practised by members of households to obtain food and an income. This was analysed by calculating the percentage of households engaged in each activity and then counting the total number of activities in each household to obtain a score for livelihood diversity in each household in each of the study sites. A chi-square test was used to determine whether there were differences between sites in terms of livelihood diversity. Secondly, respondents were asked to identify the two main sources of income for their households. After that, the percentage of households who depend on those particular activities was determined.

b. Social capital

Proxies for social capital included four areas: voluntary participation in a wide range of cooperative and saving groups; involvement in political and development committees and decision-making and trust; and social cohesion within the community. With regard to voluntary participation in groups, respondents were asked if anyone in a household was a member of one of these groups. The percentage of households that had members who participate in each group was determined. This was complemented by the data obtained from local leaders on the number of groups available, the nature of the groups and number of members by gender. A chi-square test was then used to determine any differences between the study sites.

In terms of participation in village politics, respondents were asked if anyone in the household was a member of a village committee (local leader committee, development committee, environment committee, most vulnerable children committee, schools committee, religious committee). The percentages of households that had a member participating in any of these committees were determined. With regard to trust and involvement in decision-making, respondents were asked about their household members' involvement in decision-making regarding natural resources and village issues, their satisfaction with decisions made, their trust of committee members, how effectively decisions were communicated to the community, and whether more people were needed on the decision boards. Respondents responded using a four-point scale where 1 = always, 2 = sometimes, 3 = never, and 4 = I don't know to the above question. Afterwards the mean score was calculated for each of the previously mentioned variables. A t-test was used to determine the difference between the study sites regarding how local people perceived involvement in decision-making at the village level.

In this study, social cohesion or bonding capital is regarded as relations between family members, close friends and neighbours. Bonding capital is normally differentiated from bridging social capital which is defined as relations with distant colleagues who have somewhat different demographic characteristics (Narayan and Pritchett 1999; Cook, 2002; Putnam, 2000; Patulny and Svendsen, 2007). Variables measured include willingness to help each other, degree of tightness of their neighbourhood, whether borrowing and lending of money happens between neighbours, how well people get along with and trust one another, and to what extent they share beliefs, norms and culture. The respondents answered using a four-point likert scale where 1=strongly agree, 2=disagree, 3=agree, and 4=strongly agree. The responses were combined to give a mean score of respondents' perceptions of their fellow villagers and the degree of social cohesion. A t-test was used to determine the difference between the sites.

c. Financial capital

Respondents were asked if they had access to credit and grants, if they had savings in banks or saving clubs/groups, if they had savings in non-productive assets, if they had outstanding debts and if they had

faced an income shortfall in the previous 12 months. The percentage of respondents saying ‘Yes’ or ‘No’ to each of these questions was determined and a chi-square test was used to discover the differences between the sites.

d. Human capital

The results on human capital were expected to provide an understanding of the sensitivity of household members to various illnesses, as well as the vulnerability of the household when these illnesses were linked with risks and shocks related to current and future variability in climate. Variables measured as indicators of human capital included: education level, skills, and health. With regard to education, respondents were asked to identify their level of education, after which the proportion of respondents in each education category was determined. The data were complemented by secondary data on the current status of literacy to provide a picture for both household and district levels. In terms of skills, respondents were asked to identify the various skills available in their household that could be used to increase household income. The percentage of households with each type of skill was then determined. With regard to health, respondents were asked if members of their household are regularly affected by various illnesses and whether the illness affected household welfare. The responses were then counted; in addition, a chi-square test was used to test the difference between sites with regard to the illnesses which affected the households and the economic impact of illness on the households.

e. Physical capital

Physical capital, apart from being a livelihood resource, also symbolises wealth and the ability to recover from the risks and shocks related to climate variability and other linked stressors. Physical capital can be sold to recover from damage or can be used as collateral to access loans and credit from banks and other sources of funds. Proxies for physical capital included: household ownership, the quality of the house (materials used for most of the wall and roof), ownership of livestock and ownership of equipment (fishing vessels, boat engines, gear, refrigerators, scooter, bicycle, radio, television, mobile phones, sewing machines, solar panels, and electricity). The respondents were asked about the nature of house ownership, types of construction materials used for the most of walls and roofs of their homes and if they keep livestock and poultry. The respondents were also asked if their household owned stocks of assets or had access to the above-mentioned assets or services. The percentage of households for all of the above variables was then calculated. A t-test was used to determine the differences between sites regarding the construction materials used by the households interviewed. Finally, a chi-square test was used to examine the differences in other variables between sites.

3.3 RESULTS AND DISCUSSION

3.3.1 Characteristics of the respondents

Of the respondents, 51% and 72% in Kiuyu Mbuyuni, Pemba and Matemwe, Unguja respectively were male (Table 3.1). As would be expected across the sites, some half of respondents had no schooling; 44% in Kiuyu Mbuyuni and 49% Matemwe had completed compulsory education, either primary, Form II or Form III, while very few had obtained ‘O’ level (Form IV) or ‘A’ level (Form VI) certificates. The majority of respondents were married and, on average, the household size was 6.43 members for Kiuyu Mbuyuni and 6.13 members for Matemwe, Unguja. The household size in the interviewed households is slightly higher than the mean ward household size according to the 2012 households and population census. The mean household size for Kiuyu Mbuyuni was 5.3 members and Matemwe 5.0 members (URT, 2013).

Table 3.1 Characteristics of respondents and households

Characteristics	Class	Kiuyu Mbuyuni, Pemba (%) (N=100)	Matemwe, Unguja (%) (N=100)
Gender of the respondents	Male	51	72
	Female	49	28
Age	20-29	9	14
	30-39	23	27
	40-49	30	22
	50-59	25	15
	60-above	13	22
Education	Primary education	20	26
	Secondary education	23	22
	College/university	3	1
	Adult education	1	1
	None	53	50
Marital status	Married	83	86
	Divorced	4	3
	Single	2	6
	Widow (female-headed households)	11	5
Mean Household size in Kiuyu Mbuyuni, Pemba= 6.43			
Mean Household size in Matemwe, Unguja= 6.13			

3.3.2 Households livelihood activities and diversification

Respondents were asked to identify livelihood activities practiced by various members of the household. Figure 3.1 shows the wide range of activities that are practiced within households. However, the majority of households interviewed were engaged primarily in natural resource-based activities such as seaweed farming, crop farming, and animal husbandry and fishing. Crop farming as it is described in Chapter 6 is mainly used as a source of food for the majority of the households and assisted by off-farm activities, particularly fishing, to ensure that food is available and the supply is stable. With regard to formal employment, about 19% and 3% of the households interviewed in Kiuyu Mbuyuni and Matemwe respectively, had a member or members engaged in formal employment. Most of these people were employed, especially in Kiuyu Mbuyuni, as teachers. Kiuyu Mbuyuni reported more people who are employed compared with Matemwe probably due to the presence of teachers’ college and two schools.

Only 10% of the households interviewed in Matemwe had members working in the tourism industry. An interview with the leaders of an NGO called MCAEE revealed that a lack of education and tourism-related skills prevent local people from being employed in the tourism industry (see Chapter 6). No one was working in the tourism industry in Kiuyu Mbuyuni, Pemba where there are no tourist activities.

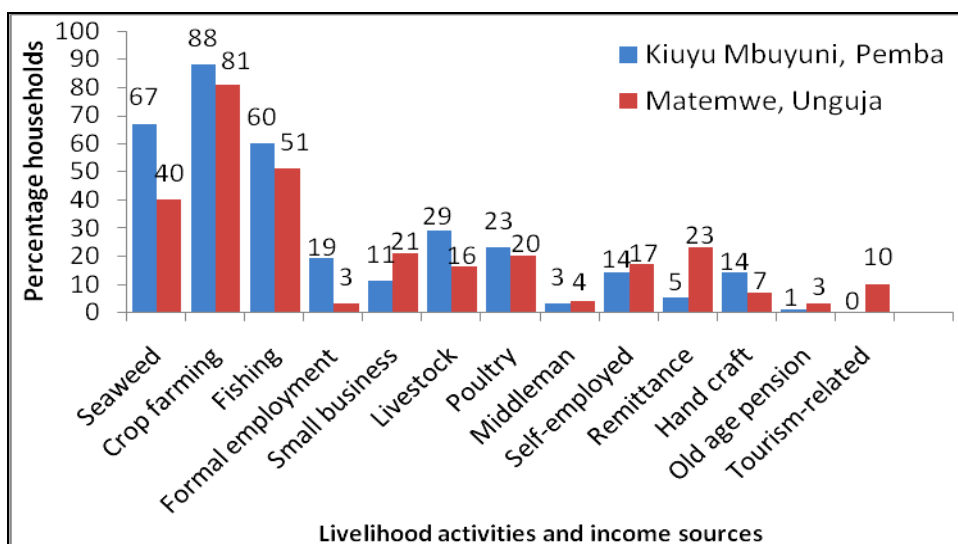


Figure 3.1: Livelihood activities and income sources across the sites

In terms of self-employment, about 11% and 21% of the households in Kiuyu Mbuyuni and Matemwe respectively had members who engaged in small business, whereas 3% of the households in Kiuyu Mbuyuni and 4% in Matemwe had members who worked as middlemen (Figure 3.1). The large percentage of households who engaged in small business in Matemwe, Unguja may be influenced by the fact that the area is in transition toward urbanisation. Increasing land values, influenced by the development of tourism, the desire of the affluent population to own rest houses close to the beach, and concurrent infrastructure development deprive the poor of access to land for farming, but offer opportunities for small-scale business and informal employment. Other activities and sources of income cited included informal employment (which include brick and stone work, quarrying, lime-making, traditional healers), old age pensions, remittances and art work.

In understanding primary sources of income in the study sites, respondents were asked to identify two main sources of income for household needs. The results in Figure 3.2 and 3.3 revealed that fisheries, seaweed farming and farming were again the main sources of income. Of the respondents, 19% in Kiuyu Mbuyuni and 3% in Matemwe identified formal employment as their main sources of income for households; none identified formal employment as a second source of income (Figures 3.2 and 3.3), as formal employment can ensure a constant flow of money to the household, unlike fishing and farming which are affected by seasonality (see Chapters 5 and 6). The off-farming and off-fishing activities such as small businesses and self-employment emerge very strongly in Matemwe, Unguja (Figure 3.3) compared with Kiuyu Mbuyuni,

Pemba (Figure 3.2). This again, has probably been influenced by expanding tourism activities and increasing land values.

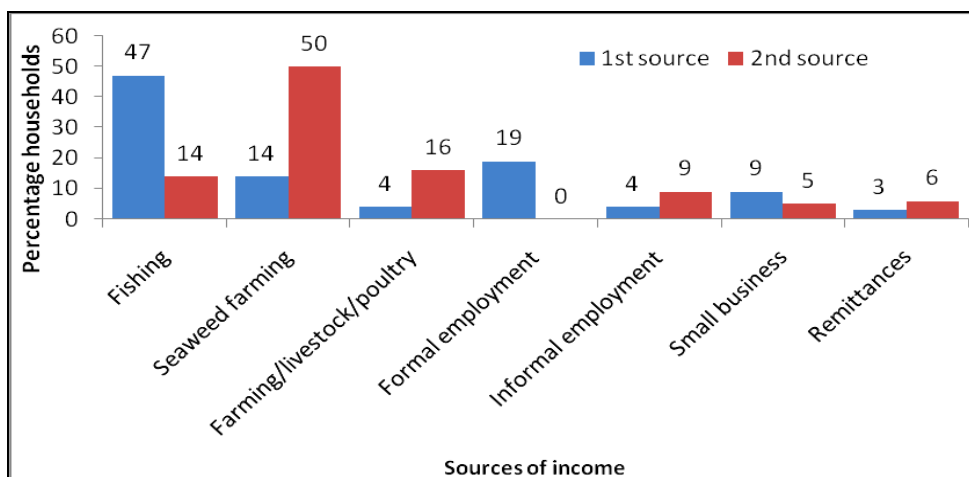


Figure 3.2: Primary sources of income in Kiuyu Mbuyuni, Pemba

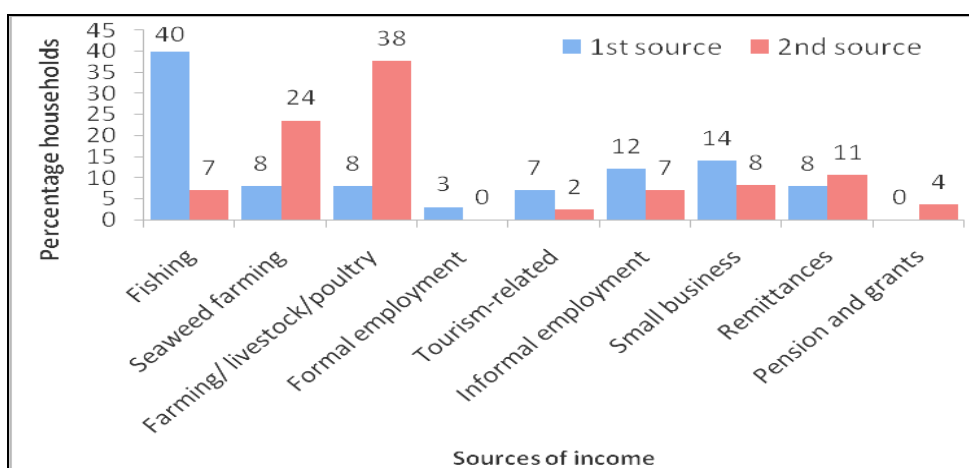


Figure 3.3: Primary sources of income in Matemwe, Unguja

It is interesting to note that, although 67% and 40% of the households in Kiuyu Mbuyuni and Matemwe respectively had members who engaged in seaweed farming (see Figure 3.1), this was considered mainly as a secondary source of income (Figures 3.2 and 3.3). This is because the majority of the seaweed farmers are women and girls (Msuya, 2011), and based on Zanzibar culture and traditions, they are not obliged to use their income for daily household expenses (Eklund and Petterson, 1992). In most cases, the head of the household (husband) is responsible for providing the income for household needs. This is highlighted by a respondent from Kiuyu Mbuyuni, Pemba who said:

“My daughter is also engaged in seaweed farming, but the money she obtained she used for her personal needs”

The income earned by women (wives), however, is used during times of crisis and to take care of the needs of children. The income of sons (fishermen) and daughters (seaweed farmers) is used mainly for their

personal needs such as clothing, air-time vouchers and saving for a new life outside their parent's homes, though again, this income can also be used during a crisis. Despite the fact that the income of the head matters most, the contribution of other members of the household is also crucial to meet the household needs which are multiple and dynamic due to large household sizes (Table 3.1).

The results in Figures 3.2 and 3.3 tallies with those obtained from group discussions in both sites (see Appendix IV). Based on importance, the participants of group discussions in both sites ranked fishing as 1 (most important); livestock and crop farming ranked 2 in Kiuyu Mbuyuni, whereas in Matemwe it was ranked 3. Seaweed farming was ranked 3 in Kiuyu Mbuyuni and 2 in Matemwe. Activities outside farming, fishing and seaweed farming (e.g. small business, tourism, informal and part-time employment outside main activities) were less important as they employed small number of people (see Appendix IV). With regards to livelihood diversification within households, Table 3.2 reveals that the majority of households across the sites were engaged in three or four activities to cope with poverty and unexpected shocks with no difference between the sites; and the diversity in many homes comprised of fishing, farming and seaweed farming. As seen earlier, diversity outside these natural resource based activities is marginal particularly in the Pemba site due to its remoteness coupled with the generally low economy of the island compared with Unguja. As these activities (fishing, seaweed farming, farming and livestock) are highly controlled by the climate the observed overdependence on these can be considered as a key source of vulnerability.

Table 3.2: Livelihood diversity

Livelihood diversity	Kiuyu Mbuyuni (N=100) (%)	Matemwe (N=100) (%)
1 activity	4	5
2 activities	13	24
3 activities	48	50
4 activities	35	21
Chi-square	$\chi^2=6.9$, df= 3, p= .074	

The above findings provide a clear picture that shows how highly dependent coastal communities are on natural resources for their well-being. Fishing is the most important sector as it is mainly practiced by the household's heads and provides both food and cash income. Crop farming is mainly a source of food but its contribution to the household's food demand is affected by seasonality (see Chapter 4). Additionally, participation in other activities off-farming and off-fishing is almost marginal. Despite long-term attempts to increase livelihood opportunities among the coastal communities in order to reduce poverty and pressure on dwindling resources, it appears that a move away from traditional activities is not an easy path for most people. Livelihood diversification in rural Africa and Asia is seen as an effective means towards poverty eradication and coping with shocks (Ellis, 2000; Bird and Shepherd, 2003; Niehof, 2004; Salayo *et al.* 2012); however, if that diversification is based mainly on using natural resources that are sensitive to climate change as observed in the study areas in this study (Chapter 5 and 6), the majority of households

will struggle to cope with or adapt to climate variability and change, and will thus remain vulnerable. Furthermore, studies by Barrett *et al.* (2001a) and Barrett *et al.* (2001b) in rural Africa, Bird and Shepherd (2003) in Zimbabwe and Owusu *et al.* (2011) in northern Ghana have shown that rural livelihood diversity in households that contain off-farm and off-fishing activities can protect these household against shocks and poverty. For instance, the study by Owusu *et al.* (2011) revealed a direct correlation between the participation in off-farm activities and a low incidence of poverty and food insecurity. Similarly, the results in Chapter 4 of this study also showed that households engaged in formal employment or tourism-related activities were less affected by food insecurity.

Across the sites, local communities wish to diversify into more worthwhile activities ranging from modern vessel ownership to small businesses in order to escape from poverty, but they are restricted by poor skills, low savings and a lack of access to credit (see Chapter 7). Similarly, Bird and Shepherd (2003) found that a lack of skills and capital made it difficult for poor households in Zimbabwe to diversify into higher-return activities. Entry barriers also restricted access of local communities in Côte D'Ivoire to superior livelihood strategies that could ensure their survival (Barrett *et al.* 2001a). Undeniably, both seaweed and fishing on the one hand, and farming on the other, play a crucial role in livelihoods across the sites. However, the observed and reported poverty and food insecurity (Chapter 4) make it clear that these activities, as they are practised (see Chapter 6) cannot help households to escape from poverty and vulnerability to current climate variability and future changes in both climate and sea levels.

3.3.3 Social capital

3.3.3.1 Participation in cooperative and saving groups/clubs

Respondents were asked whether any member of the household belonged to a cooperative or savings group, and the results in Table 3.3 show that 38% of households in Matemwe, Unguja participated in a group, whereas in Kiuyu Mbuyuni, Pemba only 18% did so. A chi-square test revealed a statistically significant difference between the two sites.

Table 3.3: Participation in cooperative and saving groups

Kiuyu Mbuyuni (N=100) (%)	Matemwe (N=100) (%)	Chi-square
18	38	($\chi^2 = 9.9$, df =1, p= .002)*

*Significant difference between sites

The difference between the sites (Table 3.3), related to data obtained from local leaders presented in Table 3.4. This shows that Kiuyu Mbuyuni, Pemba has only five community groups, while Matemwe, Unguja possesses 22 groups. About 438 individuals from Matemwe participate in these groups, of which 61% were female and 39% were male. The 438 individuals make up only 7% of the total population in Matemwe

(total population of Matemwe was 6,381, based on the local leader registry). In Kiuyu Mbuyuni the five groups available accommodate only 107 individuals of which 68% are female and 32% male.

Table 3.4: Number, nature of groups and number of participants in the groups (percentage of gender calculated from a total number of participants in both sites)

Nature of group	Kiuyu Mbuyuni, Pemba		Matemwe, Unguja	
Saving groups/clubs (SACCOS)	1 (just introduced)		1	
Fishing and aquaculture	4 (including planting mangroves)		-	
Farming, vegetables and art work	-		7	
Poultry and goat keeping (including dairy goats)	-		9	
Tree planting and cultivating seedlings	-		3	
Alternative source of energy	-		1	
Architectural (produce local roofing tiles)	-		1	
Total number of groups	5		22	
Total number of members	107		438	
Gender	Male	Female	Male	Female
Frequency	35	72	169	269
Percentage	32%	68%	39%	61%

Source: Local leader's registry in both sites

Community groups are thus largely dominated by women participants and their participation is widely associated with positive developments of both savings groups and survival rate of cooperatives groups (Mayoux, 2001; Rankin, 2002; Westernmann *et al.* 2005; Molinas, 1998). For instance, a study by Molinas (1998) found a positive relationship between women's participation and increasing cooperation and social capital in Paraguay. Similarly, Westernmann *et al.* (2005) found that the presence of women in groups correlated with solidarity, collaboration, group survival, reciprocity and mechanisms for conflict resolution. However, the participation of women, particularly in saving groups, may exert more pressure on them as they may be forced by husbands to contribute more cash to the households needs, in addition to their customary duties of producing and processing food (Mayoux, 2001).

The findings clearly highlight that participation in groups, which provide a link to other capitals (Adger, 2003; Islam *et al.* 2011) and a means of increasing well-being and reducing vulnerability (Putnam, 2000; Cook, 2002; Cleaver, 2005; Narayan and Pritchett, 1999; Fukuyama, 2000) was very low in both sites. Less than 10% of the total population in Matemwe, for example, participated in these groups. An interview with local leaders revealed that low participation in these groups was caused by various problems which include economic conditions, perception of few tangible and intangible benefits from these groups, disagreement and lack of trust on financial management, and low skills and education. For instance, to be a member in a saving group, one needs to buy a minimum of five shares at Tsh.10000 (USD 9) per share, giving a total of Tsh.50000 (USD 35). After that, the member can deposit whatever amount of money she/he wishes and after a while can borrow more than the amount of money deposited. Thus, demand for initial capital and

continuous contributions have probably precluded the majority of the poor from participating in such groups. Cleaver (2005) reports that although membership of groups in Usangu village, Tanzania, depends on regular (weekly or monthly) contributions, people cannot contribute regularly because their income from livestock and crop farming is sensitive to seasonal variations of climate.

The above discussion highlights that social capital not only influences access to other capitals, but that different forms of social capital also interact. This is what one might term “layered social capital”. For example the observed group scheme is a form of social capital that supports both individual and household livelihoods, but the sustainability of this asset depends on another form of social asset namely trust. Similarly, access to finance (financial capital) is affected by membership in saving groups (social capital), which is, in turn, also affected by trust between members and the disposable income available to buy a share. Furthermore, low participation in savings group can also be associated with the fact that the observed variability and many of the other stressors are ubiquitous, affecting everybody in these communities thus reducing their capacity to contribute. Thus, even if the level of trust improved through increasing financial management skills within these groups, membership can still be affected by the low capacity of local people to contribute due to their poverty.

Cooperative issues, social and saving groups are not new in either the developed or the developing world. For the past decade or so, these groups have been used by development partners, particularly the World Bank, as a driver for democracy and for reducing vulnerability to poverty and global climate change (Narayan and Pritchett, 1999; Paldam and Svendsen, 2000; Uphoff and Wijayarathna, 2000; Mayoux, 2001; Grootaert and Narayan, 2004). Studies in developing countries have also presented a positive relationship between social capital and household well-being. For instance, Narayan and Pritchett (1999) found a significant relationship between memberships in groups and an increase in household income in rural Tanzania. Similarly, the successful empowerment of women in Cameroon was correlated with participation in saving groups and cooperative groups (Mayoux, 2001). The findings in Chapter 7 reveal that a lack of initial capital is a barrier for most of the respondents to embark on non-farming or fishing activities that could help them diversify their income sources. Since securing loans from formal sources is out of reach for most people (see section 3.3.4), the membership in these groups can be a way of overcoming financial constraints among the poor.

Social capital can also be a medium for spreading innovation and learning and thus helping to improve the output of activities such as fishing and farming or the introduction of new activities for income. Cooperative groups can easily disseminate knowledge of new innovations and ideas such as aquaculture, roofing tiles, alternative energy, home gardening and dairy-goat keeping (see Table 3.4; Adato and Meinzen-Dick, 2002). This study learned that the use of locally-made roofing tiles as an innovation for

adaptation to salt-laden on-shore winds which affect iron roofs was diffused to Matemwe from the south eastern coast of Unguja Island through learning as a result of peoples' interactions and networks. A study by Narayan and Pritchett (1999) in the Tanzania mainland also revealed the power of social capital in diffusing agricultural innovation. Although there are a number of determinants, such as the characteristics of innovation, that affect the diffusion and adoption of innovations (Rogers, 1995), the connectedness, shared norms, beliefs and trust within the decision units (groups, households) are also vital for successful adoption and learning (Paldam and Svendsen, 2000; Cleaver, 2005; Putnam, 2000). In summary, low participation in cooperating and saving groups across the sites affects the capacity of local people to adapt and cope, and therefore leaves them vulnerable to climate variability.

3.3.3.2 Political participation and decision-making

Various committees (e.g. school committee, local leader administrative committee, most vulnerable children committee, and development committee) were formed in order to implement plans both at local administration and in institutions such as the mosques and schools. Respondents were asked if they were members of these committees, and the result in Table 3.5 shows that only 8% of the respondents in Kiuyu Mbuyuni and 17% in Matemwe were members of these committees. The chi-square test revealed no difference between sites.

Table 3.5: Participation in political, social and development committees in the study areas

Kiuyu Mbuyuni, Pemba (N=100) (%)	Matemwe, Unguja (N=98) (%)	Chi-square
8	17	$\chi^2=12.241$, df=3, p= .007

Decision-making as an important component of social capital was measured using five variables, as shown in Table 3.6. With regard to involvement in community decision-making, the mean score for Kiuyu Mbuyuni was $2.56 \pm .083$ and Matemwe was $2.23 \pm .086$ which showed community members are seldom involved in decisions on various issues including those on the use of natural resources made by the political committees or district government. There was no significant difference between sites. The results also revealed that the majority of the respondents across the sites did not always trust committee members as their representatives, and the decisions made in the various committees were not always communicated to the public. Interestingly, however, in Matemwe, Unguja respondents wished to have more people on the decision boards for their villages, while in Kiuyu Mbuyuni, Pemba responses fell below 2 (sometimes) (Table 3.6), and the T-test was revealed a statistically significant difference between the sites for this variable.

Table 3.6: Mean score and independent sample t-test of decision-making variables

Variables	Shehia/ward	Mean± SE	SD	t-test
Involved in decision-making	Kiuyu Mbuyuni	2.56±.083	.833	(t=2.725, df=196, p= >.05)
	Matemwe	2.23±.086	.847	
Satisfied with action on the decision made	Kiuyu Mbuyuni	2.13±.091	.906	(t=1.360, df=196, p=>.05)
	Matemwe	1.96±.087	.861	
Trusted committee members	Kiuyu Mbuyuni	1.92±.082	.825	(t=.516, df=192, p=>.05)
	Matemwe	1.86±.077	.742	
Happy with the decision made	Kiuyu Mbuyuni	1.99±.070	.703	(t=1.050, df=181.31, p=>.05)
	Matemwe	1.87±.087	.845	
Communication between committee and villagers	Kiuyu Mbuyuni	1.94±.072	.722	(t=.025, df=180.46, p=>.05)
	Matemwe	1.94±.092	.897	
More people needed on the decision boards	Kiuyu Mbuyuni	2.01±.083	.835	(t=4.072, df=193, p= <.001)*
	Matemwe	1.53±.084	.823	

Note: The responses scale were 1 (always), 2 (some times), 3 (never) and 4 (I don't know) * Significant difference between study sites

The findings suggest that many respondents across the sites show low involvement in community decision-making processes and poor understanding of decisions made on these committees. This observation was also reflected during discussion in the participatory vulnerability matrix workshop in Matemwe Unguja (see Appendix III). Local people argued repeatedly that the introduction of the Mnemba tourist club and Mnemba Island Conservation Area (MIMCA) was an additional stressor for fisheries and their income (see Chapter 6). Traditionally, local fishers from surrounding villages used Mnemba Island (a tiny island offshore from Unguja Island) for fishing on the reef, fish camps and drying fish and nets (Honey, 2008). In 2002, MIMCA implemented aims for conserving the delicate reef surrounding the island, but the communities and fishers were never consulted about the development of the Mnemba tourist club and the MIMCA (Honey, 2008), and they were not involved in any decision-making process about MIMCA. Furthermore, they have not benefited from it in any way though they have sacrificed their reef for conservation (see Chapter 6). The following argument from the participant of the workshop reinforces the above comments:

“Using the money collected from tourists visiting MIMCA for snorkelling, the Department of Fisheries bought motorised boats for other villages, not for us. They have never called a meeting with us; they just met with local leaders’ committee”.

One can therefore argue that the weak link between local social capital and the state, and the lack of trust threatens both the health of the reef (natural capital) and the communities’ ability to adapt to the current and future changes related to climate variability and change. Indisputably, protecting marine areas improves the ecosystem’s health and ultimately local livelihoods and is crucial for future adaptation, but sustainability will depend on implementing actions and plans with trust and transparency. In some parts of Bangladesh, high participation in decision-making by fishers in the community-based management of their resources created a willingness to work in sustainable fisheries that could help them to cope and adapt to multiple

stressors (Islam *et al.* 2011). Social capital, whether bonding, bridging or networking has the power to promote better natural resource management through co-management (see Grafton, 2005; Ballet *et al.* 2007; Sekhar, 2007; Adger, 2003).

3.3.3.3 Social cohesion

Social cohesion or bonding social capital is one of the most important social capitals as it draws from neighbours and relatives and offers immediate support during times of crisis. Social cohesion was measured through six variables, as seen in the Table 3.7. Interestingly, the mean score for all variables across the sites was high, falling between 3 (agree) and 4 (strongly agree). However, the t-test (Table 3.7) shows a significant difference between the two sites regarding households' willingness to help each other, degree of tightness of their neighbourhood, how well they get along with each other, and on sharing beliefs, norms and culture. For all these variables Matemwe in Unguja obtained a slightly higher mean score compared with Kiuyu Mbuyuni. Although all responses across the variables fell between 3 (agree) and 4 (strongly agree), Kiuyu Mbuyuni, Pemba was expected to score a higher mean as people know each other well, and it is a highly isolated area with low immigration compared with Matemwe where tourism has caused high immigration both from within Zanzibar and outside it. However, previous political tensions and a history of a life of hardship in Kiuyu Mbuyuni have probably created rifts between people. This can also be associated with the idea of risk co-variance in this community, where all people are facing the same problems (poor soils, unreliable fishing activities and dry spells) and thus it becomes difficult for them to help each other. The overall findings, however, demonstrate the connectedness of coastal communities; which is probably attributable to shared beliefs, culture and traditions. Such bonding capital can help people to cope with shocks, but as described below, without other assets this does not necessarily provide the means to adapt.

Table 3.7: Mean score and independent sample t-test of social cohesion variables

Variables	Shehia/ward	Mean±SE	SD	t-test
People around here are willing to help their neighbours	Kiuyu Mbuyuni	3.01±.064	.643	(t=-4.366, df=197.72, p=<.001)*
	Matemwe	3.40±.062	.620	
This is a close-knit or tight neighbourhood; people know one another	Kiuyu Mbuyuni	3.03±.046	.460	(t=-5.705, df=188.9, p=<.001)*
	Matemwe	3.45±.058	.575	
If I had to borrow Tsh. 10,000 in an emergency, I could borrow it from a neighbour	Kiuyu Mbuyuni	3.03±.079	.788	(t=1.441, df=197, p= >.05)
	Matemwe	2.86±.088	.876	
People in this neighbourhood generally get along with each other	Kiuyu Mbuyuni	3.05±.044	.435	(t= -5.522, df=187.2, p=<.001)*
	Matemwe	3.44±.056	.556	
People in this neighbourhood can be trusted	Kiuyu Mbuyuni	3.37±.054	.544	(t=-2.4, df=198, p=>.05)
	Matemwe	3.55±.052	.520	
People in this neighbourhood share the same beliefs, culture and values	Kiuyu Mbuyuni	3.48±.052	.522	(t=-5.801, df=176, p=<.001)*
	Matemwe	3.85±.036	.360	

Note: The responses were 1 (strongly disagree), 2 (disagree), 3 (agree) and 4 (strongly agree)

*Significant difference between the study sites

High bonding social capital observed here has also been indicated in Chapter 4 and Chapter 6. In Chapter 4 the study found that neighbours provided a safety net during localised food shortages, whereas in Chapter 6, neighbours and relatives were cited as important sources of seeds after prolonged drought. A study by Walsh (2009) on Pemba Island also indicated the important role of neighbours as a safety net during drought and famine. Social cohesion is not only a resource to call upon during a crisis, but may be used to improve well-being, democracy and health (Grootaert, 1999; Putnam, 2000; Rose, 2000; Helliwell and Putnam, 2004). For instance, in some parts of Indonesia, households with high social capital were also found to have high savings and higher levels of well-being (Grootaert, 1999). This again demonstrates the layered social capital complexity introduced earlier in section 3.3.3.1.

Because social cohesion is characterised by strength and weakness (Sobel, 2002) its value and impact in coping and adaptation will depend on the strong links with other capitals. For example, social ties between fishers and middlemen can be a blessing, but can also potentially impoverish the fishers, as this social tie, which in most cases is based on give-and-take agreements between fishers and middlemen, can lead to downgrading of the value of the fish catch, ultimately affecting the fisher's income and the resilience of marine resources (see Chapter 6). Middlemen often give out loans to fishers during the off-season or supply fishing gear in return for cheaper prices for the landed fish catch later in the season. Furthermore, despite the relatively high social cohesion observed across the sites (Table 3.7), there were still a considerable number of households that had faced food shortages during previous erratic rainfall periods (see Chapter 4). It is clear then, that tight neighbourhoods and other bonding capital rarely reduce the severity of food insecurity, especially when the whole community experiences agricultural failure. Thus it is necessary to increase access to all capital assets amongst coastal communities in order to improve their well-being and reduce their vulnerability.

3.3.4 Financial capital

The financial capital in this study was measured using six variables, as shown in Table 3.8. The results revealed that the majority of respondents across the sites have no access to any type of grants. The chi-square test however, revealed a slight difference between the sites; more people in Matemwe received grants than in Kiuyu Mbuyuni. The low number of households that receive pensions is associated with the fact that many people in these villages were unemployed due to illiteracy. With regard to savings in formal banks or saving groups, the results show that 94% in Kiuyu Mbuyuni, Pemba and 91% in Matemwe, Unguja, had no kind of saving at all. This again may well be linked to the low returns from their livelihood activities due to the small-scale nature of these activities and their sensitivity to multiple stressors. Low savings may also be influenced by low participation in cooperative and saving groups. Furthermore, most households in both the study sites had no savings of non-productive assets such as gold (Table 3.8).

Table 3.8: Percentages of households with no access to various types of financial capital

Variables	Kiuyu Mbuyuni (N=100) (%)	Matemwe (N=98) (%)	Chi-square
Percentage of households without any type of grants	95	82	$\chi^2=8.457$, df=1, p=.004*
	Kiuyu Mbuyuni (N=100)	Matemwe (N=95)	$\chi^2=.828$, df=1, p=.363
Percentage of households without savings in a bank or saving groups	94	91	
	Kiuyu Mbuyuni (N=100)	Matemwe (N=95)	$\chi^2=1.069$, df=1, p=.301
Households without savings of non-productive assets such as gold	93	89	
	Kiuyu Mbuyuni (N=100)	Matemwe (N=95)	$\chi^2=.000$, df=1, p=.994
Households with outstanding debts	59	59	
	Kiuyu Mbuyuni (N=100)	Matemwe (N=100)	$\chi^2=15.341$, df=1, p=.000*
Households without credit	97	79	
	Kiuyu Mbuyuni (N=100)	Matemwe (N=100)	$\chi^2=2.440$, df=1, p=.118
Households that faced income shortfalls in the last 12 months	49	60	

* Significant difference between sites

In terms of debt, the results show that more than half of the households across the sites have an outstanding debt (Table 3.8). Most of these debts however, come from food loans or from borrowing money to buy food, especially during critical periods such as drought and off-fishing seasons. The existence of small food stores and the availability of food in these stores have made food loans from these stores a common coping mechanism during food shortages (see Chapter 4). About 49% of households in Kiuyu Mbuyuni and 60% in Matemwe, Unguja have faced income shortfalls during the last 12 months. The cited incidences that caused large income shortfalls include the unreliability of fishing activities; seaweed and agriculture failure; the loss of a productive household member through death; major livestock and poultry loss due to drought and theft; weddings and other costly social events, and serious illness in the family. This highlights the fact that the little cash obtained through various sources of income is used to solve a large amount of problems and, thus, people are unable to save money for future investment.

Strikingly, 97% of the households in Kiuyu Mbuyuni have no means of obtaining credit to invest in activities outside fishing or farming or to improve their farming or fishing activities, while, in Matemwe, Unguja some 79% of the households have no access to credit. A chi-square test revealed significant differences between the sites. More people in Matemwe received credit in various forms compared to Kiuyu Mbuyuni, which may be attributed to the higher participation in cooperative and saving groups observed in Matemwe (see Table 3.4). The households which received credit were asked to identify the most important sources of their credit, and the results in Table 3.9 show that two respondents out of three in Kiuyu Mbuyuni have obtained bank credit using their salaries as a guarantee. As many people in rural areas have no title deeds for their land and homes to act as a guarantee to obtain a bank loan, salaries were found to be a common assurance. But this is only possible to those who have employment. In Matemwe, Unguja, 15 respondents out of 25 obtained credit from saving groups while six respondents obtained credit from well-off individuals in the village.

Table: 3.9: Primary sources of credit across the sites

Sources of credit	Kiuyu Mbuyuni, Pemba (N=3) (Nr)	Matemwe, Unguja (N=25) (Nr)
Local wealthy person	-	6
Presidential fund	-	2
Saving groups/clubs	-	15
Wealthy person in town	1	-
Middlemen	-	1
Bank	2	-
Other	-	1

(Nr) = Number of responses

Financial capital is perhaps one of the most important assets as greater financial capacity facilitates access to other assets such as land, increased investment in physical capital (e.g. fishing vessels, gear) and increased savings (Moyoux, 2002; Nkopyen and Eteng, 2012; Kazi and Leonard, 2012). In examining women's empowerment and microfinance in Cameroon, Mayoux (2001) narrated many success stories among the women who obtained credit from saving groups/clubs and which helped them obtain land for farming, whereas in Nigeria, Nkopyen and Eteng (2012) found a significant relationship between micro-lending and increased household saving and reduced poverty. Low access to financial capital as observed across the sites, therefore, prohibits households from acquiring important assets for improving their livelihood portfolios, and thus intensifies vulnerability to climate variability and change.

An interview with one of the few individuals who received a loan from the scheme known as the "Presidential fund for sustainable empowerment of local entrepreneurs" (locally known as "Billions of President Kikwete") in Matemwe, Unguja (see Table 3.9), revealed some achievements over time. The beneficiary's savings increased through new investment in small businesses including a small food store and supplying seafood to the nearby tourism hotels. He also managed to cope with salt-laden on-shore winds by roofing his house with locally-made tiles (see Plate 3.1). In order to build resilience to the expected changes of climate and sea level, the foregoing story highlights the need to increase the access of coastal communities to financial capital. However, further attempts towards better access to micro-lending and micro-finance should be based on faith, trust, value and norms within the communities (van Bastelaer, 2000; van Bastelaer and Leathers, 2006).



Plate 3.1: On the left, fish market iron-roof corroded by on-shore salt-laden winds. On the right a house roofed using locally-made cement tiles to cope with salt-laden winds in Matemwe, Unguja.

3.3.5 Human capital

Human capital is another important capital for the well-being of the coastal community in Zanzibar. This was measured using two variables: education and skills, and health.

3.3.5.1 Education and skills

The results in Figure 3.4 show that about 50% of respondents across the sites had not attended school at all, whereas 23% in Kiuyu Mbuyuni, Pemba and 20% in Matemwe, Unguja had attained secondary education. The results concur with the Micheweni district statistics in Pemba, where Kiuyu Mbuyuni is located. About 60% of its population (total population of Micheweni district was estimated at about 88,000) are illiterate. Within this, 41% of the rural population never attended school (UN, nd). The absence of school facilities, parents' attitudes towards education, and school dropouts attributable to fishing has probably contributed to the observed illiteracy (UN, nd). Over time, education facilities have improved across the sites; for instance, Kiuyu Mbuyuni now has two schools and one teacher training college and Matemwe has three schools. However, the level by which illiteracy will be reduced will depend strongly on changing attitudes towards education among parents and the quality of the teaching and learning environment in the schools. The small number of people employed in formal jobs (Figure 3.1, 3.2 and 3.3), coupled with the results in Figure 3.4 and the UN study (UN, nd) provides insight into household level illiteracy across the sites.

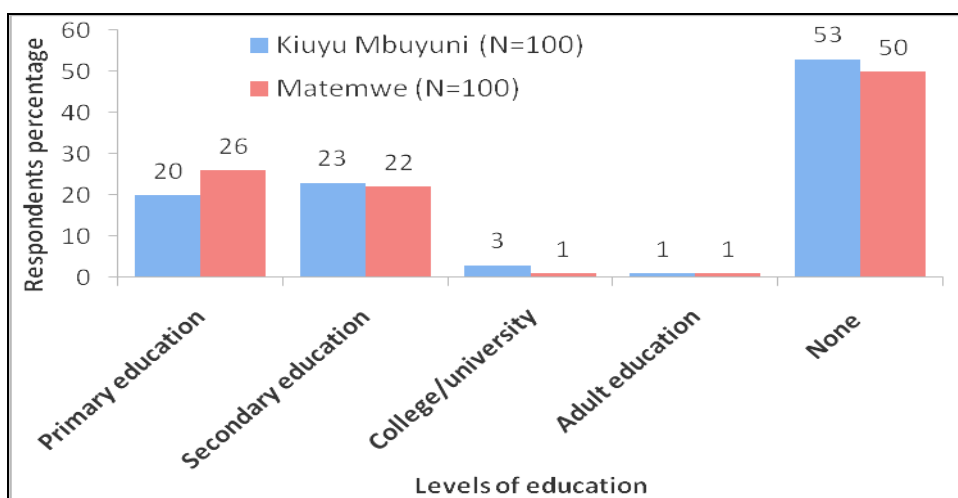


Figure 3.4: Education levels of the respondents

The low level of literacy means local people are denied the opportunity of being employed in the formal sector. This argument is also supported by the results in Figure 3.2 (Kiuyu Mbuyuni) and Figure 3.3 (Matemwe) which showed that only a few households among those interviewed depended on income from formal employment. Similarly, only 10% of the households interviewed have one household member employed in the tourism sector (Figure 3.3). With more than 15 hotels along the north east coast, one would expect a substantial percent of locals to be employed; an interview with local NGOs revealed that very few people from Matemwe were employed, and most of those were in low earning positions such as watchmen and gardeners. Illiteracy, perceptions of the locals regarding tourism, perceptions of the hotel owners about the abilities of local coastal people, and poor legislation were cited as major obstacles to employing local people in tourism. As a result most of the workers employed come from the mainland (see Chapter 7). Elsewhere in the developing world, high levels of illiteracy bar the attempts of the local people to diversify their livelihoods in order to cope with climate variability which affects their traditional activities (Islam *et al.* 2011).

Findings showed that households which depend on formal employment suffer less food insecurity than those that solely depended on risky fishing and unreliable farming (Chapter 4; Barrett *et al.* 2001a; Barrett *et al.* 2001b). Similarly, McDowell and Hess (2012) found that illiteracy, which was driven by poor quality rural schools and culturally inadequate curricula, was itself a limit to successful adaptation. Education not only provides opportunities for employment and competency, it also provides life skills and increases trust among people (Lanzi, 2007; Dinda, 2008). In examining social capital in the creation of human capital and economic growth, Dinda (2008) found a significant relationship between education and trust on the one hand, and disposable income. In the opinion of Lanzi (2007) and Dinda (2008), schooling has the potential to create both social and financial capital.

Regarding skills, the results in Table 3.10 reveal various skills available in the studied households across the sites. The most frequently cited skills included tailoring and making craft items (varieties of handbags, mats, traditional headgear, pots and embroidery). In Matemwe, Unguja for example, there were women's groups specifically engaged in craft and art work (see Table 3.4). By contrast, despite the large number of households that had various craft skills in Kiuyu Mbuyuni, Pemba there were no women's groups dealing with craft work (Table 3.4). This is probably influenced by the fact that Kiuyu Mbuyuni has no tourism to provide a market for locally-made craft goods as the local market is very small (see Issa, 2012). It is obvious that the demand for locally-made handbags and mats in the local market has declined over time, probably because plastic bags and mats are now imported and urban dwellers' perceptions about locally produced goods have changed. Based on this researcher's experience, it is now hard to find someone who carries a locally-made hand-bag in all the major towns of Zanzibar (Unguja and Pemba Islands).

Table 3.10: Available skills that could increase participation in off-farming and off-fishing activities

Skills	Kiuyu Mbuyuni (N=65) (%)	Matemwe (N=56) (%)
Craft work	88	50
Tailoring	5	25
Households with more than one skill	6	23
Brick/stonework	1	2

Note: The question needed multiple responses

In other parts of Pemba Island, women's groups who are engaged in craft work managed to join forces and were able to establish a link to a few tourist hotspots on the island to trade their products (Issa, 2012). This demonstrates that even in Kiuyu Mbuyuni, women could work together to overcome distance barriers and trade their craft work in those areas and perhaps to the neighbouring and international market. The observed richness of skills across the sites, if carefully promoted could increase a household's income and reduce vulnerability.

3.3.5.2 Health

Respondents were asked if members of households were affected by any type of illness and if the answer was yes, respondents were asked whether the illness affected the welfare of the household. The results of the analysis of these two questions in Table 3.11 show that 31% and 64% of the households in Kiuyu Mbuyuni, Pemba and Matemwe, Unguja respectively are affected by the various kinds of illness. Further, about 57% and 77% of those households that are affected believed that the illness affected the household economically. A chi-square test revealed a significant difference between sites for both variables (see Table 3.11). Compared with Kiuyu Mbuyuni, Matemwe is more affected by various types of illness and most of the households affected by illnesses were also affected economically

Table 3.11: Health capital

Variables	Kiuyu Mbuyuni (N=100) (%)	Matemwe (N=100) (%)	Chi-square
Households affected by various illnesses	31	64	$\chi^2=21.835$, $df=1$, $p=.000^*$
	Kiuyu Mbuyuni (N=30) (%)	Matemwe (N=65) (%)	Chi-square
Households affected economically due to illness	57	77	$\chi^2=4.052$, $df=1$, $p=.044^*$

* Significant difference between sites

Knowing that most people are self-employed and depend on natural resource-based activities, respondents whose households are affected economically by the illness of household heads or members of the households, were asked to identify responses used to cope with the absence of contributions by the ill persons. The most cited responses included food loans from local shops, selling assets (chickens, goats, cattle and other physical assets) and remittances (Figure 3.5). About 24% and 30% of the respondents in Kiuyu Mbuyuni, Pemba and Matemwe, Unguja respectively, were doing nothing to cope with illnesses in their households.

The findings highlight the fact that health problems not only undermine production, but also affect savings and well-being, and thus weaken the capacity of the household to cope and adapt to variability and future changes of climate and sea level. Health problems in the households may also disrupt traditional security nets and cause death (Topouzis and du Guerny, 1999). Across developing countries, HIV/AIDS and other chronic illnesses have negatively interacted with climate variability and existing challenges such as poverty and conflicts, and thus intensified vulnerability (Misselhorn, 2005; Reid and Vogel; 2006; Drimie and Gillespie, 2010). As health problems undermine the capacity and capabilities of households to withstand shocks such as drought and associated food insecurity, health issues need to be mainstreamed in the national adaptation strategies, as future predictions of temperature in Zanzibar and at the global level (see Chapter 5) is likely to increase the incidence and prevalence of malaria and water-borne diseases (Martens *et al.* 1999; Githeko and Ndegwa, 2001; Hay *et al.* 2002; Tanser *et al.* 2003; Klein, 2008; Wandiga *et al.* 2010). Moreover, movement of the fishers (short- and long-term migrations) to cope with fish stock decline is likely to increase the prevalence of HIV/AIDS as they stay away from their family for longer periods (see Allison and Horemans, 2006).

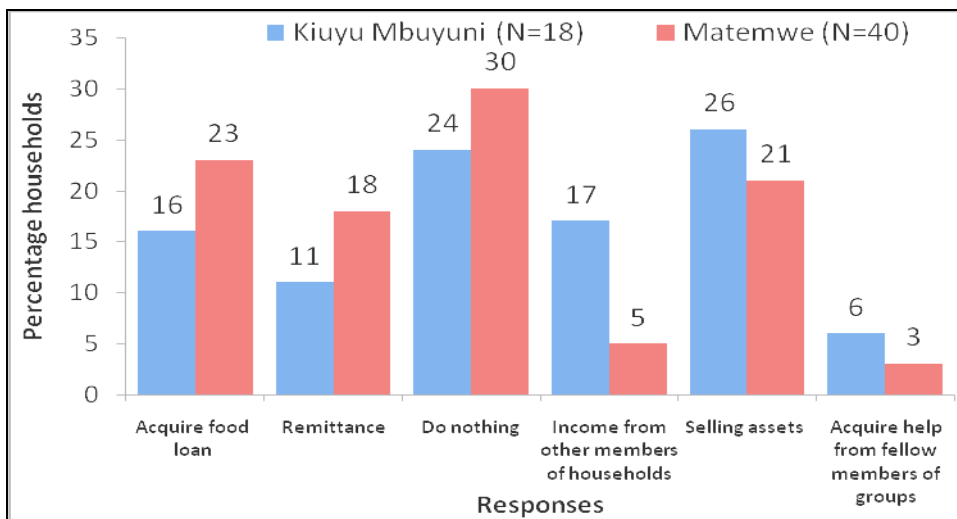


Figure 3.5: Responses to illness of working persons in the households

3.3.6 Physical capital

Physical assets are good indicators of the income and well-being of a household and the sale of physical assets can be used as a safety net during times of crisis. Physical assets studied in this section include house ownership, evidence of ownership, housing materials, ownership of fishing assets, and home assets, including water and electricity infrastructure and animals (see Tables 3.12, 3.13, 3.14 and 3.15).

3.3.6.1 Housing ownership and construction materials

The study found that the majority of the respondents interviewed lived in their own houses; however, 97% of the respondents in Kiuyu Mbuyuni and 98% of the respondents in Matemwe, Unguja have no title deeds for their house or the land on which the house is built (Table 3.12). This was mainly due to the lack of financial capital to process the application which requires a survey of the site and legal fees. This precludes the majority of the people using the title of their land and houses as a guarantee to access credit from banks. Legal ownership often provides an alternative to formal employment as a guarantee. Land in many east coast Zanzibar communities used to be acquired through clearing, but the owner needs to process the legal documents that authorise ownership (see Singer, 1996). In examining multiple stressors on livelihoods in the Bolivian highlands under climate change, McDowell and Hess (2012) found the absence of title deeds for lands prohibited local people from accessing financial capital, especially from formal sources such as banks. With the increasing value of land in Matemwe, Unguja due to tourism, the provision of title deeds for the home and land owners would be a step toward building strong financial capacity for many, as it would increase accessibility to financial capital.

Table 3.12: Nature of the house ownership in the study areas

Nature of the house ownership		
Variables	Kiuyu Mbuyuni (N=100) (%)	Matemwe (N=100) (%)
Sole owner	93	90
Owned with others	5	10
Other	2	-
Household without title deeds	97	98

Group discussion workshops in both the sites revealed that the nature of houses has changed greatly in the past 30 years or so, from predominantly mud walls and coconut-thatch roofs to stone/brick walls and iron roofs. This is also reflected in the Table 3.13 which shows that only 21% and 19% of the respondents in both Kiuyu Mbuyuni and Matemwe, respectively, lived in mud houses. A t-test revealed no significant difference between the sites regarding construction materials. Stones with lime are the most common building material along the coast on both islands. Regarding the types of roof, Kiuyu Mbuyuni, Pemba lagged behind with only 53% of the respondents interviewed having homes roofed with iron sheets, whereas in Matemwe, Unguja about 84% of houses were roofed with iron sheets. A t-test revealed a significant difference between sites (Table 3.13), which is probably influenced by the fact that Matemwe, Unguja is more urbanised than Kiuyu Mbuyuni. The transition toward iron roofs may also be influenced by the increasing price of coconut thatch, partly attributed to urban expansion all over the islands and a high demand for coconut thatch for tourist hotels.

Table 3.13: Constructions materials used for housing

Type of the materials of most of the walls			t-test
	Kiuyu Mbuyuni (N=100) (%)	Matemwe (N=100) (%)	
Mud/soil	21	19	t=.375, df=198, p=>.05
Bricks	24	36	
Stones	55	45	
Mean±SE	3.13±.118	3.07±.110	
Type of materials of most of the roof			t test
Coconut thatch (<i>Makuti</i>)	47	14	t=-5.543, df=185.3, p=<.05*
Iron or other sheet material	53	84	
Locally-made tiles	-	2	
Mean±SE	1.53±.502	1.88±.038	

*Significant difference, (1) materials of most of the walls: the responses were 1= mud/soil, 2 = bricks, 3 stones (2) materials of most of the roofs: the responses were 1 = coconut thatch, 2 = iron or other sheet materials, 3 = locally-made tiles

Although stones are readily available, the transition from mud to stone-walled houses, according to some participants in group discussions, was restricted by the fear of being bewitched. Participants in Kiuyu Mbuyuni, Pemba however, contend that the construction of ‘cottage houses’ by government in the late 60’s within the villages has opened the way toward modernisation. Despite the fact that both sites are located in the poorest district in their respective islands, the observed development in houses demonstrates some improvements in the well-being of households and more robust housing able to withstand heavy winds and rains.

3.3.6.2 Equipment, household goods and infrastructure

Table 3.14 presents various goods that indicate the wealth and well-being of the households across the sites. Strikingly, the majority of the households interviewed lacked crucial equipment and assets for fishing such as fishing vessels, boat engine, gear and refrigeration (Table 3.14). With regard to the ownership of the vessels and gear, the results fitted findings in Chapter 6, where low ownership of these assets among fishers was also observed. The results are also in line with a fisheries survey of 2010 which indicated that there were only 45 boat engines in the district of Micheweni, Pemba in which Kiuyu Mbuyuni is located (Department of Fisheries Zanzibar, 2012).

Table 3.14: Ownership of other physical assets

Variables	Kiuyu Mbuyuni (N=100) (%)	Matemwe (N=100) (%)	Chi-square
Household without fishing vessels	81	76	$\chi^2=.741$, df=1, p=.389
Household without boat engine	99	99	$\chi^2=.000$, df=1, p=1.000
Household without gear (traps)	89	79	$\chi^2=3.720$, df=1, p=.054
Household without refrigeration	99	98	$\chi^2=.338$, df=1, p=.561
Household without scooter	93	95	$\chi^2=.355$, df=1, p=.552
Household with bicycle	64	71	$\chi^2=1.117$, df=1, p=.291
Household without electricity	98	95	$\chi^2=1.332$, df=1, p=.248
Household with mobile	50	63	$\chi^2=3.438$, df=1, p=.064
Household without TV	96	96	$\chi^2=.000$, df=1, p= 1.000
Household with radio	71	88	$\chi^2=8.866$, df=1, p=.003*
Household without furniture (e.g. lounge suite, dinning set etc)	97	86	$\chi^2=7.779$, df=1, p=.005*
Household without solar panel	100	100	Responses were constant
Household without a sewing machine	92	88	$\chi^2=.889$, df=1, p=.346

*Significant difference between the sites

Apart from the equipment related to fisheries, most of the households across the sites were also without home-based equipment such as a scooter, television, furniture, and sewing machine and infrastructure such as electricity and solar panel (Table 3.14). Other goods and infrastructure that are not in the Table 3.14 but captured in other Chapters included water infrastructure in the households and a latrine (see Chapter 4). A chi-square test revealed significant differences in the ownership of radios and furniture; more households in Matemwe, Unguja have a radio and furniture than those in Kiuyu Mbuyuni, Pemba. Since these assets and services have financial implications (Badjeck, 2008), their absence in the homes demonstrated a low return

from livelihood activities, low savings and a high level of poverty across the sites. Although local people tend to have little interest in listening to weather forecasts on the radio (see Chapter 5), the fact that many households owned radios and cell phones makes it possible to disseminate early warnings to both farmers and fishers to assist them to cope and adapt to current extreme and future changes in climate.

The results demonstrate that low ownership of important equipment and services is not only in the households interviewed, but also in the respective districts. Studies amongst coastal communities in other developing countries also reflect low ownership of fishing vessels and gear. For instance, a study by Badjeck (2008) in rural Peru found more than 94% of the fishers do not own vessels and other fishing equipment. Most of the equipment is owned by middlemen or wealthy local people; thus, the observed low ownership of important assets across the sites makes households easy prey for oppressive social-economic ties with middlemen, who in most cases do influence the price of the fish catch in their favour (see Chapter 6). The reciprocal agreement between fishers and vessels and gear owners (middlemen) restricts fisher's attempts to build strong financial capital, and thus makes them more vulnerable to variability in fish catch.

3.3.6.3 Livestock and poultry as assets

The results in Table 3.15 show that 50% of the households interviewed in Kiuyu Mbuyuni, Pemba keep cattle, whereas, only 18% of the households interviewed in Matemwe, Unguja were doing the same. Households with cattle in Kiuyu Mbuyuni, owned an average of three cattle, while in Matemwe, households owned five; however, a chi-square test revealed that more people keep cattle in Kiuyu Mbuyuni than in Matemwe (Table 3.15). The increasing value of land and competition between traditional uses of land and expansion of tourism (Chapter 6) has probably reduced the number of livestock keepers in Matemwe. In terms of goats, about 21% of the households interviewed in Matemwe keep goats, an average of six goats per household, but no one keeps goats in Kiuyu Mbuyuni, Pemba because of superstitious beliefs (see Chapter 7). Likewise, there were a couple of community groups in Matemwe, Unguja engaged in keeping both local breeds and dairy goats (see Table 3.4). Furthermore, 70% and 55% of the households in Kiuyu Mbuyuni and Matemwe respectively, keep poultry in their homesteads. A chi-square test again revealed that significantly more households keep chickens in Kiuyu Mbuyuni, Pemba than in Matemwe. This is mainly because in Pemba Island keeping chickens is seen as a safety net and is thus common in many villages. These chickens are traded as far as Unguja.

In all developing countries, livestock is treated as 'live bank' and an important safety net that can be called upon during major financial shocks to the household. In the study areas, apart from being sources of manure to cope with poor soil, livestock are treated as a safety net. Even poultry were not kept for consumption, but rather as a live bank for those shocks requiring immediate responses (see Chapter 4). The findings tally with the results in Figure 3.5 which indicate that selling assets, including live animals, is a

major response in households coping with difficulties resulting from the illness of a working person. Indeed livestock in these areas are the life-line for the local community's survival. Across the sites the use of cow dung is the only way to replenish the coral rag soils. Cattle accumulation was also used to acquire other capital such as fishing vessels and houses; however the survival of these animals is consistently challenged by increased frequency of dry spells, sea water coastal flooding and sea water intrusion into water sources triggered by the increase in sea level (see Chapter 4, 5 and 6). Apart from these challenges, the increase of pests and diseases, a decrease in land holdings due to population pressure and expansion of tourism, and the lack of access to financial capital all hinder households in acquiring more cattle (see Chapter 6; McDowell and Hess, 2012).

Table 3.15: Livestock keeping and poultry as assets

	Kiuyu Mbuyuni (N=98) (%)	Matemwe (N=83) (%)	Chi-square
Households that keep cattle	50	18	$\chi^2=20.043$, df=1, p=.000*
Mean cattle per household	3 $\pm$.212	5 $\pm$.704	
	Kiuyu Mbuyuni (N=99)	Matemwe (N=96)	
Households that keep goats	-	21	
Mean goat per household	-	6 $\pm$.761	
	Kiuyu Mbuyuni (N=96)	Matemwe (N=93)	
Households that keep chickens	70	55	$\chi^2=4.503$, df=1, p=.034*

*Significant differences

3.4 CONCLUSIONS

The Chapter has examined the vulnerability context and adaptive capacity of coastal communities through consideration of their livelihoods and capital stocks and access to these. With regard to livelihoods, the findings match those of other studies in that livelihood diversity in the household has positive outcomes for poverty reduction and increasing wealth (Barrett *et al*, 2001a; Barrett *et al*. 2001b; Bird and Shephard, 2003). But this study further articulated that diversification within activities sensitive to climate change and other stressors is likely to lessen the positive effect on reducing poverty and vulnerability. Although the study found a diverse range of livelihood activities amongst most households, this diversification mainly involved activities based on the exploitation of natural resources such as fishing, farming, seaweed farming and livestock keeping. Peoples' attempts to improve existing activities such as fishing or to turn to more lucrative livelihood activities outside farming and fishing are challenged by poverty and low access to multiple assets. As all of their important activities are sensitive and controlled by climate (see Chapter 5), overdependence on natural resources for their livelihoods make these communities particularly vulnerable to variability in climate and sea level.

While the majority of the respondents were not involved in politics and decision-making in the villages, their informal social relations were high. The relationship between two or more people, particularly relatives, friends and neighbours, which is known collectively as bonding capital, is perhaps among the most important capitals in both the sites as it acts as a safety net in hard times. However this can be undermined by risk co-variance especially in the more isolated Pemba site as their capacity to help each other would be severely tested. This is illustrated by the large number of people who experienced localised food shortages during the last dry spells (2009-2011) (Said, 2011). Despite this the spirit of helping each other during crisis is not completely overwhelmed (Gray, 1956 cited in Walsh, 2009). This study, for example, found people giving out seeds to their neighbours so that they were able to plant after the dry spells across the sites (see Chapter 4). Despite previous political tensions within the communities, particularly in Pemba, communities have remained together and do help one another during crises. Social cohesion should be extended beyond normal neighbourhood affairs and used to build trust among people in cooperative groups and saving groups in order to increase wider participation in these groups, which can increase savings and improve well-being.

The findings showed that, there were few cooperative and savings groups, and the membership in these groups is less than 10% of the total population across the sites.. In a situation where few people have salaries, and none have title to their land or houses to act as collateral for obtaining soft credit and loans from banks, membership in micro-finance clubs appears to be the only available option for them. Apart from poverty that holds back the majority of the people from buying the initial shares to become a member of a saving group, trust between one another (especially when it comes the issue of money handling and management) may also be a major factor for low participation. However, other studies in Africa and Latin America have shown that micro-lending through saving groups or loan schemes can increase access to other assets such as land and physical assets. This needs to be made to work in rural Zanzibar in order to raise resilience to climate variability and change. The study observed some resilience in a few individuals that obtained loan through formal loan schemes.

Perhaps the most striking findings that also corroborates findings with other fishing communities in developing countries was the low ownership of important physical assets needed for fishing such as vessels and fishing gear. This situation increased the vulnerability context of fishers as they were forced to get into unequal agreements with owners of these assets (mainly middlemen). These agreements in most cases force them to sell their catch at a cheaper price. In summary it appears that the coastal communities studied are characterised by low capital stocks and low access to various forms of capital. As these assets have the capacity to reduce poverty and create wealth the observed limited access to capital assets is a major source of vulnerability across the sites.

CHAPTER 4

UNDERSTANDING FOOD AND FRESH WATER SECURITY AMONGST EAST COAST HOUSEHOLDS

4.1 INTRODUCTION

4.1.1 Overview

This Chapter examines the local vulnerability context of households in the two study communities focusing on food and water security. It specifically seeks to (1) understand the status of food and water security in the households and (2) to identify the strategies employed to cope with both food and water insecurity. It is widely acknowledged that water, food and poverty are intricately linked. A reliable and accessible supply of sufficient water for farming is likely to increase farming production, and thus reduce vulnerability to hunger and poverty. Similarly, water scarcity not only affects crop production, but also basic human needs such as drinking, washing, bathing and cooking, and ultimately it impacts negatively on both the well-being and health of households. Therefore, this Chapter provides some insights into the current vulnerability context of households regarding food and water security, both of which are expected to be negatively impacted by climate variability and change.

The Chapter starts with a discussion on food and water security focusing on Zanzibar. This is followed by an explanation of the concepts of both food and water security as defined for this study. I then present the set of methods used to collect data in relation to major pillars of both food and water security. The results and discussion section focuses on major components of food security in households (availability, accessibility and stability) and water security for both households and farming (availability and accessibility of quality water). The coping mechanisms used by households in the face of food and water insecurity are also discussed. This is followed by a concluding section which summarises the key findings and suggests ways to improve the water and food security context of households on the east coast of Zanzibar.

4.1.2 General background

The food and water sectors have direct links to, are influenced by and are sensitive to variability and change in climate. They are also affected by development challenges such as poverty, land degradation and pollution, among others. The fourth assessment report (AR 4) of the IPCC confidently contends that the observed climate variability and predicted changes in climate will potentially impact food and water security in Africa (Boko *et al.* 2007). Evidence in support of this argument includes the considerable incidents of famine, food insecurity and water stress across Africa, which are partly associated with the variability of climate and the domination of El Niño-Southern Oscillation (ENSO) events on the regional climatic patterns (Dai, 2011; Droogers, 2004; Chapter 5). For example, about 40% or more of people in

Africa go to bed without enough nourishing food due to environmental changes and the rain-fed nature of farming (Cordell *et al.* 2009).

For the past two decades Zanzibar has gone through a number of droughts of varying intensity as well as periods of food insecurity. The 1971-72 famine, although partly influenced by a food importation ban by the government, is considered as the “most notorious famine of this kind in living memory” as it spread across the major islands in both the west and east coasts (Walsh, 2009:220). The east coasts of both islands, where the soil is poor, are frequently affected by localised food shortages and, are sensitive to even moderate abnormalities of rainfall (see Chapter 6). For instance, in 2010-2011 more than 7,000 people in Micheweni district, north-east Pemba, in which Kiuyu Mbuyuni is located, did not have enough food (Said, 2011). This was caused by high fluctuations in rainfall which started around 2006 and which affected crop production (Chapter 5). Indeed, even without climate variability, access to food for the majority of the households along the drier east coasts of both islands is problematic and is one of the major food security problems of Zanzibar (Boetekees and Immink, 2008). Rose (1994), cited in Walsh (2009) argues that even during the best years, malnutrition along the east coasts is widespread.

In terms of water availability, globally the supply of fresh water has declined and estimates calculate that currently 1.6 billion people live in areas of high water scarcity and stress for both household and agriculture needs (UNEP, 2011). This figure is expected to rise to 3 billion people by 2025 thanks to population increase and the desire to increase agricultural output under the threat of climate change (Perveen and James, 2011; Hanjra and Qureshi, 2010). However, the scarcity and stress will be unevenly distributed, with the poorest and most marginalised segments of the population, who rely on natural water resources for their livelihoods, especially for crop and animal farming, often experiencing the most limited water supply (UNEP, 2011). Small islands, both in the Pacific and Indian Oceans, lack sufficient permanent surface water in the form of big rivers or lakes and rely completely on rainfall and groundwater harvesting for drinking and agriculture (Kuruppu, 2009; Mimura *et al.* 2007). The Zanzibar Islands are no exception; this makes them highly sensitive to variability in climate and sea level rise and the predicted changes.

While the Zanzibar Islands are considered to have very rich aquifers compared to water demand (Halcrow, 1994), like any other island whose freshwater aquifers overlie denser seawater they are sensitive to sea level rise; to increasing demands, especially for agriculture; poor water governance; and variability in rainfall (Hansson, 2010; Kuruppu, 2009). In such islands there is a direct relationship between the volume of both underground and surface water and rainfall. According to Mimura *et al.* (2007), a 10% reduction in average rainfall by 2050 in the Pacific would lead to a 20% reduction in the size of the freshwater lens on Tarawa and Kiribati Islands. Other studies show that even current climate variability and extreme regional events such as drought, attributable to ENSO events, have triggered water scarcity and food insecurity in

the Pacific Islands of American Samoa, Tonga, Fiji, Marshal, Micronesia and Kiribati (Kuruppu and Liverman, 2011; Kuruppu, 2009; Pelling and Uitto, 2001). As seen earlier, climate change is not the only stressor affecting small islands' water scarcity. It adversely interacts with other characteristics of islands (e.g. small size and economy) and existing development challenges such as poverty, poor governance and low technology to aggravate both food and water insecurity (Pelling and Uitto, 2001; Kuruppu and Liverman, 2011; Mortreux and Barnett, 2009).

Attaining food and water security at both national and household level is a priority not only for Zanzibar but also for the global community because of its complex interaction with climate, demand, and increasing population and poverty. Because of this complexity, the United Nations (UN) has agreed to implement 8 Millennium Development Goals (MDGs) in order to put to an end various problems such as extreme poverty and hunger on MDG 1 and water insecurity on MDG 7. Zanzibar, through Tanzania, formalised its commitment to implement these goals in order to accomplish poverty eradication by 2015. This highlights the fact that poverty, hunger and water are intricately linked in several dimensions and thus current observed climate and sea level variability and future changes will potentially impact the livelihood of local communities in SIDSs. This study is therefore, expected to fill various gaps in the data needed to inform future interventions to reduce poverty and vulnerability and to help to accomplish future goals set to take off after 2015 when the current UNMDGs expire.

4.1.3 Conceptualising food security/insecurity

The definition of food security provided by the FAO during the World Food Summit in 1996, recognises food security as “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (Ericksen, 2008:234). Unlike previous definitions, this one highlights the role of food availability in connection to the accessibility of food for understanding food security at all levels. Since the 1970s, food security as a concept has evolved and has been defined extensively across disciplines because of its multi-disciplinary nature and complexity. Indeed, the recent developments in the science of food security have built on various highly commended works by Amartya Sen, particularly the 1981 work entitled “*Poverty and Famine: An essay on entitlement and deprivation*” which included food accessibility as a very important pillar of food security across all levels (Ericksen, 2008; Maxwell, 1996). It is now widely recognised that food security comprises four components or dimensions: food availability, accessibility, stability and utilisation (Ziervogel and Ericksen, 2010; Balaghi *et al.* 2010; Ericksen, 2008) (see Table 4.1 for a definition of the terms).

Food availability is determined by the ability of households to produce, distribute and exchange food, while access to food is determined by affordability (purchasing power), allocation and preferences (social and

cultural determinants influencing consumers). Utilisation is influenced by the nutritional value of the food, its social value and by food safety (see Ziervogel and Ericksen, 2010; Ericksen, 2008). Indeed, as mentioned earlier, all components of food security are tightly connected to various global and local determinants and thus they are sensitive to a number of stressors that may include environment, politics, ethics, employment, energy (including expansion of bio-fuels), choices, land degradation and climate variability and change (Chakrabortya and Newton, 2011; Ziervogel and Ericksen, 2010; Merino *et al.* 2012; Barnett, 2011). This highlights the fact that food insecurity is unevenly distributed both between and within social systems, as interactions between these determinants vary both between and within social systems or decision units, such as the household.

Table 4.1 Definitions of food security terms and concepts

Term	Definition	Source
Stability	The ability of a household to have consistent access to food over time	Balaghi <i>et al.</i> (2010)
Availability	The amount, type and quality of food a unit has at its disposal to consume	Ericksen (2008: 238)
Accessibility	The ability of a unit to obtain access to the type, quality, and quantity of food it requires	
Utilisation	Individual or household capacity to consume and benefit from the food	

It is estimated that urban expansion and conversion of crops and crop land to non-food production will reduce the total global cropping area by 8-20% by 2050 and will thus intensify food insecurity (Nellemann *et al.* 2009 cited in Chakrabortya and Newton, 2011; also see Ericksen, 2008; Harvey and Pilgrim, 2011). According to Erickson (2008), throughout sub-Saharan Africa, including Zanzibar, food insecurity is still widespread due to economic factors, poverty, political instability, market failure and the increasing incidence of drought. Global food prices, which are influenced by the volatility of crude oil prices and by droughts which strike big producers, were also found to affect local food security all over the world (Wang, 2010). At the household level however, food insecurity may also be triggered by household choices and preferences influenced by livelihood security. For example, a household may choose to go hungry to preserve assets and future livelihoods (Ericksen, 2008; Maxwell, 1996).

Climate change is an additional pressure on food security and in fact affects all four components of food security in many ways. Erratic rainfall, floods, increasingly warm conditions, increasing intensity and frequency of drought and storms and sea level change affect livelihoods, purchasing power, distribution systems, health, fresh water availability for farming and drinking, important global agricultural areas and marine resources and ultimately affect the stability of food resources (Wang 2010; Hanjra and Qureshi, 2010; Boko *et al.* 2007; Droogers, 2004; Droogers and Aerts, 2005; Swaminathan, 2010; Ziervogel and Ericksen, 2010; Balaghi *et al.* 2010; Ericksen, 2008). Therefore, the poor, who have low coping strategies

and those who are dependent on climate-sensitive ecosystems such as coastal and marine systems, dry lands fields and rangelands, are highly vulnerable to food insecurity.

4.1.4 Conceptualising water security/insecurity

Water security as a concept has been used extensively across disciplines for at least the last decade (Table 4.2) mainly because water is an issue that cuts across various components of human welfare and survival. For instance in agriculture, water security focuses on continuous availability of water as a crucial input for food production, whereas in environmental science, water security focuses on “access to water functions and services for humans and the environment” (Cook and Bakker, 2012:96; Table 4.2). At the household level, Ariyabandu (1999) cited in Brauch *et al.* (2009:178) has defined water security as “accessibility, reliability and timely availability of adequate, safe water to satisfy basic human needs”. Cheng *et al.* (2004) (cited in Bu-Chun *et al.* (2007: 13)) have provided perhaps the most comprehensive definition of water security for the purpose of this study, since it covers both household and economic activities (e.g. agriculture). They define water security as “access to safe water at an affordable cost for everybody; the water available should be potable and fit for human consumption, besides meeting the needs of sanitation, healthy, disease-free living, and food production, simultaneously ensuring that the water environment is protected”.

Table 4.2: Focus and definitions of water security from various sources

Subject area	Water security focus and definition
Agriculture	Input to agricultural production and food security
Engineering	Protection against water-related hazards (floods, droughts, contamination and tourism) Supply security (percentage of demand satisfied)
Environmental Science, Environmental Studies	Access to water functions and services for humans and the environment Water availability in terms of quality and quantity Minimising impact of hydrological variability
Anthropology, Economics, Geography, History, Law, Management and Political Science	Drinking water infrastructure security Input to food production and human health/well-being Minimising (household) vulnerability to hydrological variability Interdisciplinary links (food, climate, energy, economy and human security) Armed/violent conflict (motivator for occupation or barrier to cooperation and peace)
Policy	Sustainable development Protection against water-related hazards
Public Health	Supply security and access to safe water Prevent and assess contamination of water in distribution systems

Adopted from Cook and Bakker (2012:96)

Table 4.3: Definitions of the water security terms and concepts

Term	Focus/definition	Source
Availability	Sources (e.g. stand pipe, wells, caves and rainfall), reliability and quantity of water fit for human consumption and economic activities (e.g. farming, home gardening, watering livestock).	Bu-Chun <i>et al.</i> (2007); Asare (2004); WHO/ UNICEF (2000); Brauch <i>et al.</i> (2009)
Accessibility	Capacity of a household to easily access the sources of water for basic household needs (washing, bathing, cooking and drinking) and farming.	
Quality	Quality water that ensures disease-free household and good animal and crop production	

In rural settings as in the study areas, the availability of water is determined by the presence of water resources and supply in a particular locality, while accessibility to water may depend on affordable cost (payment, mechanism for water withdrawal and harvesting), physical location (reasonable distance and depth) and capacity to carry water (energy, health and household manpower). Based on distance and quantity of water per person, WHO/UNICEF (2000) have defined water access as availability of at least 20 litres per person per day from a source within one kilometre of the user's dwelling, whereas quality of water, for both household and farming, is a relative term and thus can attract different meanings based on perception, culture, clinical and pollutant levels (Asare, 2004). As with the components of food security, these components (accessibility, availability and safe water) are likely to be affected by a wide range of stressors. These include climate variability and change, infrastructure, land use and human interference, population increase and changes in social values and preferences, among others (see Savenije *et al.* 2009; Gleick, 1998; Asare, 2004; Arnel, 1999; Arnel, 2004; Falkenmark, 1990). For example, increasing dry spells not only affect water volume in a stream or well, they also compromise quality by increasing salinity through evaporation. Similarly, increasing demand due to population increase and expansion of economic activities that consume water may reduce water volume, thus affecting both availability and accessibility.

Indeed, there are direct linkages between water, food security and poverty. Water reliability will increase agricultural productivity and output, allowing local people to graduate from the food insecurity trap and in due course from poverty (UNEP, 2011; Hanjra and Qureshi, 2010). Although Zanzibar has done much to improve water accessibility and availability, at least at the household level (RGZ, 2009b), water supply in some coastal villages remains erratic, and local people, to a large extent still depend on local sources such as wells and caves which are prone to contamination and the impact of climate variability (Hansson, 2010; Kombo, 2011). For many coastal villages in Zanzibar, water from wells and community stand pipes and caves is commonly used for household needs and tourism (Hansson, 2010). Piped water is normally supplied from distant sources, as underground water close to the shore may be affected by salt water intrusion, even under minimum pressure. A study by Hansson (2010) has indicated that the richness of the aquifers in Zanzibar is unevenly distributed. Central Zanzibar has good aquifers compared to its peripheries; particularly the eastern parts where this study was conducted (also see Halcrow, 1994). The

hydrological cycle of oceanic islands like Zanzibar suggests that the depth of water lenses decreases as distance increases from the centre, thus making peripheral areas (e.g. the study sites) less resilient to salt water incursions and sea level rise (see Chapter 2). Further, although Zanzibar (Unguja and Pemba) has both perennial and ephemeral streams, the study sites are devoid of any of those streams. As there are direct relationships between water and food security and human welfare (Cook and Baker, 2012; Bu-Chun *et al.* 2007; Gbadegesin and Olorunfemi, 2011), this study considers water security as accessibility and availability of adequate, reliable and safe water for household needs, agriculture and other development sectors such as tourism without comprising the future of the water environment (see Table 4.3 for the meaning of these concepts). Thus, this Chapter will provide insight into the current status of water security across the study sites in order to understand the sensitivity and vulnerability of coastal communities to climate variability and change.

4.2 METHODS

This chapter combines data from several sources for triangulation. Apart from a household survey administered to 200 households (see Chapter 3 for more details and a profile of respondents), the results, particularly in relation to water security, were largely based on PLA approaches (see Chapter 2 for more details pertaining to PLA), interviews and collection of secondary information. Secondary data collected included those related to the number of households with latrines, number of households connected to electricity, number of people and households per village, number of local sources of water (coral caves and wells), and number of community stand pipes in each village within both the study sites. Regarding food security, the survey was designed to capture information on the availability and accessibility of major sources of food (staple, fish and vegetables), accessibility to other sources of food (seafood, meat and chickens), stability of accessibility of various types of food, and coping strategies to deal with food insecurity. In terms of water security, the survey captured information on sources of water for both farming and households, and water availability. The sections of the questionnaire and their analysis are outlined below.

a. Availability and accessibility of main sources of food

The households questionnaire was designed to gather data on variables such as access to sufficient staple food, fish, and vegetables throughout the year; the sources of major types of food (staple food, fish and vegetables), the costs of staple food and fish per month in households; and accessibility to other types of food (seafood, meat and chicken). This provided insight into the current status of food availability and accessibility amongst coastal households in both study sites. Regarding access to sufficient staple food, fish and vegetables, respondents were asked if their households had an adequate supply of these types of food throughout the year; the percentages of respondents saying ‘Yes’ or ‘No’ to each type of food was determined. In order to obtain more insight into which households were food secure or insecure, the

responses from the above question were first correlated with data that showed the diversity of livelihood activities for each household, and secondly cross-tabulated with the data on marital status to determine the relationship between food security and various social segments of the populations.

With regard to the sources of major food types (staple foods, fish and vegetables), respondents were asked three questions. The first question related to where households obtained most of their staple food, fish and vegetables. The second question provided an indication of the proportion of staple food, fish and vegetables bought from the market in comparison to the staple foods, fish and vegetables produced. This question was for those respondents who obtained most of their staple food, fish and vegetables through a combination of buying and producing their own. In the third question, respondents were asked to provide reasons for depending on a combination of buying and producing for themselves. Percentages of households were determined to understand the availability and accessibility of various types of foods in the households. With regard to accessibility to other types of food, respondents were asked how often they consumed meat, seafood and chicken (the responses were (1) often, (2) sometimes and (3) rarely), and the percentage of households consuming these foods was determined to understand the accessibility to these foods. The cost of food per month was intended to give an insight into the purchasing power of households which is an important component of food accessibility. The responses were then correlated using bivariate correlation with household size to determine the amount of money used for buying fish and staple food in relation to household size.

Stability of staple food/fish and vegetables

Respondents were asked three questions: firstly if they had ever experienced an unstable supply of the various types of food. If the answer was 'Yes', respondents were asked to identify seasons or years in which they experienced instability over the last five years. The last question aimed to identify strategies for coping with food instability in the households.

b. Availability of water for basic household needs, livestock and crop farming

Respondents were asked to identify the main source from which they obtained most of their water for household needs, livestock and crop farming. They were also asked if the chosen source provided sufficient water through the year. Water availability was then measured by the percentage of households with sufficient water throughout the year.

c. Water accessibility, quality and coping strategies

Accessibility of water was measured by the ratio of water sources to number of residents, distance to the nearest collection point of water, depth of the wells and the terrain of caves. The ratio was calculated from the population data and water source information obtained from local leaders and verified by a water

resources inventory. All local wells and caves were visited and depths of the wells were measured using rope and a measuring tape while the terrain of the coral caves was observed during the water resources inventory. Shallow wells, particularly those along the coast of Matemwe, were assumed to be more sensitive to contamination than those at the high ground of Kiuyu Mbuyuni and Matemwe which are very deep. Distance from the villages that had no easy access to community stand pipes to the nearest villages where water is readily available was calculated using ArcGIS. The vulnerability matrix workshops (see Appendix III) were also used to provide insights into all components of water security (see Chapter 2).

Semi-structured interviews were carried out to collect information on the current trends in water availability; accessibility and quality (see Box 4.1). Sixteen local people from all important water related sectors (household, livestock and crop farmers) were involved in the interviews, eight from each site, including the local leaders known as *sheha*. Interviews with key informants were also used to capture information on water security.

4.3 RESULTS AND DISCUSSION

4.3.1 Food security

4.3.1.1 Availability and accessibility of food in the households

Respondents across the sites were asked if they had enough staple foods (cassava, sweet potatoes, rice, sorghum and maize meal), fish and vegetables throughout the year and the results show that more than half of the households in all food categories (staple food, fish and vegetables) experienced periods of inadequate availability (Table 4.4). The number of households that experienced staple food shortages is slightly higher in Kiuyu Mbuyuni, Pemba compared with Matemwe Unguja. A sizeable percent of the households who perceived inconsistency in the accessibility and availability of these may be influenced by the fact that the surveys were undertaken in the aftermath of the 2007-2010 droughts which impacted local farming and production, and is normally associated with localised food shortages. With regard to fishery products the number of households that experienced inadequate availability of fish is slightly higher in Matemwe, Unguja than in Kiuyu Mbuyuni (Table 4.4). Low availability of fish in Matemwe, Unguja is probably influenced by the high demand triggered by tourism and the urban market in Zanzibar town. Similarly vegetables, both wild and locally grown are sensitive to erratic rainfall, especially where the soil is poor. This is captured in the following quote from a respondent in Matemwe:

“If rainfall becomes erratic we get a small amount of wild spinach in the bush, but these days even if we receive good rainfall and thus more wild spinach, we can’t enjoy it because after a short while the plants are affected by pests. I remember in those early days we used to have massive coverage of wild spinach in the bush, to the extent of inviting people from the neighbouring villages to come and harvest”.

Table 4.4: Adequate availability of staple food, fish and vegetables

Responses	Staple food (%)		Fish (%)		Vegetables (%)	
	Kiuyu Mbuyuni (N=94)	Matemwe (N=97)	Kiuyu Mbuyuni (N=93)	Matemwe (N=92)	Kiuyu Mbuyuni (N=85)	Matemwe (N=96)
Yes	15	29	32	20	11	16
No	85	71	68	80	89	84

These high levels of food insecurity mirror the findings in a study by Walsh (2009) which showed that localised food shortages along the east coast of both major islands including the study sites, is attributed to poverty, unreliable rainfall, and poor soils. Along a similar line of argument, Boetekees and Immink (2008) also contend that the observed problem of food security across the Zanzibar Islands, both urban and rural, is attributable to the low accessibility of food. Unlike the 1971/72 famine, which was influenced by both drought and the banning of food imports (Walsh, 2009), current food shortages may well be linked to the low capacity of people to purchase or produce food as even during good years, food insecurity and malnutrition are prevalent (Walsh, 2009). Furthermore, the small size of the farm plots (see Chapter 6) and a preference for rice, which is an imported commodity, may also contribute to the observed food shortage across the sites. While local climate variability, including decreased rainfall (see Chapter 5 and 6), affects locally grown crops (cassava, sweet potatoes, sorghum and millet), global climate change affects rice production in Asia, the major supplier of rice to Zanzibar (Peng *et al.* 2004; Mohandrass *et al.* 1995), and the global price of rice (Wang, 2010). In terms of fish, households that were solely dependent on buying fish are vulnerable compared to those who fish as they cannot afford to consume fish on a daily basis because of high price particularly during the fishing off-season. This is in line with Kent (1998) who concluded that, although fish is regarded as the food of the poor, in most cases it tends to disappear first from their plates when the supply is limited (also see Bell *et al.* 2009 and Pauly *et al.* 2005).

4.3.1.2 Relationship between food availability, livelihood diversification and gender of the household head

A bivariate correlation was performed to understand whether there was a relationship between inadequate availability of food and fish, as observed in Table 4.4, and livelihood diversification. The results of the test in Table 4.5 revealed no relationship between these variables across the sites ($p > 0.05$). The result suggests that livelihood diversity (multiple activities engaged in one household) within the household does not necessarily reduce the risk of food insecurity. Possibly, most of the diversification is on climate sensitive livelihood activities rather than on off-fishing and off-farming activities (see Chapter 3). This differs from a study conducted in northern Ghana which highlighted the positive and statistically significant impact of livelihood diversity particularly off-farm activities, on household food security (Owusu *et al.* 2011).

Table 4.5: Pearson correlation results between inadequate availability of food and fish and livelihood diversification and family size

Kiuyu Mbuyuni, Pemba			Matemwe, Unguja		
Types of food	Pearson Correlation	Livelihood diversification	Types of food	Pearson Correlation	Livelihood diversification
Food (N=94)	Correlation	-.002	Food (N=97)	Correlation	-.022
	P value	.982*		P value	.834*
Fish (N=93)	Correlation	.015	Fish (N=92)	Correlation	.121
	P value	.886*		P value	.249*

* Pearson correlation was not significant ($p > 0.05$ level, 2 tailed).

Although livelihood diversification is known as a coping strategy to food security (Ellis, 2000; Barrett *et al.* 2001a; Barrett *et al.* 2001b), the observed low availability of food throughout the year is indicative of the failure of livelihood diversification to ensure food security in the study areas. This is mainly due to the fact that diversification of livelihoods was based on activities such seaweed farming, livestock and poultry and fishing (Chapter 3) that are sensitive to normal seasonal variations in climate (Chapter 6). Therefore, households that have diversified only on fishing, seaweed farming and farming are likely to face problems in food supply due to low returns. This again demonstrates the idea of risk co-variance across the communities where risks from climate variability affects all important activities and thus compromise food security for the majority.

Furthermore, low availability of food across the sites might also be linked with the role of wife and husband in the well-being of a household. Seaweed farming is viewed as an alternative source of income in many coastal villages (Msuya, 2011). It is mostly practiced by women who, based on gender roles stipulated in Islamic religion and culture, are not required to use their income from seaweed farming or other sources for household needs (see Chapter 3). One can also argue that the observed food insecurity may be influenced by gender roles as husbands, who either engage in fishing or other small-scale informal activities, are unable to ensure the availability of food throughout the year, because of various obstacles to those activities. Along the lines of this argument, Barrett *et al.* (2001a) argue that the prosperity of off-farm and off-fishing activities is highly dependent on access to markets and to finance and skills. In investigating the features, dimensions and impacts of rural livelihood diversification, Start (2001) found that the rural economy is mostly associated with low returns and limited opportunities for local people to graduate from poverty.

Lastly, despite decreased land holding and increased frequency of droughts across the sites (see Chapter 6), the introduction of seaweed farming in the early 1990s continuously divides family labour between seaweed farming and crop farming. Since women were big players in small-scale farming (Becker, 2000; Scanlan, 2004), the introduction of seaweed farming has probably reduced their contribution to crop production and thus reduced agricultural production per household.

A cross-tabulation was performed to determine whether there was a relationship between ‘lack of enough food’ and female-headed households (widows). Although the number of female-headed households was very small, the results in Table 4.6 show that across the sites, households that were headed by a female (widow) were sensitive to food insecurity. For example all the widows interviewed in Kiuyu Mbuyuni and four out of five in Matemwe, experienced food shortages. Similarly, eight out of nine widows in Kiuyu Mbuyuni and two out of three in Matemwe could not access adequate fisheries resources. Most of the households with married couples, however, also experienced inconsistent supplies of food and fish in their homes (see Table 4.6). Although the results demonstrate that food availability and accessibility problems cut across marital status, female-headed households are more vulnerable to food insecurity as the majority experienced poor availability of staple food and fish. Other studies showed that vulnerability of female headed households to poverty and food insecurity is attributable to scarce resources, fewer working people in the household, less access to remunerative jobs and to productive resources such as land, as well as poor livelihood diversification (Buvinić and Gupta, 1997). However, one should be cautious about associating female-headed households with poverty and food insecurity in general, as sometimes they can be more powerful and wealthy than households headed by males or they may use their resources more carefully often putting food for their families first (Buvinić and Gupta, 1997; Chant, 2009).

Table 4.6: Relationship between marital status and inadequate availability of food

Staple food availability	Kiuyu Mbuyuni, Pemba (F)				Matemwe, Unguja (F)			
	Married (N=80)	Divorced (N=3)	Single (N=2)	Widow (N=9)	Married (N=84)	Divorced (N=2)	Single (N=6)	Widow (N=5)
Yes	13	1	-	-	26	1	-	1
No	67	2	2	9	58	1	6	4
Fish availability	Kiuyu Mbuyuni, Pemba (F)				Matemwe, Unguja (F)			
	Married (N=78)	Divorced (N=4)	Single (N=2)	Widow (N=9)	Married (N=80)	Divorced (N=3)	Single (N=6)	Widow (N=3)
Yes	25	3	1	1	15	-	2	1
No	53	1	1	8	65	3	4	2

Note= Widow implies a woman who has lost her husband; divorced can be either male or female

4.3.1.3 Understanding sources of major food types in connection with availability and accessibility of food in the households

Respondents were asked, ‘Where does your household get most of its food, fish, and vegetables?’ The results in Table 4.7 show that none of the households interviewed depended solely on the farm to meet their staple food demands throughout the year. About 17% and 40% of households in Kiuyu Mbuyuni and Matemwe respectively, bought most of their food. As expected, the majority of the households (85%) in Kiuyu Mbuyuni, and more than half of the households in Matemwe were buying and producing their staple food. When asked to estimate the proportion of the food they bought compared with the food obtained from farm plots, the results in Table 4.8 show that 98% of the households in Matemwe, Unguja were buying more than half of their food needs. This dependence on purchased food is highlighted below in a comment

from a respondent in Matemwe. The reasons cited for the high dependence on food from shops included poor soils, low rainfall, saving money, scarcity of land, no water for irrigation, pests and diseases, and the absence of rice fields (Table 4.9).

“For five years now, a large part of my food comes from shops. Farming is like our religion: one must do it but truly speaking, we are getting nothing out of it. The soil is very poor and rains during short rainy seasons have disappeared lately”.

Table 4.7: Sources of major food types

Sources	Staple Food (%)		Fisheries products (%)		Vegetables (%)	
	Kiuyu (N=99)	Matemwe (N=96)	Kiuyu (N=100)	Matemwe (N=91)	Kiuyu (N=99)	Matemwe (N=99)
Buying	17	40	36	34	29	29
Own farm/fish	-	-	42	39	19	11
Buying+ own/fish/gardens	83	60	22	22	52	50
Relatives/neighbours	-	-	-	5	-	-
Wild	-	-	-	-	-	10

With regard to fish, a large proportion of the respondents across the sites caught their own fish for consumption (Table 4.7). About 36% and 34% respondents in Kiuyu Mbuyuni and Matemwe respectively, bought most of their fish, whereas, 22% in both the sites were both buying and fishing for themselves. When asked to estimate the proportion of the fish they bought compared with the fish obtained from their fishing activities, the results in Table 4.8 show that 41% of the respondents in Kiuyu Mbuyuni and 52% in Matemwe were buying about half, while 27% and 38% in Kiuyu Mbuyuni and Matemwe respectively, were buying more than half of their requirements (Table 4.8). Households that combined both buying and fishing for most of their fisheries product demands were asked to give reasons for this combination and the results in Table 4.9 show reasons such as other work, old age and health and seasonality of winds and tides. About 5% of the households in Matemwe were mostly dependent on relatives and neighbours for fish products. This implies the power of social capital as safety net (see Chapter 3)

Perhaps the most striking results relate to the sources of vegetables. Unexpectedly, only 19% and 11% of the households in both Kiuyu Mbuyuni and Matemwe respectively, were solely dependent on their gardens for vegetables. About 29% in both sites bought most of their vegetables, while 53% in Kiuyu Mbuyuni and 50% in Matemwe bought and produced their vegetables (Table 4.7). When asked to estimate the proportion of the vegetables bought, about 40% and 41% of the respondents in Kiuyu Mbuyuni and Matemwe respectively said they bought about half of what they needed, whereas 23% in Kiuyu Mbuyuni and 44% in Matemwe bought more than half of their vegetables (see Table 4.8). Reasons given for not being self-sufficient were poor soils, low rainfall, scarcity of land, diseases and pests and insufficient water for irrigation (Table 4.9). Furthermore, about 10% of the households in Matemwe drew many of their vegetables from the wild (Table 4.7). These findings further demonstrate the sensitivity of these communities to stressors such as price fluctuations as the majority of the respondents were either buying all

of their vegetables needs or buying almost half of their needs. One would expect to see communities like these self sufficient in vegetables through home gardening.

Table 4.8: Proportion of the food bought by the household in relation to the food produced

Responses	Staple food (%)		Fisheries products (%)		Vegetables (%)	
	Kiuyu (N=83)	Matemwe (N=59)	Kiuyu (N=22)	Matemwe (N=21)	Kiuyu (N=47)	Matemwe (N=46)
About half	21	2	41	52	40	41
Less than half	5	-	32	10	36	15
More than half	75	98	27	38	23	44

Table 4.9: Reasons for households buying and producing their own food

Variables	Reasons	Kiuyu, Mbuyuni	Matemwe
	Fishing products	NR=22	NR=22
Reasons for buying and fishing	Doing other work	30	64
	Old age/health	4	-
	Seasonality of winds and tides	55	32
	Fishers camped and fish outside areas	11	5
	Staple food	NR=126	NR=118
Reasons for buying and cultivating staple food (e.g. banana, cassava)	Poor soils	26	18
	Low rainfall	19	21
	Save money	23	21
	Scarcity of land	6	18
	No water for irrigation	14	11
	No rice paddies	9	5
	Busy with other job	3	1
	Pests and diseases	-	5
	Greens and vegetables	NR=66	NR=77
Reasons for buying and cultivating (e.g. spinach, green peas, beans)	Poor soils	19	21
	Low rainfall	16	23
	Save money	27	20
	Scarcity of land	3	10
	No water for irrigations	28	18
	Busy with other job	6	-
	Diseases and pests	-	8

NR= number of the responses

Table 4.7 and 4.8 clearly demonstrate that the majority of the households across the sites were either buying or using a combination of buying and producing their staple food, vegetables and fish. The results are inconsistent with other parts of Africa, particularly with regard to staple food; for instance, in the rural district of Moma and Mabote in Mozambique more than 80% of households draw their food solely from their farm plots (Hahn *et al.* 2009). Given the high levels of poverty within the households across the sites (Mkenda cited in RGZ, 2009; Wash, 2009), concentrating on buying all sources of food, including vegetables, is a major source of vulnerability as they depend on unreliable sources of income such as fishing and seaweed farming. The observed trend toward solely buying diminishes the purchasing power, savings and access to assets for future adaptation to climate variability and change in the long run. This sheds light on the reported localised food shortages in 2006-2007 (Walsh, 2009) and 2009-2011 (Said, 2011), especially in the Pemba site (Kiuyu Mbuyuni) being largely influenced by low purchasing power in the households as imported food is readily available in the food stores.

The findings also suggested that a household's self-sufficiency with regard to the main types of food is challenged by a number of factors both climatic and non-climatic. Some of the reasons cited, such as scarcity of land for farming, poor soils and infrastructure for irrigation, are more powerful than the observed variability of rainfall and future changes in climate. However, climate change has the potential to interact adversely with these natural and developmental challenges, increasing vulnerability to food insecurity. Even in countries with massive land resources, these challenges threaten rural livelihoods and food security all over the developing world (Droogers, 2004; McDowell and Hess, 2012; Aggarwal *et al.* 2010; Ellis and Mdoe, 2003). For instance, a study by Ellis and Mdoe (2003) in Tanzania found that poverty and associated food insecurity in rural areas is linked to a lack of land, livestock and low diversification into off-farming activities (also see McDowell and Hess, 2012). Thus, reducing the severity of localised food shortages in small islands like Zanzibar requires a strict land use plan and increased access to irrigation facilities, farming inputs and assets related to fisheries. Creating employment is also an important strategy as it would expand the livelihood portfolio in these communities.

4.3.1.4 Costs of staple food and fish

Apart from production, purchasing power is one of the important determinants of food accessibility in the households (see sub-section 4.1.3). In this regard, respondents from households that were solely buying food/fish and those households that combined buying and self-production in both fish and food were asked to estimate the cost of each type of food per month. The results in Table 4.10 show that a large proportion of the households used between Tsh.70000 to more than Tsh.100000 for buying staple food (mainly rice), and with regard to buying fish, the majority of households used between Tsh.10000 to Tsh. 50000. The mean monthly staple food cost was calculated at Tsh.70000-100000 across the study sites. This average cost of food per month was a bit higher compared with the average income of the fishers per month (Tsh.50000-70000) across the sites (see Chapter 6), which was found to be the main source of income. Further, the mean monthly cost for buying fish was Tshs.30000-50000 with minor variations, in both sites (Table 4.10). As the majority of the fishers were heads of their households, the findings imply that they used more than what they earned and thus their capacity to save money was reduced. This supports findings in Chapter 3 which revealed that the majority of the people lacked disposable income that would enable them to participate in savings clubs.

Table 4.10: Cost of staple food and fish per month

Cost (in Tanzania shillings)	Staple food		Fish	
	Kiuyu Mbuyuni (N=97) (%)	Matemwe (N=95) (%)	Kiuyu Mbuyuni (N=57) (%)	Matemwe (N=52) (%)
5000-10,000	-	-	2	4
10,000-30,000	-	3	42	50
30,000-50,000	13	17	40	34
50,000-70,000	19	29	14	10
70,000-100,000	36	28	2	2
100,000 and above	32	23	-	-
Mean ±SE	70,000-100,000±.103	70,000-100,000±.115	30,000-50,000±.125	30,000-50,000±.177

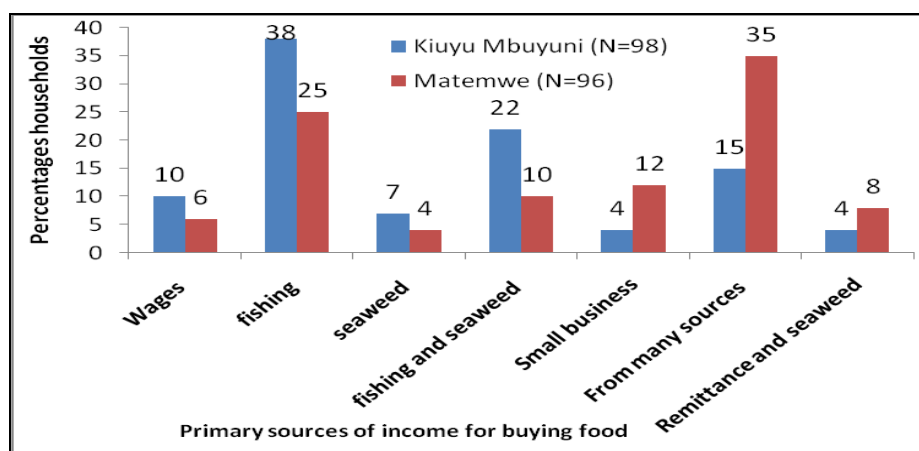
Exchange rate in 2011 was 1 USD = 1,600 Tanzanian shillings

A Pearson bivariate correlation was performed to calculate the cost of food and fish per month related to household size, and the results in Table 4.11 as expected revealed a significant positive correlation between the cost of food and household size. However, there was no correlation between the cost of fish and household size. This again demonstrates that fishery products are no longer an important part of the normal meal due to declining fish catches, more alternative markets and increasing prices for those who buy their fishery products. For fishers the perceived decline in fish catch has forced them to sell a larger part of their catch compared to what is supplied to their home. The average household size for the interviewed household was six in both sites (Table 3.1 in Chapter 3). Although Chapter 3 showed that natural resource-related activities were the major source of both cash and kind across the sites, respondents were also asked to identify sources of money for buying staple food. This question was also asked for fish and for vegetables, but because the responses were almost the same the question above was used to represent sources of money for buying vegetables and fish. The results in Figure 4.1 show that 38% and 25% of the respondents in Kiuyu Mbuyuni and Matemwe households used money from fish to buy food. About 22% in Kiuyu Mbuyuni and 10% in Matemwe used money from a combination of fish and seaweed. The fact that more people depend on seaweed in Kiuyu Mbuyuni is because more males are engaged in seaweed production compared to Matemwe (Chapter 3). Respondents cited other sources of money including wages, small businesses and a combination of remittances and seaweed. A considerable number of respondents were also drawing money from several sources to buy food. This highlights how sensitive local people are to food insecurity as most of their sources of income for buying food are vulnerable to current variability and future changes in climate (Chapter 6).

Table 4.11: Pearson correlation between cost of food and fish per month and household size

Kiuyu Mbuyuni, Pemba			Matemwe, Unguja		
Food expenses	Correlation	Household size	Food expenses	Correlation	Household size
Food (N=97)	Correlation	.388	Food (n=95)	Correlation	.594
	P value	.000*		P value	.000*
Fish (N=57)	Correlation	.185	Fish (n=52)	Correlation	.000
	P value	.167		P value	.998

*Correlation was significant

**Figure 4.1: Primary sources of income for buying food**

The high use of income mainly obtained through fishing or other natural resource-based activities to buy food in the two study sites is similar to other developing countries. For example, a study by FAO (2011) shows that in many developing countries, total food expenses are about 70% of total household expenditure. Apart from food, these households are expected to spend on health, education, cooking energy, lighting and clothes, among others. This means household saving is reduced and the household's capacity to respond to risks and shocks related to climate change and other linked stressors is weakened. For example, since the income from fishing which is the main source of income across the study sites, is affected by seasonality (see Chapter 6), and crop farming is sensitive to variability in climate and soils, food insecurity along the east coast may also be influenced by the low food purchasing power of households. In the line of this argument, Boetekees and Immink (2008) also contend that low purchasing power, associated with few off-fishing and off-farming activities are responsible for food insecurity and malnutrition in rural Zanzibar.

For instance, apart from low fish consumption in the households during fishing off-season (see section 4.3.1.5), even during good seasons this study observed low purchasing power amongst local people in local markets and landing sites in both the study sites. Most of the fish landed were bought by middlemen and traded outside the areas (urban centres) or in tourism hotels; it is clear that low income groups and the poor consumed far less fish compared with the more affluent population (Kent, 1998). FAO has since acknowledged that increased demand by people in urban areas with purchasing power will ultimately

impact the fish consumption of the growing population of the poor (FAO, 2012). Coastal communities along the Zanzibar coast are more vulnerable because other sources of protein are far beyond their reach or not preferred (see section 4.3.1.6). Other researchers have made similar findings pertaining to the decline in fish consumption due to an increasing demand in urban centres and in developed countries. For example, a study by Molony *et al.* (2007) and Johnson (2008) found that low levels of fish consumption and high rates of malnutrition and stunted growth as a result of protein deficiency in areas around Lake Victoria in Tanzania, could be attributed to the high demand for fillets of Nile perch in Europe. The current national fish per capita consumption in Zanzibar is 20-25 kg (Zanzibar Department of Fisheries, 2011), lower than that of other SIDSs, especially in the Pacific. For example, in Tuvalu Islands, the per capita consumption of fish was 110.7 kg, while in Samoa and French Polynesia it was 87.4 kg and 70.3 kg respectively (Bell *et al.* 2009). Although fish production has increased globally, the recent report on the state of the world fisheries and aquaculture shows that fish consumption in Africa in general was far below that of Asia (FAO, 2012).

Food availability and accessibility is threatened not only by climate variability but also by a number of development challenges (Barrett, 2007). Whatever the factors may be, deteriorating purchasing power of the coastal communities would have huge effects both on food security and utilisation of natural resources, which are crucial for future adaptation to climate change. For example, increasing the size of households means increasing demands for cash to feed the population that will in turn lead to competition and over-utilization of resources such as water, cooking energy and fisheries resources (Charles *et al.* 2010; Hanjra and Qureshi, 2010). At the global scale, many recent studies argue that the world will not be able to feed nine billion people by 2050, unless strict measures are in place (Charles *et al.* 2010; Tomlinson, 2013; Merino *et al.* 2012). With limited land and a small economy, coupled with a high population increase (The population of Zanzibar had increased from 988,754 in 2002 to 1,303,568 by 2012 (URT, 2013)), Zanzibar needs to be in the front position to manage its limited resources in order to increase availability and accessibility of food in the face of current variability of climate, and future changes in climate.

4.3.1.5 Stability of food in the household

Stability refers to a consistent supply of food in the household. In order to understand the nature of food stability in the study areas, respondents from all categories (self-producing/fishing, buying, and a combination of buying and self-producing/fishing) were asked whether they had ever experienced an inconsistent supply of food/fish/vegetables in their household over last five years. The results in Figure 4.2 show that the majority of the respondents across the study sites said that their households had experienced such inconsistency and instability in the supply of fish. With regard to staple food, 76% of the respondents in Kiuyu Mbuyuni and 81% in Matemwe said that inconsistency in the supply of staple food was a common phenomena in their households, whilst about 69% and 85% of the respondents in Kiuyu Mbuyuni and Matemwe respectively, also experienced instability in the supply of vegetables.

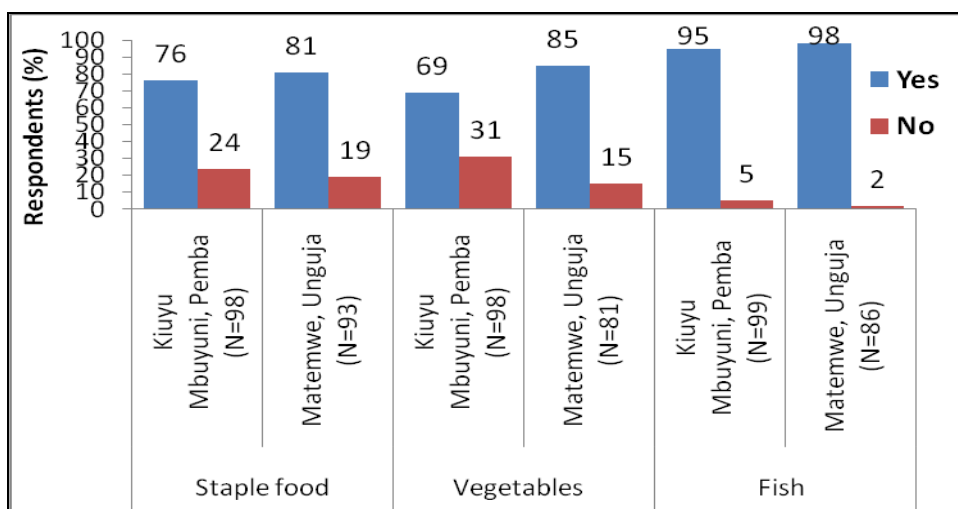


Figure 4.2: Responses of respondents on whether households ever experienced food/fish/vegetable instability over last five years

In order to understand the primary causes of food supply instability in the households, respondents from all categories (as identified above) were asked to identify years or seasons when households were severely affected by supply inconsistency over the last five years. The results in Table 4.12 show that the responses related to staple food and vegetables were very similar. Most of the respondents mentioned the 2009-2010 period in which they faced both food and vegetable instability. During this particular period, both islands particularly along the east coast, experienced high rates of abnormal rainfall which resulted in localised food shortages across the sites (see Chapters 5 and 6). The largest percentage of respondents who mentioned this period were probably influenced both by difficulties during this period and the fact that the study survey was conducted in the aftermath of the drought associated with this period.

Table 4.12: Years or seasons of difficulty in obtaining enough food

Variables	Year/season	Kiuyu (N=72)	Matemwe (N=67)
Year or season shortage of food experienced	Dry season of each year	4	10
	South-easterly wind season each year	10	13
	2009-2010	83	75
	2007-2008	3	2
Year or season shortage of vegetables experienced	Vegetables	N=66	N=67
	Dry season of each year	17	36
	South-easterly wind season each year	-	2
	2009-2010	80	60
	2007-2008	3	3
Season shortage of fish products experienced	Fisheries products	N= 93	N=86
	South-easterly wind season of each year	97	94
	Rainy season of each year	3	4
	North-easterly wind season of each year	-	2

Other periods identified in which households experienced difficulties in obtaining food and vegetables include the dry season of each year, every season of south-easterly winds, and the period between 2007-

2008 (Table 4.12). This period was one of dry spells, particularly along the east coast, that affected both crops and vegetables (see Chapter 5). Since the majority of the households depended on fishing for their income to buy food, a considerable number of the households faced food and vegetables instability during the fishing off-season (season of south-easterly winds) (see Table 4.12). Therefore, the reported difficulties in obtaining food during this period can be translated as a lack of savings obtained during the fishing seasons; this again highlights the danger of over-dependence on purchased staple food. This point is also highlighted by a comment made by a respondent in Kiuyu Mbuyuni:

“Although we have now obtained more money for selling just a small amount of fish catch, whatever we earn ends up in buying food, so we are facing difficulties of obtaining money for food during the off-season”.

As expected, the majority of the households across the sites believed that the insufficient availability of fish is most pronounced during the south-easterly wind season which lasts approximately three months (Table 4.12). This wind season, known locally as *kusi*, is a period in which the wind blows in a south-easterly direction away from the Zanzibar coast and is believed to drive fish away from the coast (Chapter 5). More importantly, the wind hampers small vessels (outrigger canoes), the most common fishing vessels, from making fishing trips, mainly because small vessels like these cannot sail against the south-easterly wind on their way back from fishing trips. Thus many fishers remain at home during this season to minimise risk (see Chapters 5 and 6). During this period therefore very few boats operate (mostly motorised boats), and thus demand increases and the price of fish products becomes too high for most people to afford. Even those households who were solely buying fish from the market faced instability of fish consumption as they could not compete with the prices paid in urban and tourism markets during this time of the year.

Even during normal fishing seasons (calm and north-easterly wind seasons), most of the fishers only operate during spring tides (approximately 17 or 20 days in each month). A spring tide occurs when the moon is either new or full and the difference between high and low tide is the greatest. Given the decline in fish catch per fisher (Chapter 6) and the high demand for cash amongst fishers to buy staples, it appears that many households experience food instability on a monthly basis as far as the availability and accessibility of fish goes, as demonstrated in the following comment by a respondent in Matemwe:

“The amount of fish supplied at home depends on the amount of fish caught; if we land more fish we will consume more fish, but if we land less we will consume less”.

Apart from seasonality and tidal variations, instability in the accessibility and availability of fish in the households can also be linked with poor rural electrification and lack of refrigeration facilities (see Chapter 3), which prevent households from saving fish on good days. As a result, they constantly face the problem of fish availability and accessibility during the off-season, as reflected in this comment by a respondent in Kiuyu Mbuyuni, Pemba:

“Since we have no refrigeration to freeze fisheries products on good days, we are forced to consume dry anchovies (*dagaa kavu*) or plain meal (staple food alone) during the off-season”.

The foregoing analysis demonstrates that seasonality, coupled with variability of rainfall, lack of savings and of course, lack of off-farming and off-fishing activities affects the availability and accessibility of staple food, vegetables and fish. For example, although food instability and widespread malnutrition are common along the east coast, even in good years (Walsh, 2009) seasonal variation in rainfall intensifies the severity of food insecurity and nutritional status of the coastal communities. In Dinajpur, Bangladesh, food instability is far higher during the monsoon season than other seasons in the year (Hilbruner and Egan, 2008). Similarly, poor rural families in India are forced to cope with food insecurity attributed to seasonal agriculture production caused by erratic rainfall and calamities (Agarwal, 1990). In assessing the risk of climate variability and change in two Mozambican communities, Hahn *et al.* (2009) also found that, apart from other factors, climate variability and change disasters such as floods and droughts have caused food instability for between three and eight months per year. In summary, rural populations are unable to cope with normal seasonality, and thus are more sensitive to future extremes of both weather and sea level change.

4.3.1.6 Availability and accessibility of other food types

In a situation where the consumption of fish in coastal villages is perceived to be declining because of seasonality, lack of technology, increasing demand and low access to storage facilities such as electricity and refrigeration, respondents were asked how often their household consumed other seafood, meat and chicken. Here, seafood does not comprise of fish but crustaceans (crabs, prawns, shrimps, and lobsters), molluscs (various types of shellfish), cuttlefish and octopus. Meat comprised both beef and meat from goats. The results in Table 4.13 show that more than half of the households in both the study sites rarely consumed seafood, while 42% and 38% of the households in Kiuyu Mbuyuni and Matemwe respectively only consumed seafood sometimes. Seafood consumption, which was once regarded as an important source of additional protein in coastal villages has diminished considerably and become rare for the majority, because of its value to both tourists and urban dwellers.

Table 4.13: The consumption of other sources of protein

Variables	Seafood (%)		Meat (%)		Chickens (%)	
	Kiuyu (N=100)	Matemwe (N=88)	Kiuyu (N=98)	Matemwe (N=88)	Kiuyu (N=99)	Matemwe (N=94)
Often	5	4	-	1	1	1
Sometime	42	38	14	32	86	65
Rarely	53	58	86	67	13	34
Mean±SE	2.48±.059	2.53±.062	2.86±.036	2.66±.053	2.12±.036	2.33±.051

Numbers used to generate mean score: 1=often, 2=sometimes and 3=rarely

Although Kiuyu Mbuyuni has no tourism hotels, seafood is traded as far as Zanzibar town and Mombasa, Kenya; it has been observed that in Kiuyu Mbuyuni, Pemba, octopuses were informally traded in Mombasa, Kenya. Despite the local belief that eating octopus increases male potency, fishers themselves cannot afford to eat them; they prefer to sell them in order to provide for household needs, including food and iron roofing for their homes. This is highlighted in the following testimonies from respondents in Kiuyu Mbuyuni and Matemwe:

“Currently one octopus can fetch up to USD 10, thus no one dares to consume octopus; after all, octopus is not a staple food. He would rather sell it in order to obtain money to meet other demands. Truly speaking, octopus has become a food for tourists and not for the poor”.

“Since octopus is no longer available in shallow water, they have remained out of reach for the majority of foot fishers who have no vessels that could take them offshore where the octopus is available. Because of the value of octopus, most fishers who concentrated on collecting them managed to roof their homes with iron”.

“Fish are available in Matemwe but people who are eating good fish are not natives. Most of them are tourists. People of this village can't afford to buy fish. I, like other villagers, we eat vegetable mostly. The only type of fish we afford to buy is dry anchovy (dagaa kavu). Octopus and squids are very expensive and none of the villagers can afford to buy them”.

With regard to various types of meat, the results in Table 4.13 show that most households across the sites rarely consumed meat. About 14% of the interviewed households in Kiuyu Mbuyuni and 32% in Matemwe consumed meat only sometimes. The mean for Kiuyu Mbuyuni was $2.86 \pm .036$ and Matemwe, $2.66 \pm .053$, the degree of consumption ranged from 1 (often) to 3 (rarely). The results tally with the following testimonies from respondents:

“Since we got married two years ago, we have never eaten meat of any kind.” (Respondent from Matemwe)

“We only eat meat during Eid celebrations (Two Eid celebrations per year in the Islamic calendar) and during a wedding ceremony in the village” (Respondent from Kiuyu Mbuyuni, Pemba).

The consumption of chicken across the sites also inclined towards the rare category. The mean was $2.12 \pm .036$ for Kiuyu Mbuyuni and $2.33 \pm .051$ for Matemwe. Although livestock and poultry keeping were common, especially in Kiuyu Mbuyuni, Pemba, both cattle and chicken were used as a source of manure to improve the soil and as assets to sell when needed (see Chapter 6).

In this instance, it can be argued that Zanzibar coastal communities experience low accessibility, not only of primary sources of food (staple food, fish and vegetables) but also of other types of foods such as seafood, meat and chickens and are thus vulnerable to food insecurity. However, the observed low consumption of meat and chicken may be associated with household choices in order to increase assets (see Erickson, 2008; Maxwell, 1996). For instance, a household may opt not to sell their cattle in order to solve an immediate but small problem (e.g. a food shortage in the household) so that they can increase stock for future adaptations.

With regard to other seafood (crabs, shrimps, lobsters, octopus), the observed low consumption is clearly linked to increasing demand both within and outside the country, especially in the tourism industry (Garcia and Rosenberg 2010), and these food stuffs are no longer an important part of the diet for the majority of coastal communities. Globally, these commodities represent the most valuable fishery exports; for example, Indonesia and Nigeria export shrimps worth \$887 million and \$49 million respectively (Bondad-Reantaso *et al.* 2012). In examining the role of crustaceans and aquaculture in global food security, Bondad-Reantaso *et al.* (2012) postulated that the high income obtained from selling crustaceans would enable producers to buy lower value products and thus contribute to food security. However, changes in food patterns as observed in the study areas may have a negative impact on the nutritional status and health of coastal communities (Pelto and Vargas, 1992 cited in Hazanaki and Begossi, 2003; Receveur *et al.* 2007; Kuhnlein *et al.* 2004). Kuhnlein and Receveur (1996), cited in Hazanaki and Begossi (2003), also argue that changes in local diet, such as omitting octopus and crustaceans, as in the case of the study areas, will affect local knowledge of both consumption and conservation. At this juncture, one can argue that sacrificing consumption of various seafoods, including octopus, to generate income, without replacing it with food of equal nutritional value, may have negative consequences for the dietary patterns of the coastal communities.

4.3.1.7 Coping strategies for food instability at the household level

Periodic food shortages and famine are not new phenomena in the areas. For example, in the 1971-72 famine, local people used various strategies to cope (Walsh, 2009). The most frequently cited strategies for coping with staple food instability were loans from shops or neighbours, reducing the volume of the meal, sleeping without eating and reducing the number of meals (Table 4.14). Other coping strategies, only cited in Kiuyu Mbuyuni, were eating wild food and accruing food aid (Table 4.14). The large number of respondents who obtained food loans is largely related to the findings in Chapter 3, which showed that more than half of the respondents had outstanding debts and most of the debt came as food loans.

With regards to vegetables, which in most cases were considered as optional, respondents also cited a wide range of coping strategies (Table 4.14). These included consuming more fish, buying from the market for those used to grow vegetables themselves, consuming staple food without vegetables, eating more beans bought from the market and consuming dried wild spinach. Eating dried wild spinach locally known as *mchungu* was more common in Matemwe than in Kiuyu Mbuyuni (see Table 4.7).

Table 4.14 Coping strategies for food insecurity at the household level

Coping with staple food insecurity (%)		
Coping strategies	Kiuyu Mbuyuni (N=67)	Matemwe (N=60)
Food loan	51	52
Food aid	3	-
Eating wild food	5	-
Sleeping without eating	20	8
Reducing volume per meal	19	38
Reducing number of meals	3	2
Coping with vegetables insecurity (%)		
Coping strategies	Kiuyu Mbuyuni (N=73)	Matemwe (N=71)
Consuming fish	27	25
Buying from market or other village	22	17
Eating staple food without vegetables	48	42
Eating food with beans bought from shops	3	6
Eating dried wild spinach obtained during rain seasons	0	10
Coping with fisheries product insecurity (%)		
Coping strategies	Kiuyu Mbuyuni (N=82)	Matemwe (N=84)
Eating fish stored in fridge	1	2
Eating beans, pigeon peas and vegetables	37	31
Buying from outside	1	-
Eating fresh sardine and mackerels	-	10
Eating dried small anchovies	30	38
Eating staple food only	32	19

The findings mirror those in urban Uganda (Maxwell, 1996), in urban Accra, Ghana (Maxwell *et al.* 1999) and in an informal settlement in the Vaal Triangle, South Africa (Oldewage-Theron *et al.* 2006). In urban Uganda people ate food that was less preferred, limited portion size, borrowed food or money and skipped meals (Maxwell, 1996). Unlike the 1971-72 famine, during recent localised food shortages, the consumption of cultivated plants and wild food such as poisonous wild yam (*Dioscorea sansibarensis* Pax), locally known as *chochoni* (see Plate 4.1) as a response to famine (Walsh, 2009) was marginal, probably due to the availability of imported food in the shops, and because it is not difficult to obtain a food loan from local shops because of the high social bonding capital (Chapter 3) (for the details of other cultivated plants and wild food used in Zanzibar during previous famines see Walsh, 2009). Although food insecurity is widespread in Zanzibar (Boetekees and Immink, 2008), strong social capital, through willingness to help with each other and strong neighbourhoods (also see Chapter 3), coupled with the availability of imported food in the shops, has probably helped reduce the severity of food insecurity, especially during droughts. This spirit of helping each other during the time of crisis was also observed in the previous famines in Zanzibar (Gray, 1956 cited in Walsh, 2009).



Plate 4.1: Poisonous wild yam (*Dioscorea sansibarensis* Pax), locally known as *chochoni*, used as food during famine and prolonged drought in north east Pemba.

With regard to fisheries products, respondents also identified a range of strategies that helped them cope with insufficient fish products in their meals. The most cited coping mechanism was consuming dry anchovy and vegetables, including beans and pigeon peas (Table 4.14). About 10% of households in Matemwe replaced high-value fish species with low-value (based on the perception of the consumers), cheaper species such as sardines and Indian mackerel. These fish species move in large schools and are mostly caught in large quantities (Richmond, 2010); as a result, prices are generally affordable and thus they are a common food for the poor and needy in all the poorest countries in the developing world (Albert and Marc-Metian, 2009). In Kiuyu Mbuyuni, Pemba however, these species are perceived to be declining (see Chapter 6) which is why no one indicated them as an option for coping with fish supply instability. About 32% of households in Kiuyu Mbuyuni and 19% in Matemwe were doing nothing to cope with insufficient fisheries products; they simply ate plain meals without either vegetables or dried anchovies. Given the observed low intake of other sources of protein, these households could become more susceptible to dietary problems. The ‘do nothing’ responses demonstrates the variance in vulnerability across social groupings.

For many, eating dried anchovies (*dagaa kavu*) particularly amongst the fishers, was not preferred as they were mostly (and still are) used for making chicken feed. In other parts of the world small pelagic fish like anchovies, herring, mackerel and sardines are also used for animal feed and fishmeal (Albert and Marc-Metian, 2009), mainly because these species represent the largest landed species and, in most cases, are less preferred by the affluent population. Thus, the increasing price of fresh fish due to high demand in both urban and tourism markets, and the need for hard cash on the part of the fishers have forced households to rely heavily on dried anchovies as a replacement for fresh fish, even during fishing seasons.

Although dry anchovies used to be considered a low value food, especially along the coast, and eaten only occasionally, their value is now being realised more than ever, even by the urban poor, because of the high price of fresh fish. A dry anchovy probably contains as many important micronutrients for human health as fresh fish but competition between non-food uses and direct human consumption and global climate change (Albert and Marc-Metian, 2009; Chapter 6) is threatening this small pelagic fish all over the globe. Indeed, increasing demand for dried anchovies in urban areas and in mainland Tanzania and neighbouring countries will, sooner rather than later, put dry anchovies out of the reach for the majority of the poor in Zanzibar. This will further intensify vulnerability to food insecurity for the majority because vegetables, peas and beans, both cultivated and wild, are sensitive to periodic drought. In this regard Kent (1998:403) concluded that “when fish decline and the price goes up, poor people are forced to shift into inferior food, putting them at risk of missing important micronutrients”.

4.3.2 Water security

4.3.2.1 Sources of fresh water for households and farming

Respondents were asked where the household acquires most of its water, and data from the survey show that more than half of the respondents in Kiuyu Mbuyuni, Pemba obtained most of their water for household needs from community stand pipes, while in Matemwe, Unguja, 66% of the respondents acquired most of theirs from local wells. No one used cave water for household needs in Kiuyu Mbuyuni, Pemba, whilst in Matemwe; Unguja 11% of the respondents drew most of their water for all of their needs from coral caves (Table 4.15). The nucleated nature of settlements in Kiuyu Mbuyuni, Pemba (see Chapter 2) facilitates delivery of piped water for most people.

Table 4.15: Sources of water for household and livestock uses

Sources of water for households	Kiuyu Mbuyuni (N=100) (%)	Matemwe (n=100) (%)
Community taps	55	14
Local wells	43	66
Coral caves	-	11
Tap on property	2	9
Sources of water for livestock	Kiuyu Mbuyuni (N=85) (%)	Matemwe (N=64) (%)
Community stand pipes	1	3
Wells	32	86
Coral caves	67	11

No one in either site mentioned using rain water as a main source, because rainfall is a seasonal phenomenon and villagers generally have no means of storing it; however, small scale rainwater harvesting for short-term use in the household is common in Zanzibar. In most cases, small buckets or 200-litre containers are placed under the homestead roof to collect run-off. At the institutional level (mosques), small-scale rainwater harvesting is also common (see Plate 4.2). Rainwater is perceived as being softer than

well water and so is mainly used for dish and clothes washing during the rainy season (Hansson, 2010). Contrary to the situation in Zanzibar, in the rural areas of Oyo, Nigeria, rainwater is an important potable source of drinking water, but as in Zanzibar, local people in Oyo state were also unable to conserve the rainwater in large quantities or did not know how to make it safe for drinking in the future (Gbadegesin and Olorunfemi, 2011).



Plate 4.2: (Left) Local method for harvesting rain in one of the mosques in Kiuyu Mbuyuni, Pemba. (Right) Black pipe with pump used to draw water from one of the coral caves in Matemwe, Unguja

Across the sites, crop farming is entirely rain-fed which makes it sensitive to climate variability and future change. With regard to livestock, 67% of the respondents in Kiuyu Mbuyuni, Pemba drew most of the water for livestock from coral caves and in Matemwe, Unguja, the majority of the respondents got most of the water for livestock from local wells (Table 4.15). This is influenced by the significant number of caves within the grazing land in Kiuyu Mbuyuni, while in Matemwe, coral caves are mostly found in the southern part of the area. Across the sites, livestock keeping has become part and parcel of a mixed farming system as a response to poor soil conditions (see Chapter 6). Thus, availability of rainfall for the growth of pasture and drinking water for animals is crucial for farming, food security and livelihoods.

As expected, the results reveal that local sources of water such as wells and caves are still important for both basic household needs (drinking, bathing, sanitation, cooking and washing), and in some places these sources are supplemented with community stand pipes. The results are consistent with a study by Hansson (2010) in the central and south-east coast of Unguja, which found that wells were a common water source for households in those areas, supplemented by caves and community stand pipes. This trend reveals how these communities are vulnerable to waterborne diseases as local sources such as wells and caves are vulnerable to contamination. With regard to crop and animal farming, the results show that as in many parts of sub-Saharan Africa, the farming system has remained entirely rain-fed, and thus is threatened by

production uncertainty caused by climate variability (Cooper *et al.* 2008; Morton, 2007; Challinor *et al.* 2007; Postel, 1989). The increased frequency of localised food shortages demonstrates how sensitive rain-fed farming is in the area. Unless local people in these areas are helped to cope and adapt to water scarcity, the predicted future climate change and sea level rise will further intensify the food insecurity and poverty levels in Zanzibar because farming has already been affected by other serious non-water factors such as poor soil (see section 4.3.1 on food security).

4.3.2.2 Availability of water

Respondents were asked if their main source of water was adequate for all their household needs throughout the year. The results in (Table 4.16) show that slightly more respondents in Kiuyu Mbuyuni believed that water from community stand pipes and local wells was not adequate throughout a year compared with those who said it was. In Matemwe, Unguja, where local wells were a major source of water, 49 (79%) out of 62 respondents who used wells as their main source of water believed this inadequate. Seven (64%) out of 11 respondents who used water from caves as their main source of water believed that such water was adequate for all of their needs (Table 4.16). The only problem cited with regard to water from caves was that the water quality deteriorated because of increased salinity content, particularly during the dry season and in periods of prolonged drought. Furthermore, most of the caves are inaccessible and thus difficult to draw water from unless a water pump is used (see Plate 4.3). The study found that in areas where stand pipe water supply is erratic, tap water is used only for drinking, and water from wells or caves is used for other purposes because tap water is perceived to be safe and clean (Hansson, 2010).

Table 4.16: Availability of water from various source of water for household needs

	Is this source of water adequate for all of the household needs throughout a year?		Total respondents using each source of water
	Yes	No	
Kiuyu Mbuyuni, Pemba			
Community stand pipes	18 (38%)	29 (62%)	47 (100%)
Local wells	18 (46%)	21 (54%)	39 (100%)
Tap on property	0	2 (100%)	2 (100%)
Matemwe, Unguja			
Community stand pipes	4 (31%)	9 (69%)	13 (100%)
Local wells	13 (21%)	49 (79%)	62 (100%)
Coral caves	7 (64%)	4 (36%)	11 (100%)
Tap on property	2 (22%)	7 (78%)	9 (100%)

Regarding water for livestock, 42 (76%) out of 55 respondents who used coral caves as their main source of water for livestock in Kiuyu Mbuyuni, believed that water from the coral caves is adequate throughout the year (Table 4.17). In Matemwe, where local wells are considered as a major source of water for livestock,

the results show that 37 out of 52 respondents believed that water from local wells was inadequate for the livestock needs throughout the year. The inadequate availability of water in local wells across the sites is associated with decreasing volumes of water in the wells, partly associated with prolonged dry spells or normal dry seasons. The results clearly demonstrate that local wells are more sensitive to dry spells than are coral caves. Thus livestock, apart from being affected by the scarcity of pasture during dry spells, are also affected by the irregularity of water, particularly where owners depend on local wells.

As expected, the majority of respondents across the sites believed that rainfall as a sole source of water for farming is completely inadequate for farming needs (Table 4.17). This makes farming systems and food security vulnerable to current climate variability and future changes, especially along the east coast of each island. Although these areas have traditionally experienced irregular rainfall (Walsh, 2009; Chapter 2), the irregularities and frequency of dry spells have increased substantially (see Chapter 5).

To understand the depth of the water security problem, this study used PLA approaches such as water sources inventory and group discussions as well as interviews. Results of these methods corroborate the findings in Tables 4.16 and 4.17. Across the sites, stand pipe water was irregularly distributed and erratic; however, comparing the two sites showed that Kiuyu Mbuyuni, Pemba had a more regular supply than Matemwe, Unguja, despite the fact that the former received piped water from distant sources (more than 10 km), whereas the latter received water from a source located less than 3 km away. Across the sites, the pressure of piped water decreased as distance increased from the main pipe. For example, out of nine villages in Matemwe, Unguja, only two villages (villages 1 and 3) (Table 4.18) situated close to the main pipe received water regularly. Findings from a group discussion in Matemwe, Unguja revealed that local people linked the problem to tourism demands and poor management of the spring by the Zanzibar Water Authority (ZAWA) which brings water to the villages. Local people believe that tourism hotels and bungalows pump water from the main pipe and thus reduce the pressure. Despite the compactness of settlements in Kiuyu Mbuyuni, Pemba (see Chapter 2 for the maps of both the sites), piped water is also available regularly in only two villages (villages 1 and 6) (Table 4.18) out of seven. Thus, poor technology is responsible for the irregular availability of piped water across the sites.

Table 4.17: Availability of water for livestock and farms needs from various sources

	Is this source of water adequate for all of your livestock needs		Total respondents using each source of water
	Yes	No	
Kiuyu Mbuyuni			
Community stand pipe	1(100%)	0	1 (100%)
Local wells	11(48%)	12 (52%)	23 (100%)
Coral caves	42 (76%)	13(23%)	55 (100%)
Matemwe Unguja	Yes	No	
Community stand pipe	1 (50%)	1 (5%)	2 (100%)
Local wells	15 (29%)	37 (71%)	52 (100%)
Coral caves	7 (100%)	0	7 (100%)
	Is this source of water adequate for all of your farming needs?		
	Yes	No	
Kiuyu Mbuyuni			
Rain water	2 (2%)	78 (98%)	80 (100%)
Matemwe, Unguja	Yes	No	
Rain water	1 (1%)	72 (99%)	73 (100%)
Community taps	0	1 (100%)	1 (100)

Local wells, which were found to be reliable sources across the sites, are sensitive to drawing demand and dry conditions as volumes decline or the wells dry out completely during the dry season or during prolonged dry spells. Although a study by Halcrow (1994) showed that underground aquifers are only partially recharged by rainfall (7% and 23% in Pemba and Unguja respectively), local people perceived rainfall as significant for recharging their wells. For example, in Kiuyu Mbuyuni, Pemba four wells out of nine, and three out of 35 in Matemwe have a tendency to dry up completely during dry spells, while the volume in the remaining wells fluctuates, depending on the intensity of dry spells. The 1999-2000 and 2008-2010 dry spells had a significant impact on local water resources. In examining the effect of climate variability on water availability in the communitys' surroundings of Jozani Chwaka Bay National Park, Zanzibar, Kombo (2011) also found a relationship between water availability in local sources and climate variability. Figure 4.3 adopted from Kombo (2011), shows that even springs that are run by ZAWA and located along the west or central corridors of both islands, where rainfall is generally higher than the east coasts, are also sensitive to dry conditions. Thus, given the shallow depth of local wells, coupled with poor geo-hydrology (Hansson, 2010) and unreliable rainfall (Walsh, 2009; Chapter 5), it appears that both the study sites are even more vulnerable to water insecurity.

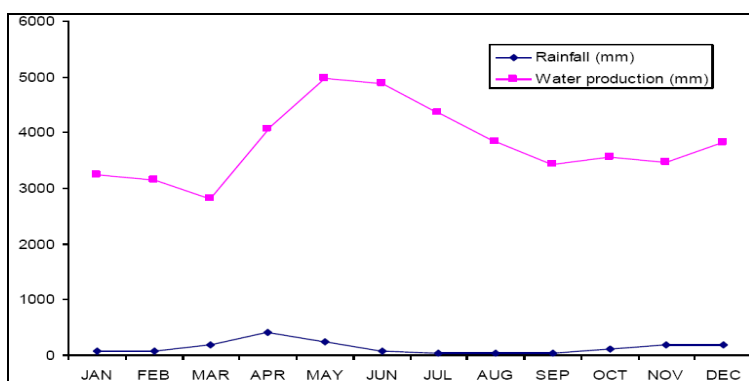


Figure 4.3: Relationship between rainfall and water production from Bububu spring (Source: Kombo, 2011:63)

Since water sources supplement each other, communities with fewer sources of water will be more vulnerable to water scarcity than communities with more sources. For instance, in Matemwe, Unguja, three communities (villages 4, 5 and 8 in Table 4.18) which are located at the south corner of the area away from the main pipeline continuously face water irregularities as they depend solely on local wells that are sensitive even to normal dry conditions. During a field visit, villagers from village 8 were found digging a new well to give the village two wells in total, in order to accommodate the ever increasing need for water. Villages further north (villages 2 and 6 in Table 4.18) are less vulnerable because of the presence of caves which are less affected by dry spells than wells, but only in terms of volume of water rather than quality. Villages 7 and 9, which are located along the shore close to the ocean, have a large number of wells compared to other villages (Table 4.18); these wells show low fluctuations in volume, but most of them contain salty water, the salinity of which increases with increasing dry conditions or prolonged dry spells. However, for local people along the shore, salinity content is also attributed to increased demand due to increased population. They argue, for example, that water in the wells within peoples' properties contains a lower concentration of salt than community wells because the demand and pressure of use is lower.

On the other hand, the majority of caves store large volumes of water and some of them contain fresh water with minimal salt content that can be used for households needs and for small-scale irrigation. However, in most of them, the water is inaccessible unless water pumps are used (section 4.3.2.3). In Matemwe, for example, there is one cave which supplies water to a hotel located on the beach. “An average cave can yield 480,000 m³/year, enough to supply 37,600 people with water for a year, calculated on 35 l/person/day” (Hansson, 2010:24, based on a calculation done by the Ministry of Water, Constitution, Energy, Lands And Environment, 1995). If this is the case, then the cave that is used to supply water to the hotel in Matemwe, Unguja could supply the entire population of 6,381. In other parts of Zanzibar, like the south east coast of Unguja, water from caves is supplied to the villages using pipes (Hansson, 2010; Kombo, 2011).

Given the fact that local sources of water are still the most reliable sources across the sites, and since local sources are sensitive to climate variability, it appears that without proper adaptation strategies in place, east coast communities will become more vulnerable to future climate change, mainly because various projections predict a decline in rainfall and an increase in the minimum temperature (see Chapter 5).

Table 4.18: Sources of water in both study sites

Sources of water in Matemwe					
S/N	Villages	# Wells	# Caves	# Tap on property	# Community stand pipes
1	Mwangaseni	5	0	6	33
2	Kachongwa	3	5	0	7
3	Mbuyu popo	1	0	2	5
4	Mbuyu maji	1	0	0	1
5	Jomba	2	0	0	6
6	Juga kuu	2	2	0	3
7	Kilima juu	6	0	4	6
8	Mikuuni	1	0	0	2
9	Tundangaa	14	0	10	20
Sources of water in Kiuyu Mbuyuni, Pemba `					
1	Shanake	1		14	6
2	Mwikibaba	2		2	7
3	Mkwaju panda	1		0	6
4	Mkwaju shauri	1		0	6
5	Mtongwe	1		1	5
6	Mkondoni	2		1	5
7	Makombani	1		0	7

Source: Local leader register book. Note: Kiuyu has more than 20 coral caves with water, located outside settlement areas so it was difficult to locate them in the specific village

4.3.2.3 Water accessibility

The results in Table 4.15 show that only 2% of the respondents in Kiuyu Mbuyuni used a tap on their property as their main source of water for household use, whereas in Matemwe, Unguja, 9% did. The results match data obtained from local leaders which show that in Kiuyu Mbuyuni, Pemba only 18 out of 1,548 households have taps on their properties, whereas, in Matemwe, Unguja 22 households out of 1,337 have taps on their properties (Table 4.18). Apart from illustrating low accessibility of the available water, this also demonstrates the level of poverty across the sites. Based on Hansson's (2010) findings on the east coast of Unguja, at 32.5 l/person/day for all uses (bathing, washing, dish washing, drinking and cooking) and with an average household size of six (see Table 3.1 in Chapter 3), each household needs 195 l/day. Women are most vulnerable to water inaccessibility, as in most cases they are responsible for collecting water for household use. Using a standard 20 l bucket means a woman would need to walk back and forth to the collection point (well, community tap, cave) ten times per day in order to get 195 l. It is obvious that this process uses a lot precious time that could be invested in other livelihood activities for reducing

poverty and food insecurity. This is reflected in the following quote from a woman in Matemwe (village No.3):

“The well is far from here and our nearest cave has rough slopes and thus it is difficult to fetch water out of it. We are facing difficulties as I have to go seaweed farming, look for firewood and fetch water daily”.

The distance between the villages with a poor supply of water from a stand pipe to the nearest villages that have a working stand pipe was calculated using Arc GIS. The results show that in Kiuyu Mbuyuni, Pemba, for example, an individual from village 7, which has a poor supply of piped water, normally covers a distance of about 583 m to village 6, or 434 m to village 1 where piped water is regularly available because it is close to the main pipeline (see Appendix V). Likewise, someone in village 4 has to cover a distance of about 450 m to village 1, and 506 m to the centre of village 6 (see Appendix V). The scattered nature of settlements in Matemwe (see Appendix V) has caused a high degree of piped water inaccessibility compared with Kiuyu Mbuyuni. For instance the distance to village 1, where water is regularly available, from other villages ranges from 1483 m to 3451 m (see Appendix V). Additionally an individual from village 8, which had only one local well during the time of the field study, had to walk up to 2474 m to fetch water from a stand pipe in village 1 or 3, especially during dry spells. The only local well available in this village is very old, it is said to have been made by the Portuguese in the 16th or 17th century and its volume is highly sensitive even under normal dry conditions. A woman or a girl in this village is expected to spend approximately two hours per trip to the nearest collection point, as calculated by Kamuzungu (2009) cited in Gbadegesin and Olorunfemi (2011), who found that in rural Zimbabwe local people covered more than 500 m to the nearest water source, spending more than 30 minutes per trip. This ultimately reduces time for other activities and “impacts the health of the water carrier as water is mostly carried on the head” (Gbadegesin and Olorunfemi, 2011:490). The distance covered by local people in Matemwe is above the reasonable distance of 1 km from the user’s dwelling to a collection point as suggested by WHO/UNICEF (2000).

In most cases, coral caves contain a considerable volume of water (see section 4.3.2.2), but most of them are inaccessible. For instance, in Matemwe, Unguja only one out of six reported caves is accessible, with terrain that allows someone to walk into it and collect water. The remaining caves need water pumps in order to access water from them; poverty and poor rural electrification bar this option for most local communities (Box 4.1). According to data obtained from local leaders in Matemwe, only 77 households out of 1 337 were connected to electricity, whereas in Kiuyu Mbuyuni, Pemba only 30 households out of 1 548 were connected. Apart from poverty and poor rural electrification, Box 4.1 also shows that the nature of the rock impacts the accessibility of water in Zanzibar coastal villages. In Kiuyu Mbuyuni, Pemba where caves are the main source of water for livestock (Table 4.15), almost all of the caves are also inaccessible. However, livestock keepers in this area use various means, such as ladders, to get into the cave and collect water for their animals (Plate 4.3).

Box 4.1: An interview with the Imam of a mosque at a small village called Mlilile which is found within main village No. 2

I think you have seen that abandoned unfinished well beside the mosque on your way here. The underneath rock is too hard for the local tools to dig further, so we decided to leave it. As water has ceased to flow from our taps for 10 years or so, our only source of water is the caves around us that have been used by all generations before us. But so far, we have access to only one cave as the second cave supplies water to the hotel and at the third one, the terrain doesn't allow us to walk in unless we install a water pump.....One Islamic organisation from town, after seeing our suffering from water insecurity, gave us a water pump, black pipe, tanks and a generator in order to be able to pull out the water easily from one of the caves that have fresh water compared to what we are using now, but I have to tell you the truth that we are struggling with getting money for fuel to run the generator. The money we get from fishing is not enough for our household needs, let alone buying fuel for the generator to run the water pump.



Plate 4.3: Left livestock keepers use a ladder to get into the cave to fetch water for their animals. Right at the foreground of the picture a man sits close to the remnant of a hand pump that was used to help livestock keepers draw water easily from the cave but which was corroded by the high salinity content of the water, particularly during dry seasons. All photos from Kiuyu Mbuyuni, Pemba.

With regard to the number of community stand pipes for the population, the results in Table 4.19 show that in Matemwe, Unguja one stand pipe supplied 77 people and in Kiuyu Mbuyuni, Pemba 186 people. However, as mentioned previously, most of these stand pipes were dry and thus, in most cases there was a long queue at the stand pipe points that had regularly flowing water. The group discussions revealed that in Kiuyu Mbuyuni, out of 42 community taps, only six taps recorded a constant flow, while water started flowing only after midnight in the rest of the taps. With regard to the wells (the most reliable source of water across the sites), the number of people per well was 182 in Matemwe, Unguja and 867 in Kiuyu Mbuyuni, Pemba. The results in Table 4.19 show that each well in individual villages in Kiuyu Mbuyuni, Pemba had to supply large numbers of users. A combination of caves located far from the settlements, high salinity and irregular tap water supply coupled with the sensitivity of wells to dry conditions, and the low capacity of the people to conserve water, has had significant implications for health and livelihoods in Kiuyu Mbuyuni as considerable time is used collecting water.

Table 4.19: Number of persons per water source

Matemwe, Unguja				
S/n	Villages	Population	Well/person	Community tap/person
1	Mwangaseni	1179	1:235	1:36
2	Kachongwa	763	1:254	1:109
3	Mbuyu popo	504	1:504	1:101
4	Mbuyu maji	531	1:531	1:531
5	Jomba	337	1:169	1:56
6	Juga kuu	750	1:375	1:250
7	Kilima juu	610	1:102	1:102
8	Mikuuni	254	1:254	1:12
9	Tundangaa	1453	1:104	1:73
Kiuyu Mbuyuni, Pemba				
1	Shanake	1091	1:1091	1:182
2	Mwikibaba	1575	1:788	1:225
3	Mkwaju panda	860	1:860	1:143
4	Mkwaju shauri	997	1:997	1:166
5	Mtongwe	1061	1:1062	1:212
6	Mkondoni	1082	1:541	1:216
7	Makombani	1136	1:1136	1:162

Sources of data: Local leader's registry

In Matemwe, Unguja the results revealed that the number of wells is higher along the shore/beach and decreases with distance from the shore, mainly because the water lens is shallower near the shore and the depth of water lenses increases with distance from the shore (also see Chapter 1). For instance, in villages 7 and 9, which are located along the shore, the ratio of wells to people was 1:102 and 1:104 respectively (Table 4.19), whereas in villages 3 and 4, which are located away from the shore, this ratio 1:504 and 1:531 respectively. Furthermore, the average depth of the wells along the shore of Matemwe was 10 m, which makes them sensitive to contamination because of their shallowness, while at the upland locations the average depth in Matemwe was 25 m and in Kiuyu Mbuyuni 19 m, which make them difficult to access. Despite the depth of these wells the study found no hand pumps across the sites that could reduce the amount of energy and time spent on water collection.

Water access in the study sites is influenced by many factors: climatic, natural and social. Accessibility of the piped water, for example, is affected by decreased pressure as distance increases from the main pipe, the scattered nature of the settlements particularly in Matemwe, Unguja and people's low financial capacity to connect their pipe water to their household. Decreased pressure is attributed to the quality of infrastructure and sometimes to climate variability caused by the decrease in water volume from the sources (springs in this case) and is a common problem, even in urban areas both in Zanzibar (based on my experience) and in other developing countries, including India (Lundqvist *et al.* 2003). For example Lundqvist *et al.* (2003) argue that inferior distribution systems of water to the households affect timely availability of water and increase time spent for water collection.

Using water pumps to draw water from coral caves in order to avoid the rough terrain associated with them was found to be the only valid option to make water more accessible from caves across the sites. However, this option is compromised by poor rural electrification, the low capacity of people to find alternative sources of energy to run water pumps, and lack of assistance from district governments. The high salinity content of the water in many of these caves also affects accessibility because even if the hand pumps are installed they are rapidly corroded unless the pumps are made of salt-resistant materials such as plastic. Hand pumps in both caves and wells could reduce the fatigue of water carriers and the time spent collecting water. Because of the importance of hand pumps, the government in Uganda recently introduced hand-pump mechanics' associations in many rural districts in order to improve the accessibility of rural water (WSTL, 2012). In a situation where reliable and safe water delivery for all has remained out of reach, installing hand pumps in the wells in both the study sites would increase accessibility and thus shape people's responses to current variability and future changes in climate and sea level.

4.3.2.4 Quality of the available water

While water supplied by pipes is perceived to be clean and fresh, well and cave water was said to be hard. Local people perceived that salinity in the water of both caves and wells has increased with increased temperature and decreased rainfall. The distance from the shore also sometimes influences the quality of water. For instance, 57% of wells in Matemwe, Unguja which are located within 100 - 200 m from the shoreline have high salinity concentrations compared with wells at the upper part of the shehia/ward. In Kiuyu Mbuyuni, Pemba local people also perceived the salt content in their water to have increased; furthermore, most of the caves across the sites contain water of varying hardness. In Kiuyu Mbuyuni, Pemba out of more than 20 caves, local people believed that only one or two caves contain fresh water, but they were inaccessible unless water pumps were used. The remaining caves contain considerable amounts of salt and thus are only used for livestock.

Most of the caves in Kiuyu Mbuyuni are located within a short distance from the ocean, unlike Matemwe, Unguja where some of them are tidal (their volume depending on the high and low tides). The following testimony from a woman in Matemwe, Unguja (village 2) illustrates the perceptions of the local community on the salinity content of water in the caves:

“Water from this coral cave is water that has high content of salt in such a way that sometimes we don't add salt while cooking, especially in the dry season. We also drink the same water as we have no option; pipes are empty, located at a distant place and we are fail to draw water from the other cave which has fresh water as it is inaccessible and we have no money for generator fuel to run a water pump”.

Although livestock keepers in Kiuyu Mbuyuni, Pemba perceived no impact of salty water on the productivity of cattle (milk and meat), a scientific study may be needed to examine whether there is a relationship between the perceived decline in livestock productivity in the areas and increasing

concentrations of salt in cave water: an interview with old men in Kiuyu Mbuyuni revealed that previously, with just few cattle, a livestock keeper could obtain a large volume of milk. Studies conducted in other parts of the world have shown a relationship between high salt content in water and growth and production of cattle. For instance a study by Patterson and Johnson (2003) based on various laboratory experiments, concluded that high salinity content in the water, particularly sulphate salt, has negative impacts on the production and health of growing cattle. Similarly in Canada, beef cattle were diagnosed with abnormalities after being exposed to saline well water; however, the disorder was more closely related to sulphate than sodium ions (Beke and Hironaka, 1991).

Apart from salinity problems, local wells particularly those shallow wells along the shore in Matemwe, Unguja and caves are prone to contamination. An interview with key informants revealed that across the sites, waterborne diseases such as diarrhoea and cholera are common (also see Appendix 1). For the case of Matemwe, the results revealed that cholera always starts along the shore as wells are shallower and thus sensitive to contamination as the number of people without latrines is also high. The results from the local leader register book show that 90% of the households in Kiuyu Mbuyuni, Pemba had no latrine while, in Matemwe, Unguja, 74% of households had none. The number of households with latrines in both the study sites is low compared with the south-east coast villages of Unguja Island/Zanzibar (Hansson, 2010). In terms of caves, although there are some norms and beliefs that govern utilisation of their water, water quality in these caves is still susceptible to contamination by animals, birds and bats that live in these caves.

The foregoing analysis highlights the sensitivity of coastal water resources to various stressors and the vulnerability of coastal communities to the quality of water. A study by Kombo (2011) in Jozani Chwaka Bay National Park, Unguja and Hansson (2010) in the south-east coast of Unguja found similar results. Hansson (2010), for example found that 66% of the respondents in his study perceived an increase in salt content in the local water sources. Other water problems identified were water quantity and bad smells. Similarly, a study by Halcrow (1994) revealed seasonal variation in salinity content, even in the boreholes run by the Zanzibar Water Authority (ZAWA) which are mostly located far from the ocean in both islands. Although sea water intrusion in the wells and caves is not new along the coast, rising sea levels coupled with an increasing population and water needs will ultimately intensify seawater incursions into local wells and caves which, so far are the major sources for household needs all over coastal villages in Zanzibar. The abandonment of wells in and around Chwaka Bay, Unguja due to increasing salinity (Kombo, 2011), and the abandonment of a cave in Kiuyu Mbuyuni, Pemba by livestock keepers for the same reason demonstrates just how sensitive the local water resources are to climate variability and sea level rise (see Chapter 5). A projected rise in sea level of between 9 cm and 88 cm by 2100 could increase flooding and coastal inundation in Africa's lowland areas. In SIDSs, such as Zanzibar, the impact, without adaptation, would be huge (Boko *et al.* 2007).

4.3.2.5 Responses to water insecurity

Coping with and adapting to water quality and scarcity is not new across the sites, because traditionally the east coasts of both islands receive low rainfall compared with the central and west corridors (Hansson, 2010). Similarly, proximity to the ocean has made all local sources of water (wells and caves) vulnerable to seawater intrusion. For example, it has been found that the location of the Kiuyu Mbuyuni settlement in the middle of the area was partly a strategic adaptation to sea water intrusion (Figure 4.3). Inhabitants perceived that as distance increased from the shore, the salinity content in the water decreased, so they chose the central location of their area in order to get fresh water from wells. People in village 2 (Table 4.18) of Matemwe, Unguja, who depend solely on water from the caves for all uses, reduced the frequency of washing to every three or four weeks to cope with the inaccessibility of water as demonstrated by the following testimony:

“An older person can’t get into this cave due to the rough slope, and during the rainy season it is very difficult even for us as the slope becomes slippery”.

Further, in village 8 (Table 4.18) of Matemwe, Unguja, where there are only two dry community standpipes and villagers walk more than 2 km to the nearest water point, villagers were digging a new well during the time of the field survey to cope with water stress.

At an agricultural level, which is the crux of peoples’ livelihoods and food security across the sites, no strategies for coping and adapting to water insecurity triggered by declining of rainfall (see Chapter 5) were observed. Although the areas experience scarce rainfall, particularly during a short rainy season, it is still worthwhile capturing rainwater when it is available, particularly during a long rainy season, to use for both farming and livestock. Many vegetable farming groups formed under the so-called ‘poverty eradication initiatives’ did not last long because of scarce water and variable rainfall. While the government is busy providing motorised boats to fishers within villages to improve their resilience, it should also help farmers to get water either from underground, help them harvest rainwater for vegetable gardening and livestock and to practice water conservation farming techniques. This is mainly because, fishing, as currently practiced cannot stand alone in ensuring food security in rural households, let alone eradicating poverty (see section 4.3.1 on food security).

4.4 CONCLUSIONS

Like previous chapter, this chapter explored the vulnerability context of the two studied communities focusing on food and water security. The overall picture emerging across the sites is one in which local people are insecure with respect to most major sources of food, with some differences between sites. The findings related to insecurity of staple food are consistent with other studies conducted in Zanzibar. The observed insecurity in relation to other sources of food such as fish in fishing communities is new to this study. Unreliability and seasonality of fishing coupled with the high demand of fishery resources in towns

and at tourist hotels denies local people access to sufficient fishery products. Unlike previous studies (e.g. Owusu *et al.* 2011 in Ghana) this study has found no relationship between livelihood diversity and availability of food in the households. This has been attributed by the fact that majority of the activities practiced in the households (farming, fishing, seaweed farming, livestock and poultry) are sensitive to climate and thus are unable to ensure the access and availability of food during crisis. The results also illustrated, as found in other studies, that female-headed households are particularly sensitive to food insecurity. Because they lack enough labour to work in different activities and in most cases are characterised by less access to remunerative jobs and to productive resources such as land, and by poor livelihood diversification.

Furthermore, the study found that uncertainty in farming resulting from various factors, including local climate variability, coupled with uncertainty of fishing has pushed households towards buying most of their staple food and fish. This trend has affected food security due to low purchasing power attributed to poverty. For instance, the study found that the average cost of food per household is much higher compared with the average income accrued from fishing. Since rice is an imported commodity in Zanzibar, its price is highly volatile in response to global fluctuations in energy prices and the credit market as well as global climate change impacts and extremes in the major rice producing areas such as Pakistan and India. This clearly demonstrates the sensitivity of Zanzibar's coastal communities to external, global drivers. Increased population numbers and thus increased demand in urban areas and the expansion of tourism industries within the study area and in neighbouring countries have increased the price for the limited fisheries resources, causing the poor, including the fishers, to consume less fish and seafood.

Perhaps the most interesting findings of the Chapter relate to food stability. The study found that as fishing (main source of income) is affected by a seasonality the stability of food in the households is also challenged. Fishing is mainly practiced during north-easterly wind (*kaskazi*) and calm period (*leleji*) and less during south-easterly wind (*kusi*). Even during the fishing season, fishing is irregular and in most cases practiced in spring tides (17-20 days in each month). Thus, unreliability of fishing coupled with the seasonal nature of the activity is affecting the continuous supply of food within the households. Furthermore, consistent with other studies, the seasonal nature of farming activities has also been linked with localised food shortages in the areas. In sum, all components of food security are affected by climate trends and seasonality with some impacts from other stressors such as global food prices. .

With regard to water security, the findings are also convergent with other studies in that climate variability in its various forms affects all components of water security, namely availability, accessibility and quality. For instance, despite the reported achievement in rural water supply (RGZ, 2009); accessible piped water still remains a problem in rural areas mainly due to poor infrastructure and low capacity of the people to

connect their households with piped water. Across the sites, the study found that, generally, local sources of water such as wells and coral caves remain reliable sources for household needs. However, they are highly sensitive to dry spells and variations in both temperature and rainfall.

It was also illustrated that livestock keeping is highly dependent on wells and caves for animal drinking water and on rainfall for pasture growth and thus sensitive to observed declining rainfall. Despite the problem in accessing water from caves, the quality of water from these sources is also threatened by dry conditions. Similarly, crop farming is completely rain-fed which makes it vulnerable to current climate variability and future change. The availability and accessibility of quality water is also not uniform; communities with fewer local sources of water (wells and caves), which are sensitive to climate variability or even the normal dry season, are more vulnerable to water insecurity. It has also been argued that, even without climate variability and change and sea level rise, availability and accessibility of quality water across the sites is already affected by natural factors such as hydrogeology and hardness of the rock, and by development challenges such as poverty, low level of sanitation, lack of rural electrification, low technology, poor water governance and management, and low livelihood capital (social, financial and human).

The findings in both food and water insecurity shed light on the interconnectedness of the livelihoods and households in explaining the existing vulnerability context of these communities. For instance inaccessibility of water to the households means more time is used to collect water that could be invested in productive activities. In the present situation of limited livelihood diversity, reducing hunger and poverty in Zanzibar coastal villages may be achieved by increasing accessibility to quality fresh water for farming and for household uses. Unlike other SIDSs, Zanzibar, especially Unguja Island has good potential for ground water for irrigation in the dry areas (see Halcrow, 1994). In addition, despite the current variability in rainfall, there is still significant potential for rainwater harvesting for both crop farming and livestock. In Matemwe, Unguja, where many households are located close to the farm plots, due to the scattered nature of the settlement, even small-scale water harvesting techniques such as a roof catchment system can improve water availability for both household use and vegetable gardening. However, a subsidy to obtain big water tanks and other associated tools is required because households across the sites are extremely poor. For instance, in South Africa, due to the unreliability of conventional technology for water supply, the rural poor have been assisted with rainwater storage tanks and related works as part of the implementation of MDG 7 (Kahinda *et al.* 2007). The successful implementation of projects of this kind needs knowledge of water treatment for household uses in order to reduce the risk of water-borne diseases (Gbadegesin and Olorunfemi, 2011; Kahinda *et al.* 2007).

Adaptation to climate change is costly and people in the poorest districts, like Micheweni and North 'A', cannot afford to pay for strategic adaptation measures such as small-scale rainwater harvesting for farming. During a field visit to Kiuyu Mbuyuni, this researcher observed the construction of a water tank outside of Kiuyu Mbuyuni, Pemba to increase water pressure and thus reduce the time spent collecting water. However, supplying water to the households is just a small fraction in the implementation of MDG 1 on hunger and poverty, and MDG 7 on environmental sustainability and water supply set by the UN. Water security comprises availability of quality water for human consumption and food production (Bu-Chun *et al.* 2007). Given the strong links between water security, food security, and poverty (UNEP, 2011) increased agricultural production, mainly through small scale irrigation for home and field gardening, could help people to escape from poverty and decrease the price of food, especially now that the production of rice, which is a staple food in Zanzibar is threatened by climate change all over the world.

CHAPTER 5

PERCEIVED CLIMATE VARIABILITY AND CHANGE AMONGST EAST COAST FARMERS, FISHERS AND SEAWEED FARMERS AND COMPARISON TO OBSERVED DATA

5.1. INTRODUCTION

5.1.1 Overview

This Chapter examines the perceptions of local communities concerning climate variability and change and sea level rise in relation to observed weather and sea level data to understand the exposure of the two east coast communities to climate variability and change. The specific objectives the Chapter are to (1) document farmers, fishers and seaweed farmers' perceptions of various changes in weather elements (rainfall, temperature, wind) and sea level, (2) compare these perceptions to observed data, (3) examine local awareness of the causes of climate variability and change, and (4) examine the uptake and use of seasonal weather forecasts amongst farmers and fishers in Kiuyu Mbuyuni, Pemba and Matemwe, Unguja. This Chapter therefore, provides some insight into the exposure and sensitivity of communities in the study sites to various shocks and risks, particularly those associated with climate variability and change. Furthermore, whether and how local communities perceive the variability and changes and linked threats is important for understanding how they are likely to respond to interventions to enhance adaptive capacity and reduce vulnerability. Perceiving variability or change and the need to do something about it is one of the first steps towards adaptation.

The Chapter starts with a general background regarding climate change and the relationship between climate and the major livelihood activities in the study sites. This is followed by the review of literature on the perceptions of climate variability and change. A perception model is then introduced which is used as a lens for analysis and discussion. The variety of methods used for data collection and analysis are then presented. This is followed by a results and discussion sections which focuses on perceptions of the farmers, fishers and seaweed farmers regarding climate variability and change, and compares these perceptions to the observed variability in rainfall, temperature and sea level rise. The section also discusses perceptions regarding the causes of climate variability and change, and people's attitudes towards and uses of weather reporting and warnings. These findings therefore, shed some light on the extent into which coastal households and their livelihoods are exposed to climate variability and sea level change. Lastly, the conclusion summarises the key findings and suggests necessary steps to reduce exposure and sensitivity.

5.1.2 General background

The impact of climate variability and change and sea level rise (SLR) is increasingly threatening the existence and well-being of the world's SIDSs. The Intergovernmental Panel on Climate Change (IPCC), in

its Fourth Assessment Report (AR4), warns with high confidence that coastal systems and low lying areas (e.g islands) are highly vulnerable to climate change impacts such as sea level rise and extreme weather events (Nicholls *et al.* 2007). However, this vulnerability is unevenly distributed across SIDSs, where climate variability and change adversely interact with development stresses such as poverty, limited access to capital, low adaptive capacity and poor policies (Chapter 1; Boko *et al.* 2007; Nicholls *et al.* 2007; Brown *et al.* 2011).

The two study areas, Kiuyu Mbuyuni, Pemba and Matemwe, Unguja have experienced a number of crop failures over the last decade attributed to local climate variability (Walsh, 2009). Recent dry spells along the east coasts of Pemba and Unguja have raised the concern of both local communities and planners as they have intensified food shortages in those areas (Said, 2011). Worldwide, the overall performance of agriculture is projected to drop because of the effects of global climate change (Boko *et al.* 2007). Scenarios suggest that climate change will have a high impact on rain-fed farming along the Sahel and on some parts of East Africa in the future (Boko *et al.* 2007). The adverse impacts of climate variability and change on agriculture include reduction of crop yield due to drought, water scarcity, and sea water and rainfall flooding of farm plots (Levira, 2009; Laux *et al.* 2010; Mubaya *et al.* 2012; Sultan, 2011; Chapter 1). In Zanzibar, particularly along the east coasts where farmers are already exposed to poor soils and unreliable rainfall, further diminished rainfall will have severe impacts on the well-being of communities.

Like farming, fishing is influenced and partly controlled by climate. For instance, the south-easterly wind (*kusi*) which blows off the coast and the north-easterly wind (*kaskazi*) which blows towards the coast are said to control both the abundance of fish and the times that fishing trips can be made (Feidi, 2005; Chapter 6). Similarly, most of the important in-shore fishing grounds in the Zanzibar coral reef and mangrove ecosystems (Mkenda and Folmer, 2001) are highly vulnerable to global climate change and the regional extreme events of ENSO in the western Indian Ocean (Chapter 1; Chapter 6; Boko *et al.* 2007; Easterling *et al.* 2007; Fischlin *et al.* 2007) (see section 5.3.3.3 for the definitions of ENSO and associated events). Impacts on the fishing grounds (coral reefs and mangroves) included changes in species diversity and the composition of marine resources (Badjeck *et al.* 2010; Chapter 6). As fishing, fishery resources and fishing grounds in Zanzibar are already affected by over-fishing, illegal methods of fishing, demand for wood energy from mangroves and an ever-increasing demand for fishery products (Chapter 6), climate variability and change is an additional stressor that may intensify vulnerability.

Furthermore, the growth, the survival and the production of seaweed are sensitive to sea level, temperature and wind variability (Chapter 6). For instance, rising atmospheric and sea surface temperature is likely to affect seaweed growth, while strong winds are likely to destabilise the seaweed blocks and thus affect production. As climate largely influences the production in farming, fishing and seaweed farming, the study

of perceptions amongst farmers, fishers and seaweed farmers will provide insights regarding how they see climate variability in relation these sectors.

5.1.3 Understanding environmental perceptions as a trigger to respond to change

Understanding how local people interpret and perceive climate has been recognised as an important ingredient in examining local people's vulnerability and responses to climate variability and change (Adelekan and Gbadegesin, 2005; Hulme *et al.* 2009; Petheram *et al.* 2010; Vedwan, 2006; Vedwan and Rhoades, 2001). Studies ranging from psychology to environmental change have tried to define 'perception' and explain how it influences the actions taken in response to certain stimuli in the environment (see Brown and Besner, 2004; Marcel, 1983; Merikle *et al.* 2001; Vedwan, 2006; Vedwan and Rhoades, 2001).

In relation to environmental change, Whyte (1985:1) defines perception as a "means by which we seek to understand environmental phenomena in order to arrive at a better use of environmental resources and a more efficient response to environmental abnormalities". Thus environmental perceptions may help the farmer to make decisions and cope with perceived rainfall variability, whereas seaweed farmers and fishers may adjust to the perceived variance of wind patterns and sea level rise (Whyte, 1985; Vedwan, 2006; Vedwan and Rhoades, 2001). The success or failure of adjustments to local climate variability for example, will depend largely on the positive or negative nature of the perception in relation to climate variability. So how does an individual farmer or fisher arrive at a decision to respond to a certain stimulus such as sea level rise or erratic rainfall based on his/her perceptions? It is now widely accepted that perceptions of climate variability and change can manifest with awareness (exposure to formal and scientific knowledge) or without awareness (without being exposed to formal and scientific knowledge but rather informed by own experience and knowledge) of the stimulus (sea level rise, drought, erratic rainfall and wind variability) (Merikle *et al.* 2001; Brown and Besner, 2004). For example, a farmer may opt for short-term crops if he/she feels that the onset of rainfall has changed over time based on experience and knowledge without being exposed to measured rainfall data, scientific predictions and recommendations that they should plant short-term crops. A study by Vedwan and Rhoades (2001) in India found that apple growers perceived variability of rainfall and frost and transformed the way they practised their farming without being exposed to formal information or knowledge regarding the variability of weather (see also Teka and Vogt, 2010; Vedwan, 2006).

The perception of a stimulus (sea level rise (SLR), erratic rainfall, stronger wind), therefore, may be influenced by the interaction between local communities and the environment, crop-climate relations, and a person's direct experience of the environment (through sense of taste, touch, sight, hearing and smell) (Teka and Vogt, 2010; Vedwan, 2006; Whyte, 1985). In addition, extreme events such as drought,

windstorms, heat waves and coastal floods are likely to generate an extreme perception amongst local communities as they are beyond the “perceptual threshold of human experience” (Whyte, 1985). The perceptual threshold here means the limit within which an individual is used to experiencing those events. Thus if a ‘beyond normal’ event occurs, it is likely that it will be easily recognised and responded to. However, interpretations of ‘normal’ climate or sea level will vary both within communities and between individuals based on primary livelihood activities, culture, memory and resilience (Hulme *et al.* 2009). For instance, the perception of drought by an individual who has access to water for irrigation will be likely to differ from the perception of an individual who has no access to water for his farm. Moreover, variability and changes in temperature and rainfall patterns are complex and uncertain and thus are not easily detected by people (Bazerman *et al.* 1997). Gradual trends in these patterns are particularly hard for people to detect, and in most cases people will remember abnormal events rather than the general trend in rainfall or temperature over time (Barros, 2009). An individual expectation of climate in a certain local place may affect detection (Bazerman *et al.* 1997), while limited capacity of human cognition to understand the behaviour of climate can also affect people’s detection and perception of climate variability and changes (Gifford, 2011). Building on the diverse literature on perception studies, I developed a perception model (Figure 5.1) modified from Vedwan (2006:10) to guide the analysis of the results and discussion in this Chapter.

The model shows that the coastal environment (terrestrial and marine components) in which fishing, farming and seaweed farming take place, interacts with weather and climate systems (A). The interactions within ecosystems and the dynamic interactions between humans and their ecosystems form the basis of local ecological knowledge that may influence perceptions of environmental change and local climate variability (Vedwan, 2006). The perception of farmers, seaweed farmers and fishers of climate and sea level variability (C) is influenced by the determinants of perception (B). The determinants of perception include (1) the relationship between crops/seaweed/fishery resources and climate variability/sea level change (Teka and Vogt, 2010; Vedwan, 2006; Vedwan and Rhoades, 2001); (2) relationships between direct human experiences and climate (see Whyte, 1985); (3) intensity and frequency of extreme events beyond normal (Whytes, 1985); (4) local community’s knowledge of agricultural land, intertidal zones and fishing grounds; and lastly, (5) memory of the local communities regarding normality of climate over time. It is obvious that the perception of an individual is influenced more by recent climate phenomena than by distant ones. However, distant past events are likely to be remembered as well “if they are unusual or outstanding (i.e. above the perceptual threshold)” (Hulme *et al.* 2009: 200). The perceptions (C) ultimately may facilitate responses (D). The link between D – (responses) and A (physical system) is depicted with dash lines which denotes no direct influence between the two. However, after the initial set of responses, an individual farmer, fisher or seaweed farmer will refresh his/her view of the climate (A) and this may perhaps result in changes in the determinants of perceptions (B) and perceptions themselves (C) and thus

lead to new responses (D). This Chapter covers only perceptions; a detailed discussion on local peoples' responses to local climate variability and change, sea level change and other linked stressors as perceived is covered in Chapter 6. The model is an extension of the broader conceptual framework of the study presented in Chapter 1. The model is used to shed more light on the exposure and sensitivity of the Zanzibars' east coast communities to climate variability and change.

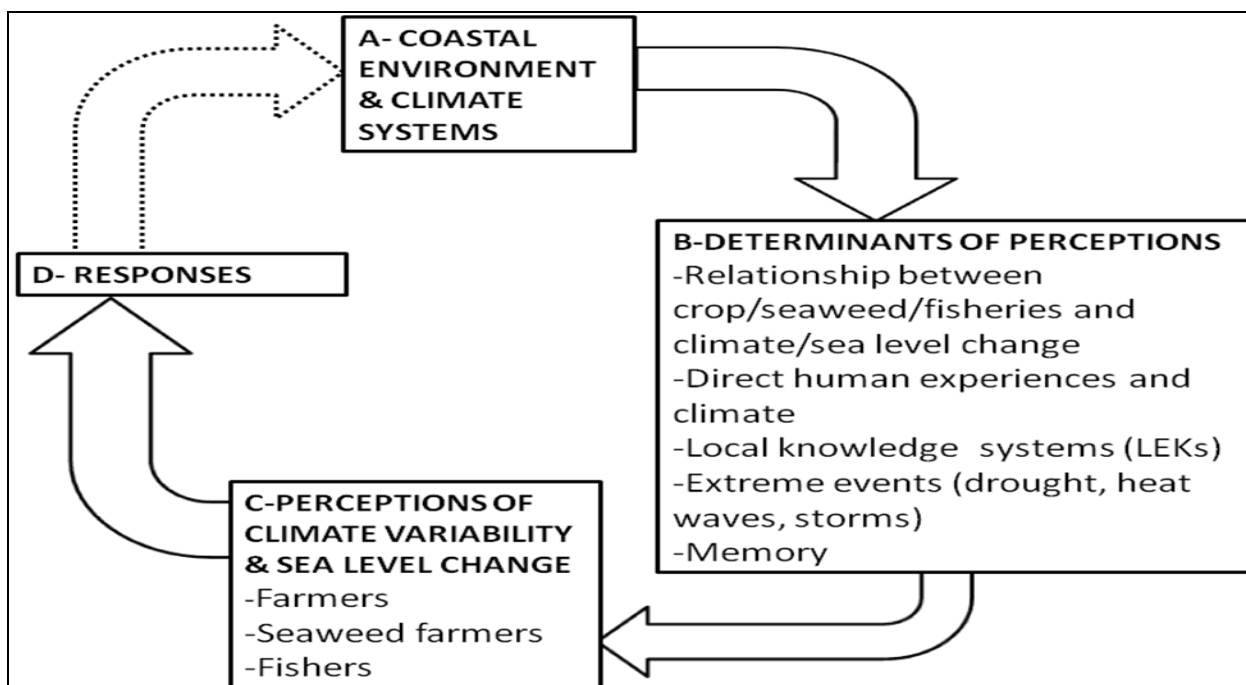


Figure 5.1: Environmental Perception model, modified from Vedwan (2006:10)

5.2 METHODS

This Chapter uses data from various sources for the purposes of triangulation. The data collection was divided into four stages.

a. Stage 1: Local perceptions

The stage involved three sets of structured questionnaires administered to fishers, seaweed farmers and farmers, respectively. This was collectively called the 'perception survey'. A total of 296 individuals were interviewed in the perception survey (see Chapter 2 for a detailed description of how individuals were selected). The perceptions of local climate variability were based on three weather elements (rainfall, temperature and winds) and on sea level and overall perception of climate variability. With regard to the overall perception respondents (farmers, fishers and seaweed farmers) were asked whether they agree or disagree with the statement that climate in their areas has changed. The percentage of the respondents in each category was then determined. A bivariate correlation test was performed to determine the relationship between the degree of agreement for the above question and the profile of the respondents (age, gender and education). For each weather element, I obtained the perceptions of the respondents for different seasons.

For instance, regarding rainfall, I assessed the perceptions of respondents regarding variability and changes in both the long-rain season (*masika*) (March-May) and the short-rain season (*vuli*) (October-December). The occurrence of floods and droughts was also determined. Drought is defined as “recurring extreme climate events over land characterised by below normal precipitation over a period of months to years” (Dai, 2011:45). It is a temporary dry period, in contrast to permanent aridity in arid areas. For wind, I looked at the south-easterly wind (*kusi*) (June-September) and north-easterly wind (*kaskazi*) (December-March) seasons separately; and for temperature, variability and change in summer (*kiangazi*) (January-March) and winter (*kipupwe* in Unugja and *mchoo* in Pemba) (June-August), temperatures variability were assessed separately (see Chapter 2). With regard to sea level, respondents were asked a general question without reference being made to any particular season.

Each question for the above parameters required the respondents to respond as given in Table 5.1. The percentage of respondents was then determined to show what individual perceptions were about the different weather elements and sea level. All respondents across the sectors (seaweed, crop farmers and fishers) were asked questions about perceptions of shifts in temperature and rainfall; whereas only seaweed farmers and fishers were asked questions about the variability of wind and sea level. It was assumed that seaweed farmers and fishers would be more perceptive regarding wind and sea level variability than farmers as their activities interact a great deal with these elements. Further, only farmers were asked questions about the frequency of floods and droughts.

Table 5.1: Responses for assessing perception of variability in climate and sea level

Responses	Rainfall		Temperature	Wind	Sea level
	Long- and short - rain season	Floods and droughts	Summer and winter	South- and north-easterly wind	
1	More rainfall	More frequent	Warmer	Stronger	Increased
2	Same	Same	Same	Same	Declined
3	Less rainfall	Less frequent	Colder	Weaker	Unidentified

With regard to the causes of climate variability and change, respondents were asked to identify the factors that they thought were responsible for the perceived variability of climate, and the percentage of respondents for each of the identified causes was determined. In terms of uptake of seasonal weather forecast and predictions, respondents were asked whether it was more difficult for them to predict rainfall compared with 20 or 15 years back. Other questions asked included whether respondents tuned into the radio to listen to seasonal forecasts and whether they had other sources of seasonal weather information apart from the radio and extension officers. The percentage of the responses was then determined to assess the perceptions of respondents regarding the predictability of rainfall and accessibility to weather forecasts. These three questions were administered to farmers only.

b. Stage 2: Meteorological data

In the second stage, data on rainfall, temperature, sea level rise and sea surface temperature in Zanzibar were obtained and analysed to establish the relationship between local perceptions and measured observations over the past 20 years and prior to that. Rainfall and minimum temperature data were obtained from the Tanzania Meteorological Agency (TMA) Zanzibar office. I was advised by the key informant from TMA to use the minimum temperature as it gives a clearer picture of variability than the maximum temperature. Sea level data were downloaded from the University of Hawaii's Sea Level Centre (UHSLC), and sea surface temperature data were obtained from the POET-website. Because of insufficient or underperforming weather stations along the east coasts of both Unguja and Pemba Islands, most of the data comes from the Zanzibar International airport located in the west for Unguja, and Chake Chake airport for Pemba. The only rainfall data (1992-2010) from the east coast was obtained from Paje weather station in Unguja (see Figure 5.5 and 5.8). Since it is known that the east coasts receive less rainfall than the west coasts of the islands (Walsh, 2009), it was assumed that if the analysis of rainfall data obtained from central or west weather stations revealed a decline in rainfall, then the study areas which are located on the east of both islands, were likely to have experienced a higher degree of decline (see Figure 5.5). Inter-annual variations of rainfall, temperature, sea level rise and sea surface temperature were computed, based on their deviation from the long-term mean, to establish the links between perceptions and observation. To obtain some understanding of the situation beyond the 20 year cut-off used for the perceptions study, longer term data for rainfall, temperature and sea level measurements, where available, were also obtained and analysed using time series analysis (see Figure 5.9, 5.10, 5.14 and 5.19). The time frames for these data were not uniform; this was due to inconsistent availability of data.

c. Stage 3: PLA

In this stage, PLA approaches including qualitative data obtained from a historical timeline (Appendix I) and participatory observation were used for triangulation purposes. Respondents' additional comments during the surveys and PLA workshops are used extensively in the Chapter to support quantitative findings.

d. Stage 4: Key informant interviews (KII)

In the fourth stage, key informant interviews were conducted to further triangulate the data from both the perceptions survey and observed data. A total of four key informants were interviewed in this study, two from Department of Fisheries, Zanzibar, one from Institute of Marine Science, Zanzibar and Tanzania Meteorological Agency (TMA) Zanzibar office.

5.3 RESULTS AND DISCUSSION

5.3.1 Profile of respondents

As expected, both males and females engaged in farming activities in the areas, while males dominated the fishing activities (Table 5.2). However, there were differences in the seaweed farmers' profiles in Kiuyu Mbuyuni, Pemba where 18% of the respondents were male, compared to Matemwe, Unguja where all respondents were female. Since the beginning of seaweed farming in Zanzibar in the early 1990s, the profile of people engaged in seaweed farming has changed from being predominantly female to include more males.

Given that the perception surveys across the sites were purposively age biased (as described in Chapter 2), the highest number of respondents across the sites and sectors fell within the 40-49 age group, except for farmers in Kiuyu Mbuyuni who fell in between 50-59. It is interesting to note that a large proportion of respondents in all three livelihoods categories had no education; more than half of the respondents among farmers and seaweed farmers across the sites had never attended school. Similarly 58% and 48% of fishers in both Kiuyu and Matemwe respectively had not attended school (Table 5.2).

Table 5.2: Profile of the respondents in Kiuyu Mbuyuni, Pemba and Matemwe, Unguja

Variables	Classes	Farmers (%)		Seaweed farmers (%)		Fishers (%)	
		Kiuyu, Pemba (N=49)	Matemwe, Unguja (N=49)	Kiuyu, Pemba (N=50)	Matemwe, Unguja (N=50)	Kiuyu, Pemba (N=50)	Matemwe, Unguja (N=48)
Gender	Male	39	57	18	-	100	100
	Female	61	43	82	100	-	-
Education	Primary	25	31	24	18	20	29
	O level	12	10	8	24	24	23
	A level	-	2	-	-	2	-
	Coll/univ.	-	-	2	-	-	-
	Adult	4	0	4	-	2	-
	none	59	57	62	58	52	48
Most common age group (mode)		50-59	40-49	40-49	40-49	40-49	40-49

Age classes were: 1=20-29, 2=30-39, 3= 40-49, 4= 50-59, 5=60 and above

5.3.2 Overall perceptions of climate variability and change

The results in Figure 5.2 show that a large proportion of respondents across the sites and livelihood categories agreed with the statement that climate has varied over time. The results of the bivariate correlation test (Table 5.3) reveal no relationship between perception of climate variability and gender, age and education. Thus, the majority of respondents, regardless of their age, gender and education have perceived changes in the climate. These findings suggest that respondents' perceptions were probably influenced by their direct experience with climate and seasons and the relationship between their livelihood sector and climate (Vedwan, 2006). The study by Whyte (1985) also found no significant variations in perception of weather and long-term climate change among three groups studied in Canada based on age,

education and gender. Their perceptions were rather highly influenced by general environmental awareness and experiences.

Decreasing rainfall, increasing temperatures, increasing wind intensity and unpredictability of the seasons have been perceived by local communities in studies undertaken in other parts of Unguja Island (Kombo, 2011; Salum, 2009). Elsewhere in Africa small-holding farmers in Zambia and Zimbabwe (Nyanga *et al.* 2011; Mubaya *et al.* 2012), and Swaziland (Manyatsi, 2010) have perceived variability and unpredictability of climate seasons over time.

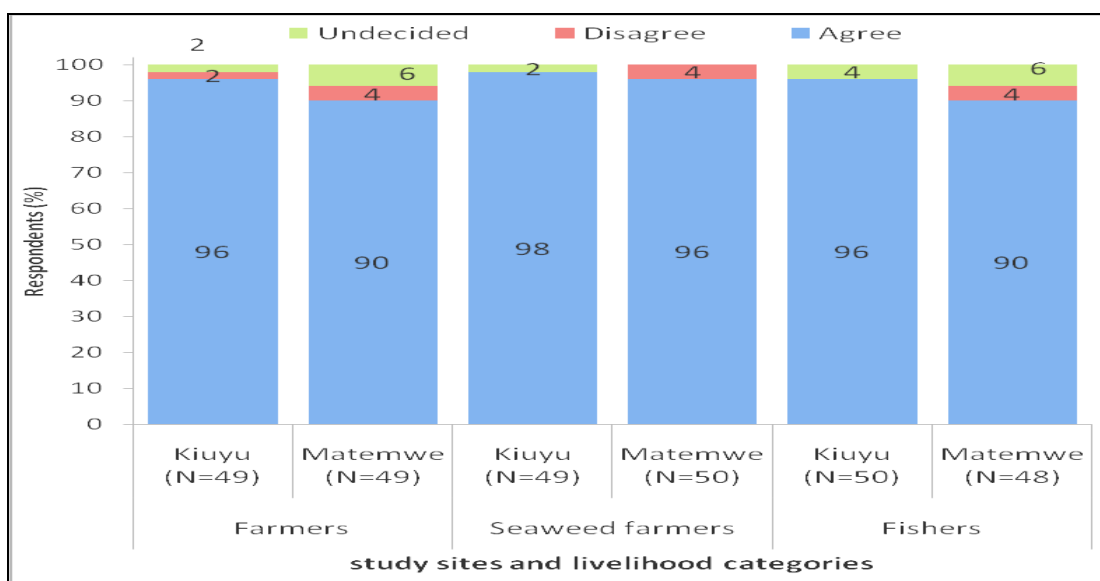


Figure 5.2: Perception of local communities of local climate variability and change

Table 5.3: Pearson correlation results between population profile and climate variability agreement

Profile of the respondents	Farmers (N=98)	Fishers (N=98)	Seaweed famers (N=99)
	Degree of agreement	Degree of agreement	Degree of agreement
	P value	P value	P value
Gender	.418*	a	.605*
Age	.889*	.742*	.545*
Education	.108*	.357*	.204*

a. Could not be computed because all respondents were male. * Pearson correlation was not significant

5.3.3 Perceived and observed variability in rainfall

5.3.3.1 Perceptions of rainfall variability and extreme events

As previously mentioned, Zanzibar Islands experience two rainy seasons per year (see Chapter 2): the long-rain season locally known as *masika* (March-May), when rainfall is long and heavy; and the short-rain season locally known as *vuli* (October-December), when rainfall is short and light. In other seasons (summer and winter), showers are isolated (Chapter 2). Mean annual rainfall received in the central areas and on the west coasts of both islands is about 1 950 mm while on the east coasts, mean annual rainfall is as

low as 1 400 mm (Walsh, 2009; Juma, 2004). The results in Table 5.4 show that more than half of the respondents across the sites and livelihood categories have perceived a decline in rainfall in both the long- and short-rain seasons. The results for the long-rain season are complex and revealed few clear patterns, especially among farmers. For example, about 58% and 64% of farmers in Kiuyu Mbuyuni and Matemwe respectively perceived declining rainfall in the long-rain season, while 42% in Kiuyu Mbuyuni and 29% in Matemwe believed that rainfall received in this season had remained the same over time. With regard to the short-rain season, 98% of farmers in both the study sites perceived a decline in this season whereas 96% of the fishers in Kiuyu Mbuyuni and 100% in Matemwe perceived a decline as well (Table 5.4). Thus, if perceptions between these two seasons were compared, more people perceived a decline rainfall during short-rain seasons than the long-rain season. Probably it is easier to perceive variable rainfall in a short-rain season as there is normally less rain compared with the long-rain season.

Table 5.4: Perceptions of rainfall variability in the long- and short-rain seasons

Seasons	Responses	Fishers %		Seaweed farmers %		Farmers %	
		Kiuyu , (N=47)	Matemwe (N=42)	Kiuyu (N=48)	Matemwe (N=47)	Kiuyu (N=45)	Matemwe, (N=44)
Long-rain season (Masika)	More rain	-	5	-	11	-	7
	Same	13	17	29	28	42	29
	Less rain	87	79	71	61	58	64
		N=48	N=42	N=48	N=48	N=45	N=44
Short-rain season (Vuli)	More rain	4	-	-	17	2	2
	Same	-	-	4	2	-	-
	Less rain	96	100	96	81	98	98

Apart from the declining rainfall in these two seasons, respondents also perceived variations in the spatial distribution of rainfall intensity and the onset of the rainfall seasons, as mentioned by a farmer from Kiuyu Mbuyuni, Pemba:

“Rainfall seasons have changed over time, rains come either late or sometime earlier than expected; now it is very hard to predict”.

However, the variability and changes were not all perceived to be bad. Some respondents believed that current variability of rainfall gave them an opportunity to do other things as it does not fall for an entire day as in the past. This is explained by a seaweed farmer from Matemwe:

“Rainfall in the long-rain season (masika) in recent years is really good, because it falls and ceases after short period and thus gives us the opportunity to do other things, but in those previous years rain can fall three days consecutively, day and night, and we remained indoors for three days. If rainfall behaves like in the past, most of us would suffer as we can’t afford staying indoors for three or four days and eat nothing, unlike in the past, now we are living from hand to mouth”.

Furthermore, a large percentage of respondents who perceived declining rainfall received during the short-rain season were probably influenced by the importance of this season on the crop calendar of both sites as commented by a farmer from Matemwe Unguja:

“These days we do not receive rainfall during short-rain season and winter, normality of rainfall in these seasons is very important as most of our crops such as cassava, big yams, small green beans (choroko) and pigeon peas (mbaazi) are grown through these seasons”.

Low water retention capacity of the soils in both sites (Chapter 6), the absence of annual and perennial streams (Chapter 2) and the low level of rainwater harvesting (Chapter 4) make the short-rain season and a normal winter crucial for the farming system and food security of these areas. This is because common crops such as maize, millet and sweet potatoes (Chapter 6) grow within or through winter and the short-rain season. With regard to annual varieties such as cassava and yams (*viazi vikuu*), even if the sites received good rain during the long-rain season (March-May), any abnormality during winter (June-August) and the short-rain season (October-December) is likely to affect these crops before harvesting. The findings support the idea that the perception of local communities that rainfall had decreased, was highly informed by a ‘crop-climate’ relationship (Vedwan, 2006; Vedwan and Rhoades, 2001) and experiences. This argument is further supported by the following testimony from Kiuyu Mbuyuni, Pemba:

“I remember those days during long-rain season (masika) we used to go fishing through rainfall and back with rainfall, but currently we are making a fishing trip under the sun and back under the sun during the long-rain season, we don’t have a long-rain season any more”.

With regard to extreme events related to rainfall, such as drought and floods, farmers were asked to indicate changes in their frequency over the past 20 years. The results in Figure 5.3 show that the majority of farmers across the sites have perceived an increasing frequency of drought and a decreasing frequency of heavy rainfall and floods over time (Figure 5.3). This is articulated by a respondent in Kiuyu Mbuyuni:

“When I was young I remember there were many temporary ponds in the forest full of water especially during long-rain season and we used to go and swim, but in recent years those ponds have disappeared as rainfall has decreased tremendously over time”.

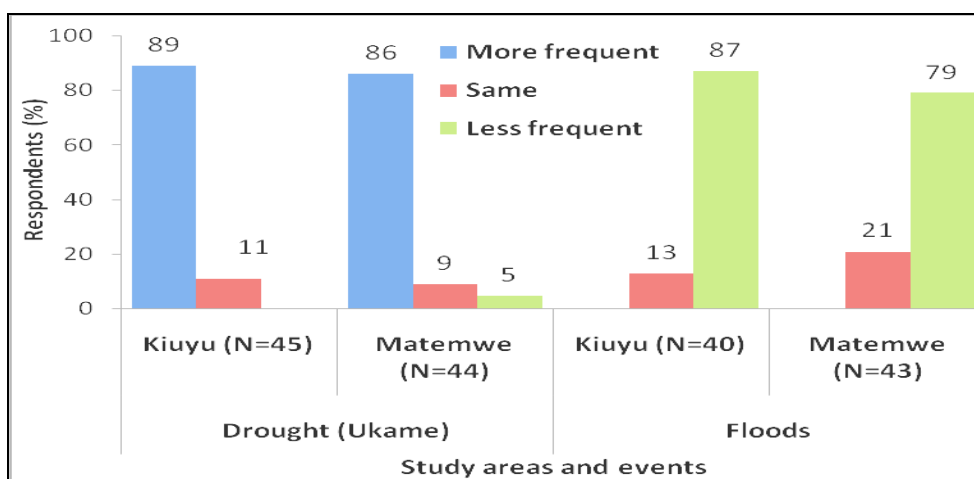


Figure 5.3: Perceptions of farmers on the frequency of drought and floods

Farmers only remembered floods in 1997-1998, which were triggered by heavy rainfall associated with the El Niño Southern Oscillation (ENSO) event in the western Indian Ocean. Their perception of increasing

frequency of drought was backed by the results obtained during ‘historical timeline’ workshops (Appendix I) which indicated that over the past decade the areas experienced drought in 1999-2000 and 2008-2010 (also see Figure 5.6 and 5.7). The participants of historical timeline in both sites also identified 1971-1972 as a period of drought and famine. In examining changing climate in East Africa, Spinage (2012), also identified periods of drought in the history of Zanzibar, which include 1859, 1949 and 1956.

The findings reveal that farmers, seaweed farmers and fishers perceived variations in rainfall in both the amount and onset of rainfall across the sites. The findings mirror similar findings within Zanzibar and the Tanzania mainland (Kombo, 2011; Slegers, 2008) and other parts of the world (Mertz *et al.* 2009; Gbetibouo, 2009; Marin, 2010; Nyanga *et al.* 2011; Fosu-Mensah, 2012). For instance, in examining the perception of small-scale farmers in Zambia, Nyanga *et al.* (2011) found that most of the farmers have perceived changes in the onset and duration of the rainy season; rainfall started later and ended within a short period. Similarly, local people in the central district of Unguja also perceived a decline in rainfall and a change in the timing of the onset of rainfall in both the short- and long-rain seasons in the past decade (Kombo, 2011), while a study by Slegers (2008) in the central Tanzanian mainland documented the high perception of local communities of a decline in rainfall and associated impacts on farming.

5.3.3.2 Observed rainfall

From 1991-2010 Unguja Island received more rainfall than Pemba Island; the annual average rainfall received during this period was 1 647 mm for Unguja, and 1 487 mm for Pemba. Seasonally, Pemba received more rainfall in the long-rain season (March-May) compared to Unguja in the same period; the average rainfall during the long-rain season was 933 mm for Pemba and 858 mm for Unguja. By contrast, Unguja received more rainfall in the short-rain season (October-December) (482 mm) compared with Pemba (232 mm) during the 1999-2010 period (Figure 5.4).

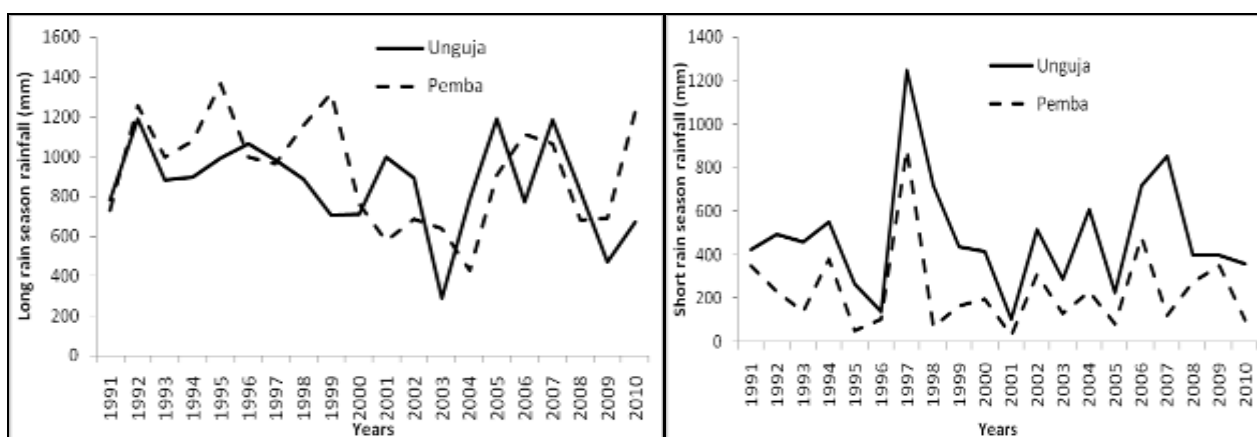


Figure 5.4: Left: inter-annual variability of rainfall in long-rain season (March-May) between Unguja and Pemba from 1991-2010. Right: inter-annual variability of rainfall in short- rain season (October-December) between Unguja and Pemba from 1999-2010 (Source of data: TMA Zanzibar office)

A comparison of rainfall received in the long-rain and short-rain seasons between 1992-2010 on the west and east coasts of Unguja/Zanzibar reveals more rainfall is received in the west compared with the east of Unguja in both seasons (Figure 5.5). The average rainfall calculated for the short-rain season during this period was 485 mm for the west and 231 mm for the east. Low rainfall received during the short-rain season during 2006-2010 was partly responsible for the drought across the sites that was identified during the ‘historical timeline’ workshops (Appendix I). Kiuyu Mbuyuni in the east of Pemba, is probably more vulnerable than Matemwe in Unguja east, as Pemba normally receives less rainfall during the short-rain season than Unguja (see Figure 5.4).

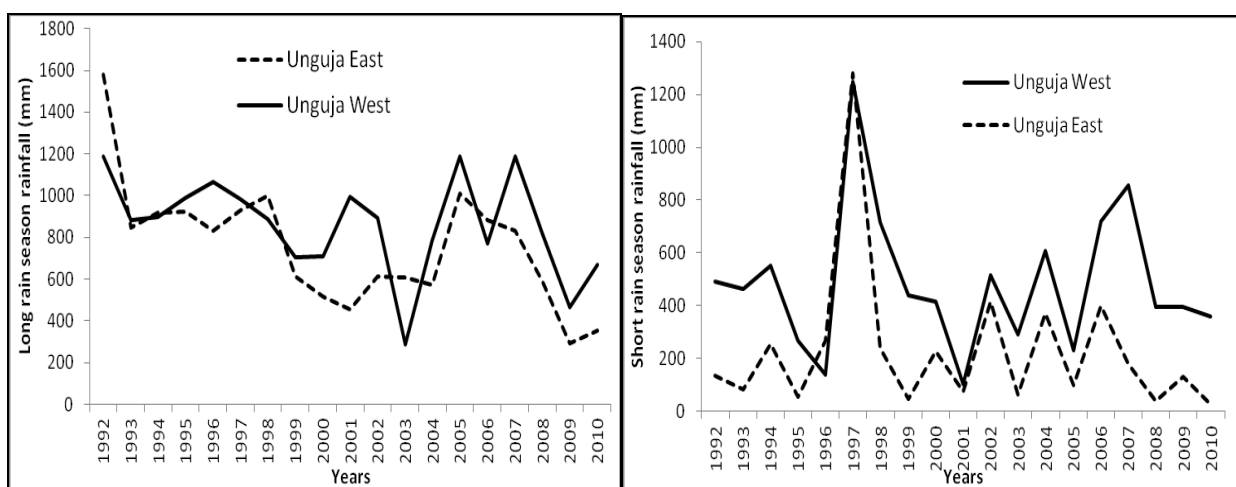


Figure 5.5: Left: inter-annual variability of rainfall in long-rain season (March-May) between Unguja West and East from 1992-2010. Right: inter-annual variability of rainfall in short- rain season (October-December) between Unguja West and East from 1992-2010 (Source of data: TMA Zanzibar office). Note: The study didnot compare rainfall received in Pemba West and East coasts as weather stations along the Pemba east coast were not operating reliably

The anomalies from the analysis of rainfall data during the long-rain season (March-May) (Figure 5.6) and short-rain season (October-December) (Figure 5.7) over the period 1991-2010 support the perceptions of local communities regarding variability in rainfall received in both long-rain (*masika*) and short-rain seasons (*vuli*). Linear trends in both figures demonstrate the dominance of below normal regimes of rainfall in both seasons, particularly for the last three years. A long-rain season in Unguja in 2000 and in Pemba in 2000-2004 showed the highest negative anomalies (below average). In 1997-1998 both islands experienced positive anomalies (above average) of rainfall during the long-rain season. Heavy rainfall during this period was linked with the El Niño event in the western Indian Ocean caused by higher sea surface temperature over the Indian ocean. However, negative anomalies in the long-rain season reappearead between 2009-2010 in Unguja and between 2008-2009 in Pemba.

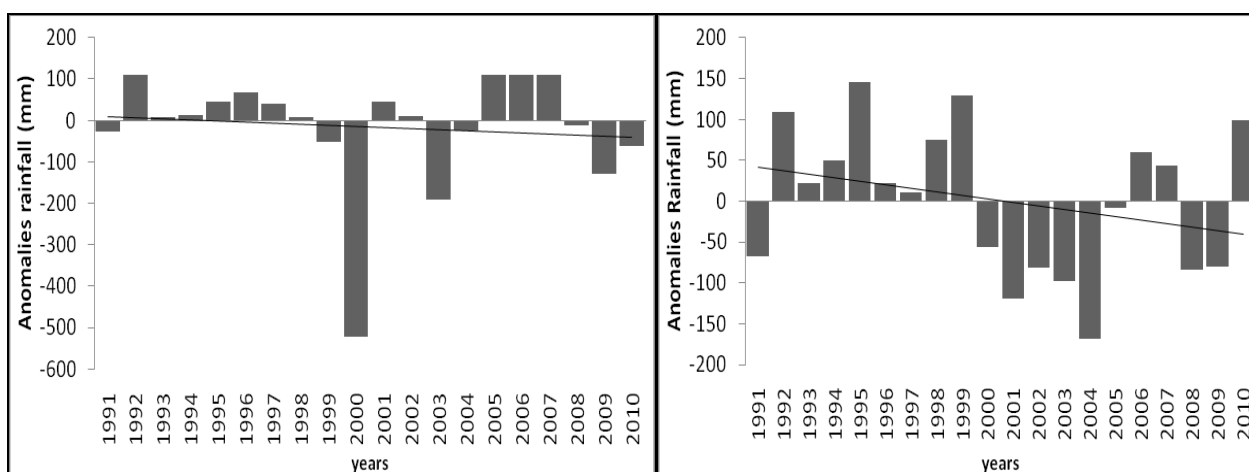


Figure 5.6: Inter-annual variability of the long rain season/*masika* (March-May) (Left: Unguja, average 858 mm; Right: Pemba, average 933) (Source: TMA, Zanzibar office)

In terms of rainfall during the short-rain season (October-December), the trend lines in Figure 5.7 are close to the average, probably due to large annual differences, but the variability of rainfall observed in the short-rain season is extreme. For instance in Pemba, above normal rainfall in the short-rain season was recorded for only six out of 20 years (1991, 1994, 1997, 2002, 2006 and 2008); negative anomalies (below normal) during this season were recorded for the remaining 15 years (Figure 5.7). In Unguja, positive rainfall anomalies during the season were only recorded in seven out of 20 years. Interestingly, even during El Niño 1998, the rainfall in Pemba during the short-rain season was below normal, while in Unguja the highest positive anomalies were recorded during this particular period. However, Pemba received more rain in the long-rain season than Unguja during the El Niño event 1997-1998 (Figure 5.6 and 5.7).

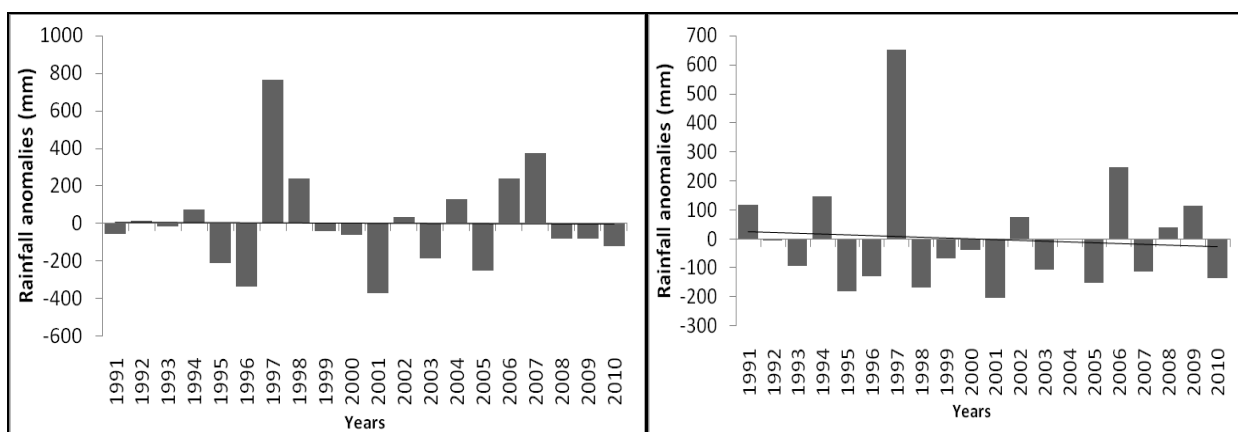


Figure 5.7: Inter-annual variability of rainfall in short-rain season/*vuli* (October-December). (Rainfall anomalies i.e. deviation from the mean) (Left: Unguja, average 482 mm; Right: Pemba, average 232 mm) (Source: TMA, Zanzibar office)

On the east coast of Unguja which normally receives low rainfall, the results in Figure 5.8 show that in the period between 1992-2010, the area recorded rainfall slightly above normal in 2007, but severely below normal rainfall in the period between 2008-2010. Like on Figure 5.7 east coast also received high rainfall

during El Niño (1997-1998) and below normal rainfall during La Niña (1999-2001). Although it was not possible to obtain rainfall data from east Pemba, for the reasons noted previously (section 5.2), its rainfall characteristics, especially in the short-rain season (*vuli*) are similar to those of Unguja east (see Walsh, 2009). The result shown in Figure 5.8 underlines the fact that when rainfall declines sharply on the west coasts of both islands, the east coasts experience an even more severe decline in rainfall which causes agriculture failure and food insecurity, as actually happened in 2009-2011 in east coast Pemba (see Chapter 4; Said, 2011). On the other hand, it should be noted that a high degree of variability was observed from the late 1990s to the present (Figure 5.6, 5.7 and 5.8).

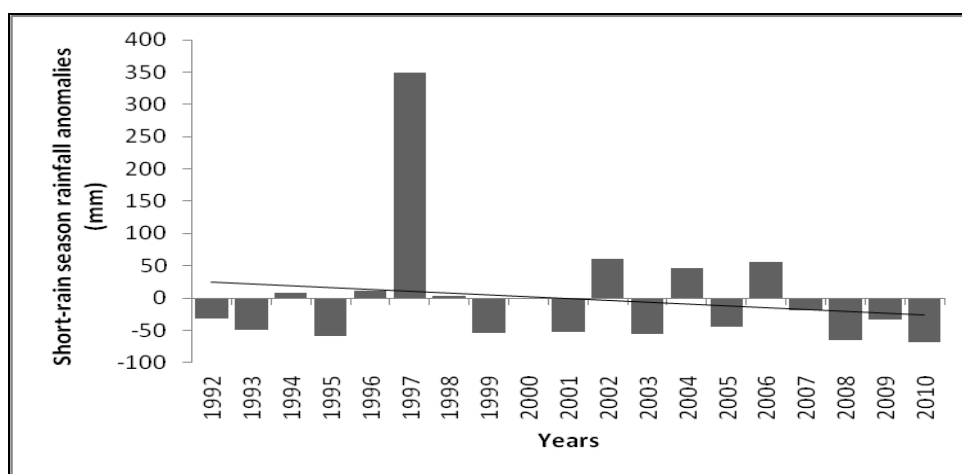


Figure 5.8 Inter-annual variability of rainfall in the short-rain season/*vuli* (October-December) on the east coast of Unguja from 1992-2010. (Source: TMA, Zanzibar office)

Furthermore, the analysis of longer term rainfall patterns in both islands using a time series analysis also revealed that reality substantiates the perceptions of the local communities regarding the variability of rainfall over the last two decades. Rainfall shows high inter-annual and seasonal variability in Zanzibar (Figure 5.9 and 5.10). Over the period of 50 years (1961-2011), for Unguja, highest amounts of rain were recorded in 1962, 1979, 1986 and 2002. However, generally the trend shows a slight decrease in rainfall for Unguja (Figure 5.9). On the other hand, Pemba recorded highest rainfall during 1978, 1982, 1986, 1992, and 1998 (Figure 5.10). Similarly, the trend over the period of 30 years (1974-2012) shows a significant decrease in rainfall on Pemba compared to Unguja.

In fact, fluctuating rainfall trends are not new in the history of Zanzibar and the east African coast in general. For example, Spinage (2012) argues that rainfall in Zanzibar probably declined from 1874 and picked up again in and around 1935-1940. A similar trend was observed in other parts of the east African coast, especially in Mombasa. Generally, the findings reflect those in a study by Hastenrath (2007) who found that rainfall received in the short-rain season decreased and became more unpredictable over the last two decades of the 19th century in East Africa. Studies by Nicholson (2000), Chappel and Agnew (2004), Dai *et al.* (2004) and Dai (2011) observed a decline in annual rainfall since the end of the 1960s in West

Africa and other parts of the world, while in southern Africa, there was evidence of changing seasonality and weather extremes, such as periods of very heavy rainfall (Usman and Reason, 2004 cited in Boko *et al.* 2007).

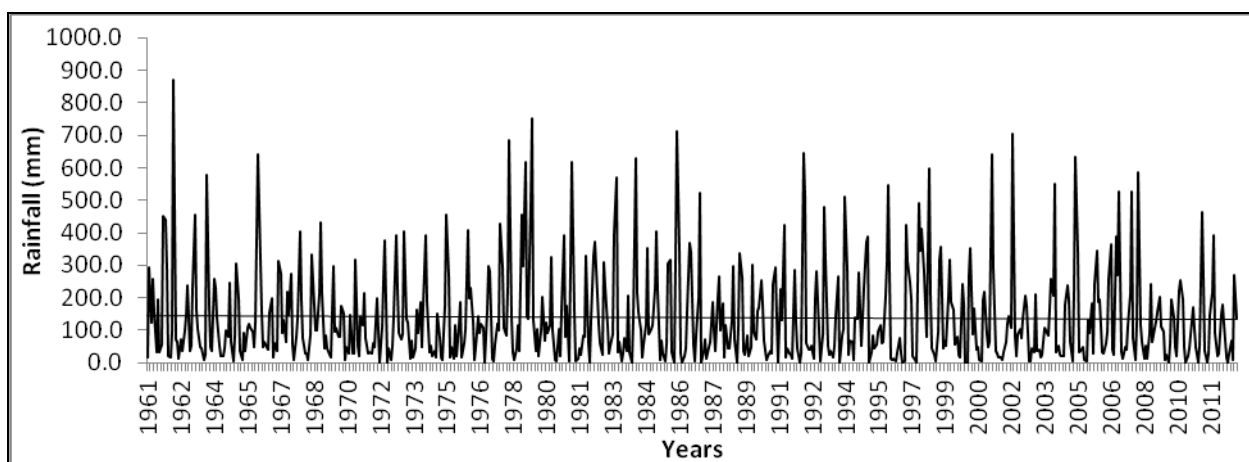


Figure 5.9: Time series of rainfall patterns at Unguja Island, 1961-2011 (Data from TMA, Zanzibar office)

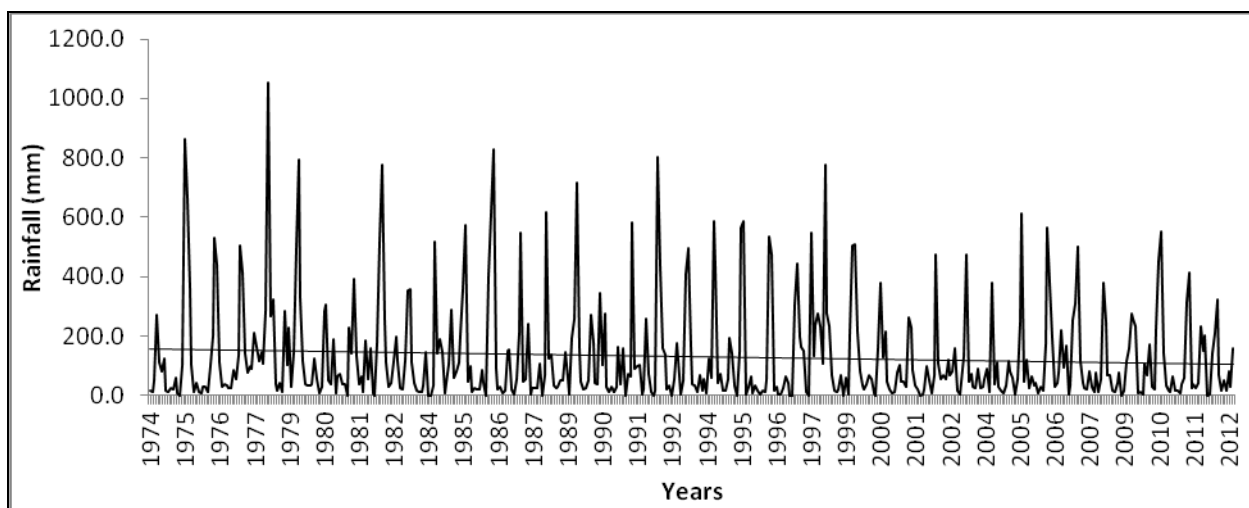


Figure 5.10: Time series of rainfall patterns at Pemba Island, 1974-2012 (Data from TMA, Zanzibar office) (Note: There was no rainfall data available for Pemba beyond this period)

5.3.3.3 The influence of ENSO on local rainfall variability and future scenarios

Figure 5.6 and 5.7 show that the variability of rainfall in Zanzibar is mostly influenced by El Niño Southern Oscillation (ENSO) events. For example, heavy rainfall (above average) observed in both the long- and short-rain seasons in 1997-1998 coincided with El Niño events, while erratic rainfall (below average) experienced in both seasons across the sites in 2000-2001 coincided with a negative ENSO (La Niña) (Figure 5.7 and 5.8). ENSO refers to semi-periodic changes in the tropical oceans and atmospheric systems, particularly in the Pacific and Indian Oceans (Adams *et al.* 2003; Rao and Behera, 2005; Zinke *et al.* 2004). ENSO events occur in two main phases, namely El Niño and La Niña (Adams *et al.* 2003). The El Niño

(positive event) occurs when sea surface temperature (SST) is above normal (positive anomaly), while La Niña (negative event) occurs when SST is below normal. In most cases, the former is associated with heavy rainfall and the latter with dry spells (Adams *et al.* 2003). Various studies, including Phillips *et al.* (1998) in Zimbabwe and Rampelloto *et al.* (2012) in Brazil found a strong relationship between the variability of rainfall, SST and ENSO in the last decade.

Although the rainfall pattern in Zanzibar is affected by various meteorological processes, the observed domination of ENSO events within the last decade increases the uncertainty of the future climate, mainly because ENSO is linked with SST anomalies. Dai (2011) for example, argues that the recent drying trend in Africa is related to SST pattern changes in the Atlantic and the steady warming in the Indian Ocean. However, according to Boko *et al.* (2007:436) understanding how events like ENSO “may influence future climate variability is critical to Africa and requires further research”. Apart from the unpredictability and the nature of ENSO events, rainfall projection in Africa is still limited by many factors (Boko *et al.* 2007). Besides the limits and barriers mentioned above, Christensen *et al.* (2007) using SRES A 1B emission scenarios, revealed that rainfall is likely to increase in tropical and eastern Africa by around 7% (also see Boko *et al.* 2007). For example, downscaled monthly rainfall projections using SRES A2 2046-2065, predict a slight increase in rainfall during the long-rain season (March-May) and a further decline in rainfall during the short-rain season (October-December) between 2046-2065 in Zanzibar (see Figure 5.11). The figure demonstrates the need for proper adaptation measures as rain during the short-rain seasons is crucial for agriculture systems, especially on the east coasts which already deal with poor soils.

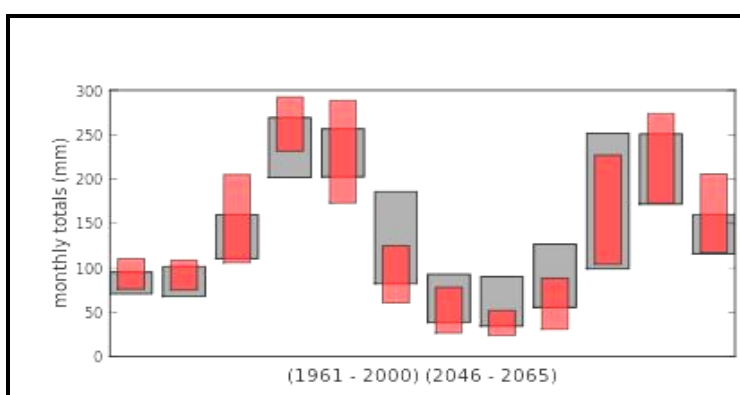


Figure 5.11: Future rainfall projection for Zanzibar: grey represents monthly rainfall totals for the 20th century; red represents a future period. A downscaled monthly rainfall projections using SRES A2 2046-2065 (Sources: CIP-UCT climate change portal).

5.3.4 Perceived and observed variability in temperature

5.3.4.1 Perceptions of temperature variability

Average annual temperature in Zanzibar is between 23-28°C; Pemba’s temperatures are a bit lower than Unguja (Juma, 2004). The summer season (*kiangazi*) in Zanzibar occurs between January-March when

temperatures can be as high as 32°C, while the lowest temperatures in winter (June-August/September) are a little above 20°C (see Chapter 2). Winter in Zanzibar is not really cold and the difference between summer and winter temperatures is not large. Respondents were asked to explain the degree of variability within these two extremes over time and the results in Table 5.5 show that a large proportion of the respondents across the sites and livelihood categories perceived an increase in warmer conditions in summer. However, among farmers in Matemwe, Unguja the differences between those who perceived warming (47%) and those who believed that temperatures have remained the same (46%) is very small (see Table 5.5). Similarly, with regard to seaweed farmers in Matemwe, 53% perceived increasingly warmer conditions, while 42% perceived no change in summer over time. Interestingly, a considerable number of respondents across the sites and livelihood categories perceived increasingly warmer trends during winter over time (see Table 5.5) as described by a farmer from Matemwe:

“Like now we are in the middle of June; we are supposed to be in winter already, but I can’t feel it”.

This quotation suggests variability in the onset of the cold season and higher temperatures during this season. Similar perceptions have been found in Zambia; farmers have also perceived the unseasonal warmth of the cold season (Nyanga *et al.* 2011), whilst on the Kiribati Islands, local people argue that there is no need for being informed as they themselves have witnessed variability in various climate parameters, including temperature (Kuruppu and Liverman, 2011). The overwhelming perception across the livelihood categories of increasing warmth in both the summer and winter season is probably influenced by what Rayner (2003) cited in Hulme *et al.* (2009:200) called ‘co-production’ between temperature and seaweed on the one hand, and temperature and farming on the other (see Chapter 6). For seaweed harvesting, winter provides favourable conditions for rapid growth and high yield, while in summer, seaweed growth slows down as the temperature of shallow water where seaweed blocks are located increases (see Chapter 6).

Table 5.5: Perceptions of variability in temperature

Seasons	Responses	Fishers (%)		Seaweed farmers (%)		Farmers (%)	
		Kiuyu (N=48)	Matemwe (N=40)	Kiuyu (N=48)	Matemwe (N=45)	Kiuyu (N=43)	Matemwe, (N=43)
Summer (Kiangazi)	Warmer	77	70	67	53	70	47
	Same	17	30	29	42	30	46
	Colder	6	-	4	5	-	7
		N=47	N=42	N=48	N=47	N=42	N=44
Winter (Pupwe/Mchoo)	Warmer	68	79	65	60	69	61
	Same	30	17	12	25	17	14
	Colder	2	5	23	15	14	25

With regard to farming, abnormalities in winter and summer intensify what Dai (2011) called ‘agricultural drought’, in which soil becomes dry because of below average rainfall coupled with above average evaporation. As winter in Zanzibar (June-August) is a transition between the long-rain (March-May) and short-rain seasons (October-December), the abnormal winter and reduced rainfall in the short-rain season

(see Figure 5.7) have resulted in agricultural drought across the sites in 2008-2010 (Walsh, 2009; Said, 2011) mainly because a dry summer season (January-March) followed the short-rain season (October-December). Thus, the perceived variability of temperature, coupled with variability in rainfall, plus the poor capacity of the soil in both sites to retain water (Chapter 6) aggravated the vulnerability of the agriculture sector in these areas. In a similar line of argument, Barron *et al.* (2003) contend that the combination of poor rainfall and severe intra-seasonal dry spells may affect crop yield. Dai (2011) on the other hand, has associated recent surface warming in Africa with high rates of evaporation and drying since the 1980s. Apart from crop/seaweed-temperature relations coupled with traditional knowledge systems, local peoples' perceptions may also be informed through direct experience and observed isolated extreme events. For instance, isolated extreme events such as the worst heat waves ever recorded in the islands in 2007 (Watkis *et al.* 2012 as mentioned in Chapter 1), might have influenced the perceptions local communities have of changes in temperatures.

5.3.4.2 Observed temperatures

The data in Figures 5.12 and 5.13 support the perceptions of local communities regarding increasing warming conditions in both summer (January-March) and winter (June-August) (Table 5.5). Linear trends show a slight increase in minimum temperature across the sites in both seasons, for at least the last decade (2000-2010). The high positive anomalies observed in Unguja and Pemba in both seasons in 2006-2007 (Figures 5.12 and 5.13) were the result of heat waves recorded during this particular period (Watkis *et al.* 2012). For example, in 2007 Unguja's minimum temperature increased by 0.8°C above the summer average (24.07°C), while in Pemba in 2006 minimum temperature increased by more than 1°C above the summer average (23.89°C) (Figure 5.10) (summer and winter averages were calculated using temperatures recorded in those seasons for the period of 1991-2010 for Unguja and 1994-2010 for Pemba). On average, for the whole of the last decade, recorded summer and winter minimum temperature showed positive anomalies (above average) with minor variations. Positive anomalies were also recorded in both summer and winter seasons across the sites in 1998 (Figures 5.12 and 5.13).

Figure 5.14 shows minimum temperatures in both Pemba and Unguja Islands over the past 30 years (1984-2012). The figures again give an insight on minimum temperatures beyond the last two decades. A steady increase in minimum temperatures has been recorded since the 1980s, although this trend was interrupted between 1994 and 1997 with very low temperatures recorded, particularly in Pemba. A sharp increase in temperature is observed in 1998 associated with El Niño. Since then the trend shows a steady increase in temperature across all months of the year.

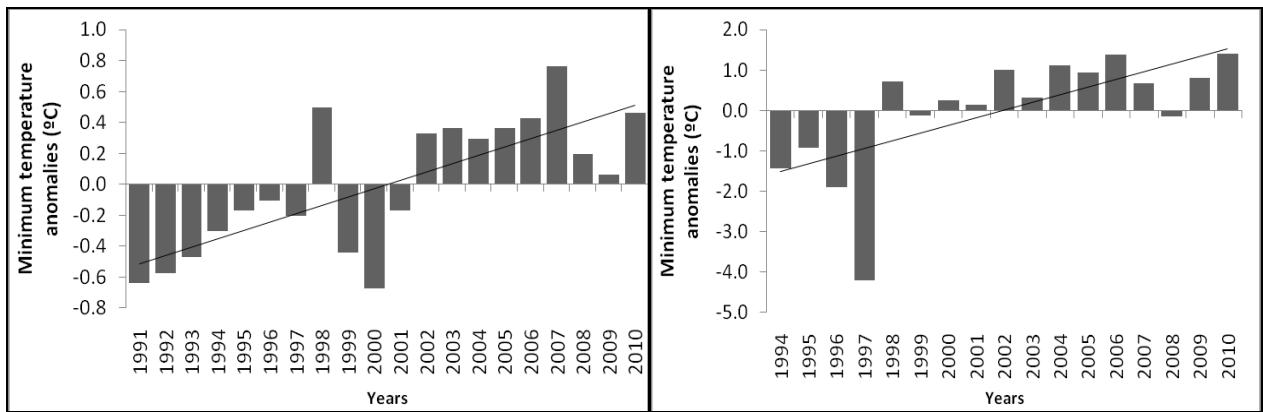


Figure 5.12: Inter-annual variability of mean minimum temperature in summer (January-March) (Left: Unguja, average 24.7°C from 1991-2010; Right: Pemba, average 23.89°C from 1994-2010) (Source: TMA, Zanzibar office).

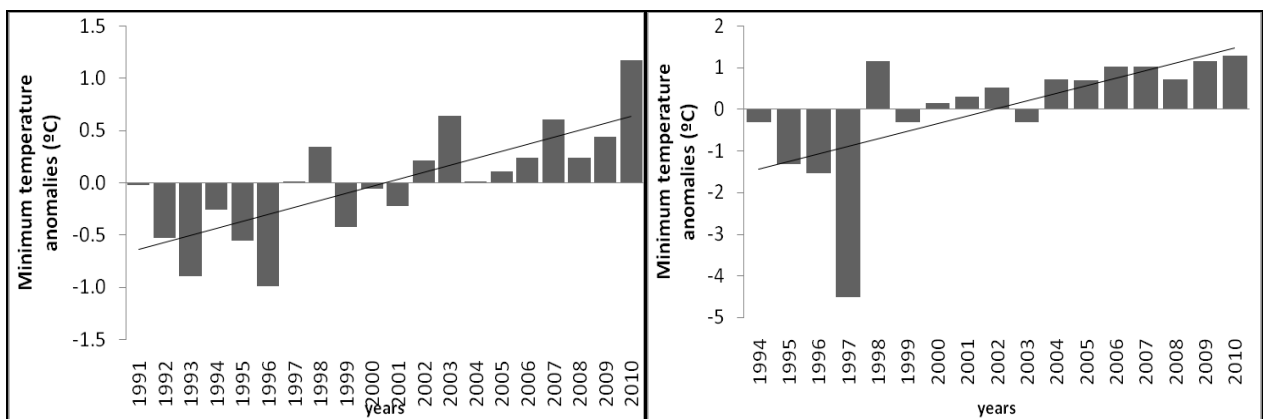


Figure 5.13: Inter-annual variability of mean minimum temperature in winter (June-August) (Left: Unguja, average 22°C from 1991-2010; Right: Pemba, average 22°C from 1994-2010) (Source: TMA, Zanzibar office).

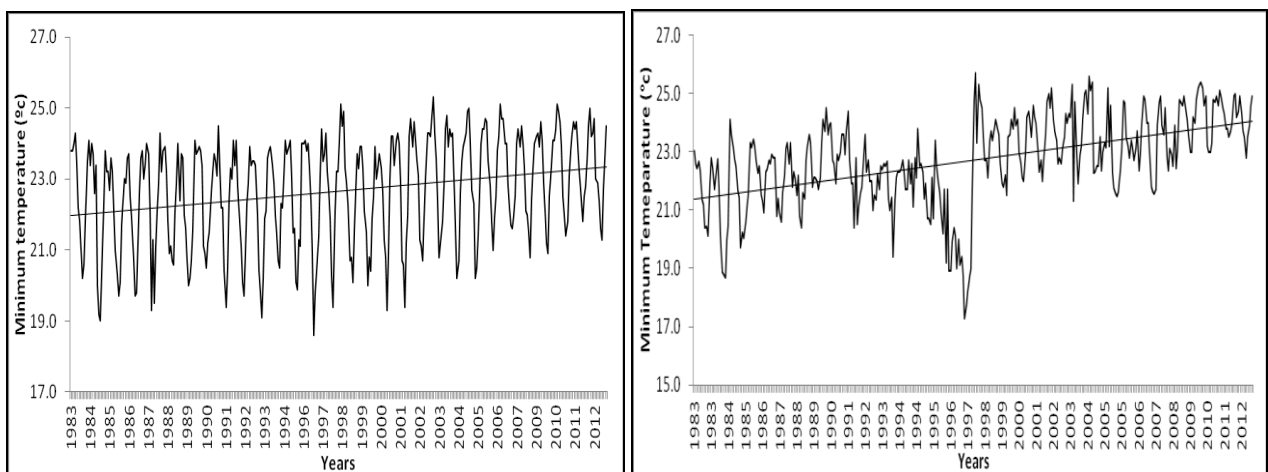


Figure 5.14: Time series of minimum temperature patterns, 1984-2012 (Left: Unguja, Right: Pemba, (Source: TMA, Zanzibar office)

The observed temperature data however, do not match those of King'uyu *et al.* (2000) who found a decrease in temperature from weather stations located close to the east African coast and major inland

lakes, probably because King'uyu's study was in 2000 whilst this study went beyond 2000, and much of the temperature increase was observed from the beginning of the last decade. Furthermore, King'uyu's study did not cover the Zanzibar Islands. According to Boko *et al.* (2007), since the Third Assessment Report of IPCC (AR3), the observed temperature has shown a warming trend since the 1960s. For instance, there was an increase in the number of warm spells over southern and western Africa, and a decrease in the number of cold days between 1961 and 2000 (New *et al.* 2006).

5.3.4.3 Relationship between SST and temperature and future scenarios

As with rainfall, Figure 5.15 shows a relationship between SST and temperature. For example, during the 1998 El Niño (high positive anomalies of SST), minimum temperatures in both summer (see Figure 5.12) and winter (Figure 5.13) showed positive anomalies (above normal). These temperatures were above 1°C and about 0.4°C above normal during the winter season in Pemba and Unguja respectively (see Figure 5.13), while during summer, temperatures increased by 0.6°C in Unguja and 0.9°C in Pemba during this particular period. Likewise, during the 2000-2001 La Niña events (highest negative anomalies of SST) the minimum temperatures in winter and summer also experienced negative anomalies (below normal) in this particular period, especially in Unguja (Figures 5.12 and 5.13). For instance, the minimum temperature for Unguja in summer was -0.7°C below average in 2000 and -0.4°C below average in the winter of 2001. Elsewhere a correlation between temperature and ENSO events has been observed. A study by Hopkins *et al.* (2010) in New Zealand found the influence of ENSO on the inter-annual variability of both temperature and strength of fronts and “they both decrease during El Niño and increase during La Niña events” (Hopkins *et al.* 2010:1535). Similarly, Pampelotto *et al.* (2012) found a close relationship between the variability of temperature and rainfall and the variability in solar activity and ENSO in Santa Maria (also see Charabi, 2009; Rao and Behera, 2005). Apart from regional events such as ENSO, temperature in Zanzibar was also found to be correlated with global temperature (Spinage, 2012); for instance, between 1905 and 1970, global temperature increased by 0.014°C per year and temperature in Zanzibar increased by 0.02°C (Spinage, 2012).

Given that a large part of the warming is attributable to human-induced greenhouse gases (Dai, 2011), Hudson and Jones (2002) cited in Boko *et al.* (2007:443) have predicted a “3.7°C increase during summer mean surface temperature and 4°C increase during winter by 2080 using HadRM3H RCM with A2 emission scenario”. Figure 5.16, sourced from the CIP-UCT website, also shows predictions of considerable increase in temperature in Zanzibar in all seasons. Thus, without comprehensive measures the projected increase will further exert significant pressure on farming, water resources, seaweed farming, fishing and tourism, all of which form the backbone of the Zanzibar economy. For example, a 30% loss of corals in 1997-1998 due to coral bleaching, attributed to the above normal SST over the southern Indian

Ocean, impacted tourism in both Zanzibar and Mombasa, and caused financial losses of about USD12-18 million (Payet and Obura, 2004).

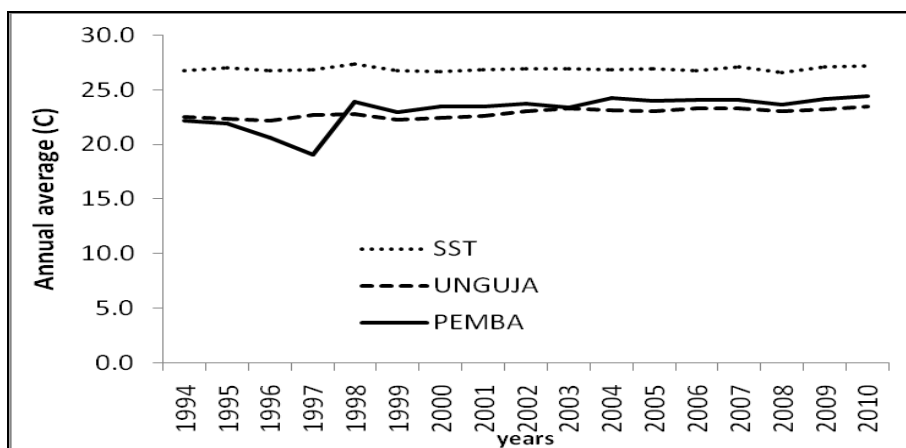


Figure 5.15: Inter-annual variability of minimum temperature in Pemba and Unguja and sea surface temperature (Source of temperature data: TMA, Zanzibar office; SST data: [POET-website](#)).

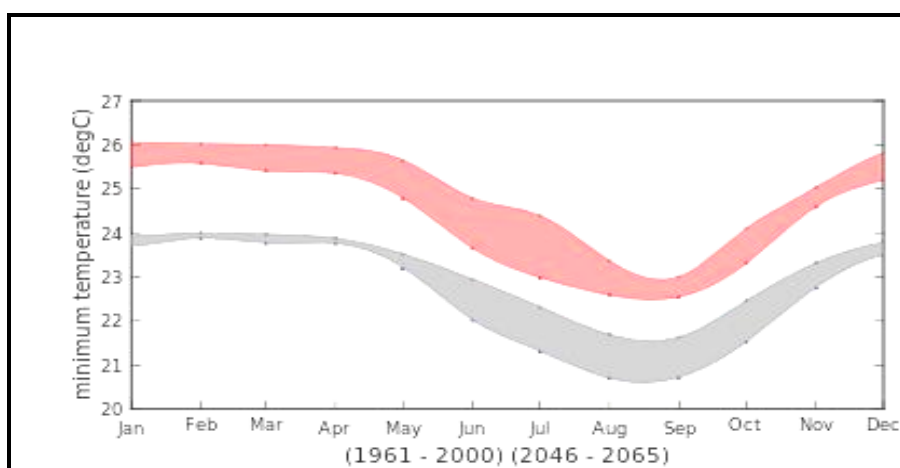


Figure 5.16: Temperature projection for Zanzibar; grey represents a range of monthly mean daily minimum temperatures for 20th century; red shows future period. A downscaled monthly minimum temperature projections using SRES A2 2046-2065 (Source: CIP-UCT Climate change portal)

5.3.5 Perception of local communities regarding wind patterns

The Zanzibar Islands experience two main wind directions, namely north-easterly winds (*kaskazi*) (December-March) and south-easterly winds (*kusi*) (June-September) with two calm periods in between locally known as *leleji* during October-November and April-May (see Chapter 2). North-easterly winds blow to the Zanzibar east coasts and are associated with summer (*kiongazi*) and are weaker winds, while south-easterly winds blow away from the east coast and are associated with winter (*pupwe/mchoo*) and are stronger winds (see Chapter 2; IXSURVEY, 2010; Msuya *et al.* 2010). The stronger wind during the south-easterly wind is partly attributed to storms and cyclones developing over the Indian Ocean during this particular period (IXSURVEY, 2010). Their formation is closely linked to the differential heating between

the northern and southern Indian Ocean regions, caused by the movement of the sun between the northern and southern hemispheres.

The multi-cultural nature of Zanzibar has been significantly shaped by these winds as they have facilitated interaction between local people and other communities within East Africa and the Middle East in the early days of civilisation (Nakamura, 2011). Apart from influencing the cultural nature of Zanzibar, the wind patterns play an important role in fisheries and emerging activities such as seaweed farming. For example, fishing trips are controlled by the winds as the majority of fishers still use traditional vessels such as outriggers and dugout canoes (see Chapter 6). The study found very few motorised boats at either site that could operate through both south-easterly and north-easterly winds (see Chapter 6). For this reason, fishing trips are limited during the south-easterly wind (*kusi*) season as *kusi* is stronger and blows away from the coast, and the local vessels cannot sail against the wind when returning home. Fishers therefore, either remain at home or sail out only a short distance to avoid being lost or drowned at sea. Thus, the majority of fishers who do not own motorised boats fish only during the north-easterly wind (*kaskazi*) which blows toward the coasts, and during calm periods. There was also the perception that the south-easterly wind, as it blows away from the coasts, drives away fish stocks. By contrast, the north-easterly wind brings fish stock into the territorial waters as it blows towards the coast. Wind patterns are also important for seaweed farming, for example south-easterly winds, since they are associated with winter (June-August), bring low temperatures which produce favourable conditions for seaweed growth and high yields, while the north-easterly wind, which is associated with summer (January-March), brings high temperatures which do not favour seaweed growth. However, south-easterly winds are stronger than north-easterly winds and thus can wash away seaweed farms.

Table 5.6: Perceptions of fishers and seaweed farmers of north and south-easterly winds

Wind seasons	Responses	Fishers (%)		Seaweed Farmers (%)	
		Kiuyu (N=45)	Matemwe (N=40)	Kiuyu (N=48)	Matemwe (N=46)
South-easterly wind (<i>kusi</i>)	Stronger	80	28	83	67
	Same	11	60	8	22
	Weaker	10	13	9	11
North-easterly wind (<i>kaskazi</i>)		(N=44)	(N=40)	(N=47)	(N=43)
	Stronger	48	10	47	44
	Same	43	63	42	37
	Weaker	9	27	11	19

To understand the perceptions of seaweed farmers and fishers to changes in wind patterns, respondents were asked to compare the intensity of wind over the last 20 years. The results in Table 5.6 reveal a variation in perception across sites and between fishers and seaweed farmers, which was probably influenced by the differential interaction between the winds and seaweed farming on the one hand, and fishing on the other. For instance, the majority of the respondents among fishers (80%) and seaweed

farmers (83%) in Kiuyu Mbuyuni, Pemba perceived an increased strength in both north- and south-easterly winds. In Matemwe, Unguja about 60% of the respondents among fishers perceived no change in the intensity of south-easterly winds, while more than half of the seaweed farmers in this site perceived stronger south-easterly winds (Table 5.6). By contrast, less than half of fishers (48%) and seaweed farmers (47%) in the Pemba site perceived an increased intensity in north-easterly winds, while in the Unguja site the majority of the respondents among fishers (63%) perceived no change. At the same time, about 44% of the seaweed farmers in Matemwe, Unguja perceived stronger winds over time (Table 5.6). The results again show that more respondents in both categories (seaweed farmers and fishers) in Kiuyu Mbuyuni perceived changes in north-easterly winds compared with Matemwe, Unguja. However, the results are mixed and show no clear trends, especially for north-easterly winds.

The higher numbers of seaweed farmers perceiving stronger north-easterly winds (*kaskazi*) across the sites, could be influenced by the seaweed-climate relationship. As already indicated, north-easterly winds blow towards the coast and thus destroy seaweed farms along the shore, and the north-easterly winds are associated with the summer season which increases the warm conditions in the shallow water where weeds flourish and thus impacts the growth and yield of seaweed (see section 5.3.4.1). The following testimonies also demonstrate this relationship:

“Kaskazi in Kiuyu (Pemba) became stronger and destroyed our seaweed blocks (farms), so we earn very little during kaskazi compared with kusi. Kusi is associated with winter which provides cool weather conditions at the seaweed blocks and thus high production” (Seaweed farmer from Kiuyu Mbuyuni, Pemba).

“Although kusi sometimes destabilised our seaweed farms because of its intensity, it is good since it is associated with cool weather which improves growth and yield, thus, enhances our income” (Seaweed farmer from Matemwe, Unguja).

5.3.5.1 Future scenarios for wind

Strong winds are not new phenomena in Zanzibar’s history for example, on April 14, 1872, Unguja Island and southern Pemba experienced a hurricane that crushed clove plantations in Unguja (Spinage, 2012). A cyclone which killed five people was also recorded in 1994 in Zanzibar (IXSURVEY, 2010). The frequency and intensity of several isolated storms that struck Zanzibar in 2009 and 2011 (Watkis *et al.* 2012), were probably influenced by observed warming of the ocean during this particular period (see section 5.3.4). As major wind patterns in Zanzibar and east Africa in general are the result of differential heating between the southern and northern hemispheres (Spinage, 2012), the projected warming (Figure 5.13) is likely to alter pressure gradients and ultimately wind patterns, and further accelerate vulnerable conditions across sites and activities.

A study by Fan and Li (2005) cited in Cruz *et al.* (2007) found that tropical cyclones over the Pacific had increased in frequency and intensity over the past two decades. A recent special report by IPCC (2011) on

extreme events however, predicts that globally, the frequency of cyclones will decrease or remain the same in the 21st century as in the 20th century, but the maximum wind speed associated with cyclones is likely to increase. However, because there have been insufficient studies, the report also revealed that the future trend of extreme winds is unknown (IPCC, 2011).

5.3.6 Perceptions and observations of sea level rise

5.3.6.1 Perceptions of sea level rise

The rise in sea level has contributed to increased coastal inundation, erosion and ecosystem losses all over the globe. Zanzibar for example, has already experienced widespread beach erosion and coastal floods which are believed to be attributable to rising sea levels (Sultan, 2011; Salum, 2009). Figure 5.17 shows that less than half of the fisher respondents (47%) in Kiuyu Mbuyuni, Pemba have perceived rising sea levels, while 35% perceived falling sea levels. In Matemwe, Unguja a large proportion of fishers (68%) perceived declining sea levels and only 20% perceived a rise in sea level. Interestingly, the majority of seaweed farmers in both sites (70% in Matemwe, Unguja and 58% in Kiuyu Mbuyuni, Pemba) have perceived a drop in sea level, while 23% in Kiuyu Mbuyuni, Pemba and 26% in Matemwe, Unguja perceived a rise over time (Figure 5.17). Thus, on average across the sites, the majority of respondents have perceived a decline in sea level. The findings do not match those of Kombo (2011) who found that 71% of the respondents in the central district of Unguja perceived a rise in sea level.

The high numbers of respondents, who perceived a fall in sea level, have linked this to high levels of sand deposition experienced across the sites. This is articulated in the following testimonies:-

“Water level within tides has declined compared with those early days; all fishing and other seafood breeding grounds close to the shore have been buried with sand” (Fisherman from Matemwe, Unguja).

“The level of the sea has declined and the floor has become more undulated than before because of high deposits of sands, to the extent that our seaweed farms are exposed to the sun during low tide” (Seaweed farmer from Matemwe-Unguja).

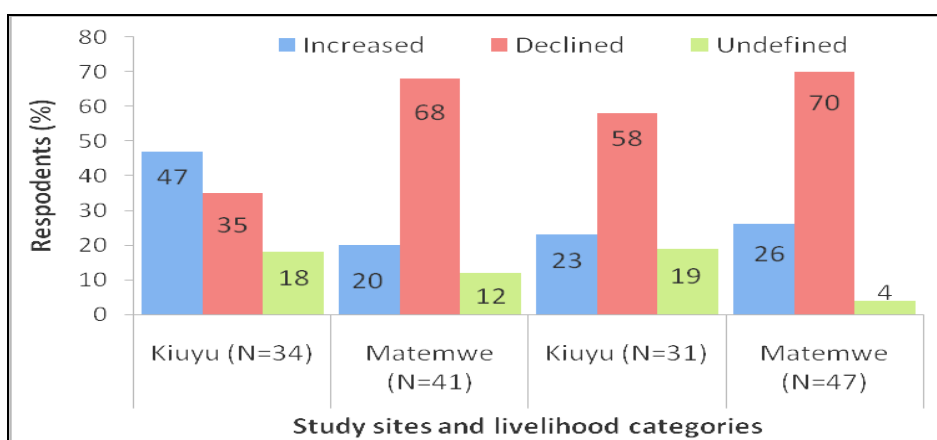


Figure 5.17: Perception of seaweed farmers and fishers on Sea Level Rise (SLR).



Plate 5.1: Seaweed farms in the study areas. Right, seaweed exposed to the sun's rays by falling of water levels within tides. Left, sea weed farm proper where the seaweed remains under water even during low tides.

Respondents at both sites believed that south-easterly winds (*kusi*) erode and deposit large amounts of sediment within intertidal zones, while north-easterly winds (*kaskazi*) remove these sediments from the zones. To them, the observed massive deposition of sand is attributed to the weakening capacity of north-easterly winds to remove all the sediment deposited by the south-easterly winds. The observed shifting of seaweed blocks seaward (also see Chapter 7) as a response to the perception that sea water level has declined within the intertidal zone, supports this finding. This is also highlighted in the following comment by a seaweed farmer in Kiuyu Mbuyuni:

“Previously we used to get lower production as our seaweed farms were covered by sand and thus the water level reduced and farms were exposed to the sun and high temperatures, but now we have moved our plots to follow the water and production has increased tremendously”.

It should be noted that for better growth and high yield, seaweed farms should remain underwater even during low tide to reduce exposure to the sun's rays (Plate 5.1). The findings therefore, revealed that local people's perceptions of falling sea levels are closely informed by seaweed-fishing-sea level relationships, local knowledge and direct experience (Vedwan, 2006; Hulme *et al.* 2009; Vedwan and Rhoades, 2001).

5.3.6.2 Observed sea level rise

Figure 5.18 shows that up to 2008, sea levels in Zanzibar were declining this can be attributed to upliftment of the coastal platforms caused by geological activities underneath. For example, out of 19 years from 1990-2008 only six years showed positive anomalies (above normal) while the remaining 13 years showed negative anomalies (below normal) in sea level. This is why the studies by Ragoonaden (2006) and Han *et al.* (2010), who analysed data between 1960 and 2008, found a decline in sea level in Zanzibar. Figure 5.18 reveals a substantial fluctuation in sea level in Zanzibar from 2007 onwards with minor inter-annual variations. The observed sea water floods over arable land and salt water intrusion into wells during 2009-2011, particularly in the northern region of Pemba (Sultan 2011), are probably associated with this recent observed instability in sea level. It should be noted, however, that although about half of fishers in Pemba

(47%) had perceived rising sea levels (Figure 5.17), their perception might be influenced by the observed extreme incidents of coastal floods during 2010-2011 which are not normal and thus could be easily noticed (section 5.1.2). A time series of longer term sea level data (1983-2013) in Figure 5.19 also shows inter-annual variability with high sea level measurement in 1990, 1993, 1998, 2007, 2009 and 2010. However, the trend does not give a clear indication on whether sea level is rising or falling but rather showed both up and down trends over time.

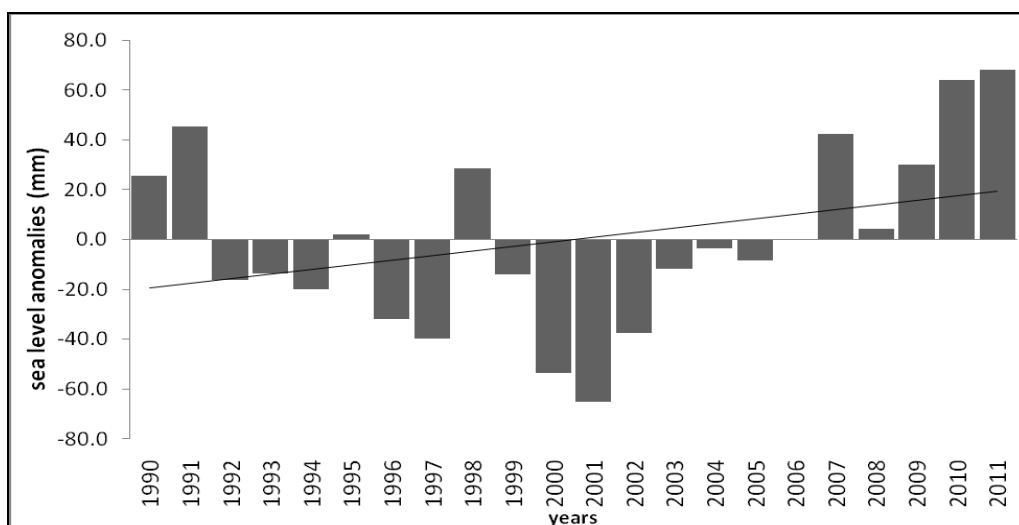


Figure 5.18: Inter-annual variability of sea levels at the Zanzibar station (Source: University of Hawaii Sea Level Centre (UHSLC)).

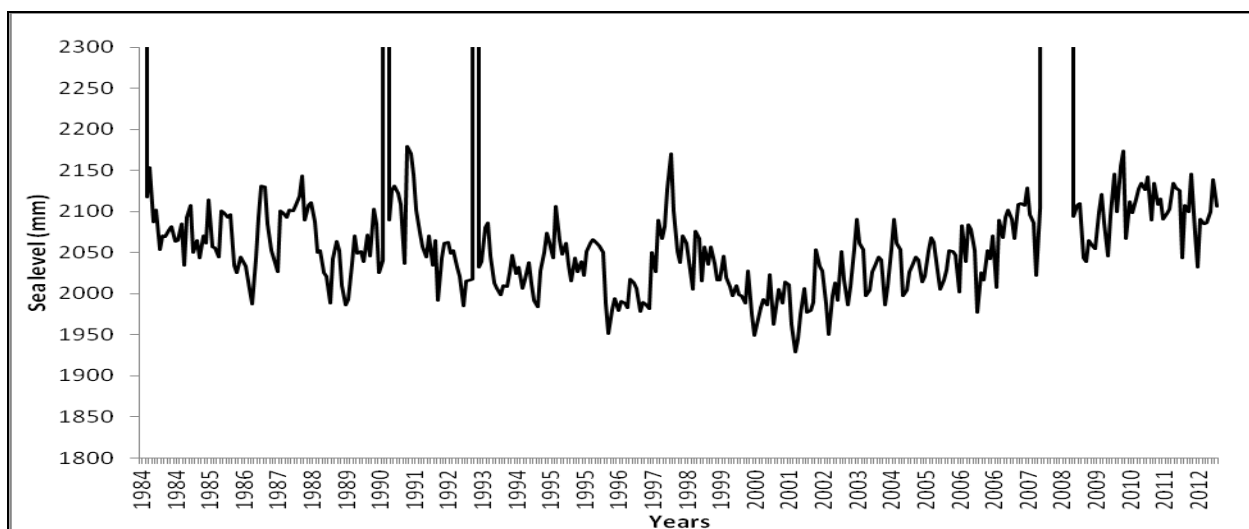


Figure 5.19: Time series of sea level measurement at Zanzibar Harbour, 1984-2013 (Data from UHSLC) (Note: Tidal gauge the instrument for taking sea level measurement installed at Zanzibar harbour in early 1984)

An interview with an expert on coastal engineering from the Institute of Marine Science at the University of Dar es Salaam in Zanzibar revealed that the observed coastal flooding may also be linked with drought that hit Zanzibar in that particular period (Figures 5.6, 5.7 and 5.8). In his opinion, the falling of water levels of

both annual and perennial streams, which are attributed to the 2008-2011 droughts, probably disturbed the existing balance between freshwater streams and sea water. Thus, in order to restore the balance, sea water invades the freshwater territories. However, others believe that sea water floods over agricultural land can be attributed to a combination of climate change and human activities such as salt farms, mangrove deforestation and destruction of coral reefs (Sultan, 2011).

Globally, low-lying areas and SIDSs are experiencing erosion and deterioration of both ecosystem functions and services. According to Nicholls *et al.* (2007), global sea levels rose at 1.7 ± 0.5 mm/yr throughout the 20th century, although it is very difficult to quantify this relationship with the observed ecosystem loss, mainly because human activities as mentioned earlier, exert pressure on the ecosystem as well and may overcome natural processes. Bird (2000), cited in Nicholls *et al.* (2007), argues that coasts that are subsiding due to natural or human-induced causes will experience larger relative rises in sea level. Whatever the causes that led to recent sea water floods over the farmlands, it is evident that the Zanzibar coastal environment is vulnerable to future sea level rise, and thus the need for proper and proactive adaptation is apparent now more than ever.

5.3.6.3 Relationship between sea level and ENSO events, and future scenarios

Figures 5.18 on sea level variability and 5.20 on sea surface temperature variability show that sea level variability in Zanzibar is related to ENSO events in the western Indian Ocean (see section 5.3.3.3 for detailed definition of ENSO events). For instance, in 1998 both sea level (Figure 5.18) and SST (Figure 5.20) showed high positive anomalies associated with El Niño, while in the 2000-2003 ENSO (La Niña) both SST and sea level showed negative anomalies (Figures 5.18 and 5.20). This means that when SST increases, sea levels also increase and when SST decreases, sea levels decline. Ngwali and Reason (2007) found a similar result while examining the sea level of Zanzibar and Lamu, Mombasa, Kenya. They found that inter-annual variation of sea level in the East Africa region was partly related to ENSO events in the tropical western Indian Ocean. Similarly, studies in the South China Sea and Indian Ocean found a close relationship between ENSO events and inter-annual variability of the observed sea level (Rong *et al.* 2007; Tiwari *et al.* 2004; Sreenivas *et al.* 2012).

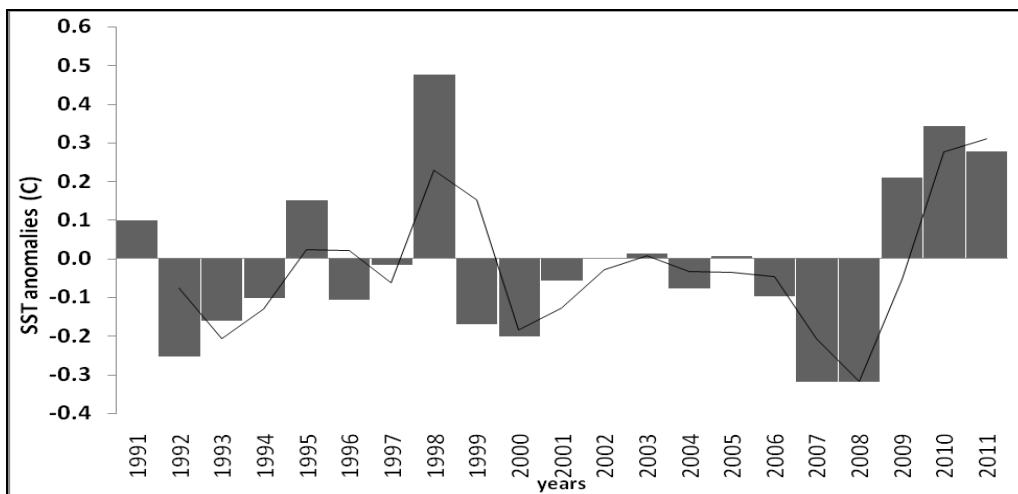


Figure 5.20: Inter-annual variability in sea surface temperature (Source of data: <http://poet.jpl.nasa.gov>)

Up to this point it can be argued that although the findings revealed no indication of falling or rising of sea level in Zanzibar, the observed sea level variability is probably influenced by many factors. These include regional climate variability (ENSO events), global climate change (increase of ocean thermal expansion and land ice loss), local droughts and upliftment of coastal platforms. As sea level rise is strongly correlated with increasing temperatures, attributable to human-induced greenhouse gas emissions, the predicted temperature increase may escalate coastal flood events (Brown *et al.* 2011). A study by Boko *et al.* (2007) shows that sea level rise, together with other man-made stressors, may impact ecosystems and their services in coastal villages and towns. A projected rise in sea level of between 9 and 88 cm by 2100 would increase flooding and coastal inundation in Africa (Boko *et al.* 2007).

The rise and resultant impact would however be unevenly distributed over Africa. Nations with explicit policies and high adaptive capacity will be less affected than the others. For example, in examining the number of people who will be flooded through sea level rise between 2000-2100, using A1B mid-range scenarios and “assumed no adaptation measures” Brown *et al.* (2011:21) found that Tanzania, including Zanzibar, has the highest number of people flooded per year at over 90,000, representing half of those in Africa as a whole by 2010. In its estimation, the study combined the average annual occurrence of coastal flooding, coastal topography, population and defences and sea level rise. A new study by IPCC (2011) revealed that SIDSs and other low-lying areas which are currently prone to shoreline change and coastal inundation will continue to be affected by increasing sea levels in the 21st century. Similarly, a new summary for policymakers (SPM) (IPCC, 2013:23) contends that “about 70% of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change”

5.3.7 Perceptions of the causes of climate variability and change

Like many perception studies, questions on the meaning of climate change and variability seem to be very complex and confusing for the majority of the respondents. Similarly, questions about causes of climate change and variability generate a wide range of answers (Kuruppu and Liverman, 2011; Manyatsi *et al.* 2010; Apata *et al.* 2009). It has been hypothesised in this study that understanding local climate variability could trigger desirable behavioural changes aimed at reducing the impacts associated with it. For this reason, respondents were questioned about the causes of the perceived variability. Across the sites and livelihood categories, the results in Table 5.7 show a low awareness of the scientific causes of the perceived climate variability and change. Similarly some respondents across the sectors had no idea on the causes of climate variability and change. For instance 40% of the seaweed farmers in Matemwe and 20% in Kiuyu Mbuyuni, Pemba knew nothing regarding the cause of climate variability.

A large proportion of respondents across the livelihood categories linked the observed variability to God; other cited causes which have links with God included sins and signs of doomsday. However, the sign of doomsday as a cause was cited by only 2% of farmers in Kiuyu Mbuyuni, Pemba and 8% of seaweed farmers in Matemwe, Unguja. Some respondents in the Matemwe, Unguja site thought that the introduction of tourism in the early 1990s had increased bad deeds in their area and thus Allah disapproves of them (the majority, if not all, of the respondents were Muslims). Other studies have yielded similar results related to the causes of climate change. In examining perceptions of farmers in Swaziland, Manyatsi *et al.* (2010) found that a large proportion of the respondents associated climate variability with biblical manifestations and spiritual causes, while in eastern Tibetan villages, most of the villagers linked the perceived climate variability to violation of taboos and spirits (Byg and Salick, 2009). Teka and Vogt (2010) categorised the aforementioned reasons as metaphysical or irrational as they have no basis in the science of climate change (also see Manyatsi *et al.* 2010).

Table 5.7: Perceived causes of climate variability and change

Causes of climate variability and change	Fishing (%)		Farming (%)		Seaweed farming (%)	
	Kiuyu (N=46)	Matemwe (N=45)	Kiuyu (N=42)	Matemwe (N=46)	Kiuyu (N=50)	Matemwe (N=48)
God's will	46	51	33	26	46	31
No idea	7	13	14	9	20	40
Deforestation	11	9	17	24	8	13
Pollution	2	2	-	4	2	-
Sins	11	7	5	9	2	4
High population	2	4	2	4	-	-
High temperature	-	2	14	9	4	-
El Niño	4	2	5	9	-	-
Tsunamis	9	4	-	-	14	2
Close to dooms day	2	-	-	-	-	8
Drought	7	4	10	7	4	2

Other causes cited which have no connection with climate variability and change includes high temperatures, drought and tsunamis. Temperature and drought are in fact the outcome and not the causes of climate variability. These were mostly cited by farmers because of their relationship with crops, while tsunamis were mostly cited by fishers and seaweed farmers probably due to the relationship between these sectors and the ocean (Table 5.7). The following testimonies support the perception that local climate change in the areas is affected by tsunamis:

“Everything has changed both over the ocean and land since the last tsunamis” (Fisherman from Matemwe, Unguja).

“These abnormalities related to rainfall and temperatures are brought by tsunamis” (Fisherman from Kiuyu, Pemba).

The Boxing Day tsunami which occurred on Sunday, 26th December 2004, triggered by the Sumatra-Andaman earthquakes were felt by the whole region of the Indian Ocean, including Zanzibar, and some local people believed that it contributed to their hardship. Local peoples’ perceptions of the links between tsunamis and climate variability is probably influenced by the fact that most of the variability in rainfall and temperature was observed from the onset of the last decade onwards and thus correlated with the year of the tsunami in 2004 (see Figures 5.4, 5.5, 5.6, 5.7, 5.8, 5.12, 5.13). Tsunamis as risks came up in various workshops conducted during field visits and many fishers believed that the 2004 Indian Ocean tsunami impacted fishing grounds and thus affected their income. Since the knowledge of risks related to climate change is an important factor that influences decisions to cope and adapt (see Chapter 7), the observed poor understanding of the science of climate variability and change may affect the capacity of the local people to cope and adapt, as they believe that they cannot alter the will of God.

Only three reasons supplied out of 11 had a basis in the science of climate change and its variability, and which Teka and Vogt (2010) called ‘rational reasons’ as they have at least a basis in the science of climate change. These include deforestation, pollution and El Niño (Table 5.7). If these three causes are compared, deforestation of both natural and mangrove forests was frequently cited. Possibly, most of these respondents had picked up the idea in various meetings aimed at increasing awareness amongst locals to conserve the remaining patches of natural forest and mangroves across the sites. In the past, both sites experienced high rates of deforestation through shifting cultivation, urban and local fuel wood demand as suggested by the following testimonies:

“We no longer have forest patches remaining in Matemwe; shifting cultivation and large numbers of people, and currently, development of tourism infrastructure have eaten up the remaining trees. We are now buying firewood from other villages or collecting dry twigs from the conserved forest nearby (Kiwengwa-Pongwe Forest Reserve)”. (Chairperson Matemwe Control HIV/AIDs, Education and Environment (MCAEE) Matemwe-Unguja).

“Much of the natural forest in Kiuyu Mbuyuni has been deforested in response to the 1971-72 famine. I remember my father was the first person to cut forest on a tiny island nearby called Kamate and other

people went to cut part of our main natural forest and planted crops and the forest never recovered. We believed that new farms after cutting forest produce better yield”. (Farmer-Kiuyu Mbuyuni, Pemba).

An interview with a key informant from the Tanzania Meteorological Agency, Zanzibar Office suggested that the absence and deterioration of both mangrove and natural forest along the east coast of both major islands is one of the factors responsible for the low rainfall on the east coast compared with west coasts and central corridors. Although the link between forest and rainfall formation is one of the myths in climatology, Burton (1872) cited in Spinage (2012) did not discount the relationship between deforestation and the dry spells experienced in Zanzibar in 1859. Deforestation has also been cited, particularly by the farmers in Zambia and Zimbabwe, as the cause of perceived climate variability (Mubaya *et al.* 2012).

5.3.8 Up-take of weather forecasts and predictions

Farmers across the sites were asked whether it was more difficult or less difficult to predict rainfall now, compared with 10 or 20 years back. A large proportion of the respondents (77% in Kiuyu Pemba and 72% in Matemwe, Unguja) perceived more difficulty in predicting rainfall now than before, while only 10% and 9% in Kiuyu and Matemwe respectively believed that it was still easy to predict rainfall (Table 5.8). Traditionally, the people of the islands have their own ways of predicting rainfall, using signs such as the direction and location of the clouds and sounds of birds and animals for making decisions at both farm and household level. However, the observed variability for the past decade has reduced farmers’ confidence in their knowledge (Kalanda-Joshua *et al.* 2011). On the other hand, forecasts of marine storms, wave height and the direction of wind storms is crucial in Zanzibar because of the dominance of small and traditional vessels (Chapter 6). However, unlike farmers, most of the fishers across the sites are still confident in their knowledge of sea waves and storm predictions, as seen in the following quotes:

“Over the span of life we have acquired knowledge from our elders on how to forecast storms and strong waves, and thus we are in a good position to understand how the ocean behaves or will not behave” (Fisherman from Kiuyu, Pemba).

“I myself have got knowledge of what will happen in the ocean in terms of storms by listening to the voice generated by waves when they hit ridges within the ocean” (Fisherman from Matemwe, Unguja).

Table 5.8: Local rainfall predictions

Responses	Farmers (%)	
	Kiuyu (N=44)	Matemwe (N=43)
More difficult	77	72
Less difficult	10	9
Neither	13	19

In a situation where the weather has become extremely difficult for farmers to predict correctly (Table 5.8), seasonal forecasts and predictions might be an important tool that could facilitate adaptation strategies in this era of high levels of abnormality. For example, access to reliable and accurate forecasts is likely to

influence a farmer's choice of seeds during drought and good years (Millner and Washington, 2001; Phillips *et al.* 2002; Manyatsi *et al.* 2010; Jones *et al.* 2000). An interview with informants revealed that the Ministry of Agriculture in Zanzibar receives seasonal weather forecasts and predictions from the Tanzania Meteorological Agency (TMA). The ministry then disseminates the news with suggestions that could help farmers to decide on how to cope with the forthcoming weather events. So far, radio programmes and extension services through districts are the common methods of outreach.

Given that a large proportion of farmers across the sites have admitted the unpredictability of rainfall (Table 5.8), the frequency of agricultural failure which is associated with food insecurity, particularly in Kiuyu Mbuyuni, Pemba in 2008-2010, could probably be partly influenced by the low uptake of seasonal weather forecasts. Since erratic rainfall is a common phenomenon along the east coasts of both islands, one would expect farmers in both sites to be able to cope with the drought after being through many dry spells in the past. Although seasonal forecasts and prediction is an important tool for decision making for farming, many studies show slow rates of uptake of seasonal forecasting among farmers all over Africa (Kalanda-Joshua *et al.* 2011; Millner and Washington, 2001). The low uptake of seasonal weather forecasts across the sites could be attributed to poor accessibility of seasonal weather forecasts and conflict between local and modern knowledge systems (see section 5.3.8.1 and 5.3.8.2).

5.3.8.1 Accessibility of weather forecasts

In this study, accessibility was defined as easy availability of seasonal forecasts and prediction news. Seasonal forecasting in Zanzibar is communicated mostly through radio and extension services through district governments. Apart from the national radio, Kiuyu Mbuyuni is also covered by a community radio station which operates in the district of Micheweni. As the main source of weather information in both sites was through radio, farmers were asked if they tuned into the radio to listen to seasonal weather forecasts. The results in Table 5.9 show that 81% in Kiuyu Mbuyuni and 63% in Matemwe do not do this.

Table 5.9: Respondents who tune into the radio to access weather forecasts and predictions

Responses	Farmers %	
	Kiuyu Mbuyuni, Pemba (n=47)	Matemwe, Unguja (n=49)
Yes	19	37
No	81	63

Although most of the households owned a radio (Chapter 3), the study found that most of the radios used batteries as many households had no electricity. For instance, out of 1,337 households in the Unguja site only 77 were connected to electricity, while in Kiuyu, Pemba out of 1,548 households only 30 were connected (Chapter 3). Given the high level of poverty across the sites (RGZ, 2009), it appears that most of the respondents select programmes to listen to in order to minimise the costs of batteries and probably,

seasonal forecasting is not among their favourite programmes, as evidenced in the following quote from Matemwe:

“We concentrate on listening to Radio Noor (a Religious FM station in Zanzibar) and sun rise news (mawiyo) from national Radio; frankly speaking we do not listen to seasonal forecasts and predictions”.

Farmers were also asked if there were other sources of seasonal forecast information (local leaders or extension officers) and the results in Table 5.10 show that the majority of the respondents (77%) in Kiuyu Mbuyuni and more than half (58%) of the respondents in Matemwe, Unguja do not receive seasonal weather forecast information from either local leaders or extension officers. Thus accessibility is affected by the poor communication between extension officers and farmers, by poverty and by low levels of rural electrification. Other studies show that in other parts of Africa accessibility of forecast information is also limited. For example, in assessing the value of climate forecast information for pastoralists in Ethiopia and Kenya, Luseno *et al.* (2003) found that radios were the major source of information for the weather forecasts and predictions as extension services covered only 3% of the pastoralists. Further, unlike the study sites (see Table 5.9) a study by Luseno *et al.* (2003) found very few respondents owned radios in either Kenya or Ethiopia.

Table 5.10: Responses to whether respondents had other sources of seasonal forecast information

	Farmers (%)	
	Kiuyu Mbuyuni, Pemba (N=47)	Matemwe, Unguja (N=48)
Yes	23	42
No	77	58

5.3.8.2 Conflict between traditional and modern knowledge

Despite the fact that rainfall has become unpredictable (Table 5.8), it appears that respondents still value their traditional knowledge related to weather forecasting over the modern knowledge system. This is evident in the following testimony from a respondent in Kiuyu Mbuyuni, Pemba:

“We used to hear radio air seasonal forecast, but truly speaking we don’t pay attention at all; we have our own means for predictions”.

Patt and Gwata (2002:189) termed this conflict as ‘legitimacy’ in which forecasting is perceived as interfering with the local knowledge system. In order to resolve legitimacy, various studies have come up with the idea of integrating forecasts and predictions with traditional knowledge. Boko *et al.* (2007:456) believed that local farmers and communities in Africa have developed sophisticated systems of “gathering, predicting, interpreting and decision-making in relation to weather” which should not be ignored. For example, in examining the integration of indigenous knowledge with conventional science in Malawi, Kalanda-Joshua *et al.* (2011) found that the majority of people were of the opinion that conventional weather and climate predictions were not useful as they failed to incorporate traditional knowledge systems.

Conversely, Patt and Gwata (2002) cited in Boko *et al.* (2007) found increasing willingness among the farmers to recognise weather forecasts if they could be disseminated in conjunction with their traditional knowledge.

Apart from accessibility and legitimacy other studies show that low uptake of seasonal forecasts may also be influenced by the loss of trust caused by either previous inaccuracy of forecasts or the inability of the information to help farmers take certain decisions to cope with rainfall variability (Patt and Gwata, 2002; Fischhoff, 1994; Millner and Washington, 2001). Orlove and Tosteson (1999) cited in Patt and Gwata (2002), studied the dissemination and uptake of weather forecasts after the 1997-1998 El Niño in Brazil, and found that people stopped trusting weather forecasts when events did not occur exactly as predicted after being communicated. Apart from ambiguity attached to the forecast information, Fischhoff (1994) argues that adoption of weather forecast information may also be affected by trust and context, whereas Millner and Washington (2001) found that forecast trustworthiness (also known as credibility by Patt and Gwata (2002)), presentation parameters and farmer's wealth may also impact the forecast uptake within the system.

5.4 CONCLUSIONS

The Chapter has examined the perceptions of local communities to climate variability and change and sea level rise in relation to observed weather and sea level data, to understand the exposure of the two east coast communities to climate variability and change. The findings are consistent with similar findings elsewhere and within Zanzibar that the abnormality of weather and sea levels has not gone unnoticed; local people's perceptions regarding changes in local climate along the east coasts of both islands were robust, regardless of their age, gender and education. Their perceptions of changes in rainfall and temperature (decreasing rainfall and increasing temperature) tally with observations of those weather elements; however, their perceptions of sea level rise did not match the observed data. While local people perceived a decline in sea level, the observed data revealed a significant fluctuation for the past five years. This discrepancy may be a barrier for coping and adapting to predicted coastal floods. Although respondents noticed climate variability and change, most of them attributed the changes to God. The tendency to link climate variability and change to God would probably reduce the likelihood of action, which is a cause for concern for future interventions (Mubaya *et al.* 2012). Despite the fact that drought is not a new phenomenon across the sites, the current reported food insecurity (see Chapter 4) caused by recent dry spells might partly be associated with low willingness to adapt, as respondents attribute drought to God and other irrational causes.

It has also been illustrated that coastal peoples' perceptions of variability in rainfall, winds, temperature and sea level were highly influenced by their direct experience, local knowledge, extreme events and the relationship between climate and sea level rise and livelihood sectors across the sites (see Figure 5.1).

Farming is highly dependent on ‘normal’ rainfall and temperature for available water and soil moisture, while the sustainability of seaweed farming and fishing are highly dependent on the variations of north- and south-easterly winds and their associated calm period, and on sea level in the inter-tidal zones. Furthermore, local peoples’ perceptions were informed by their knowledge of the environment where those livelihoods are practiced, memory, narrations and recently observed extreme events which went beyond their perceptual threshold. These extreme events include the 1999-2000 and 2008-2010 droughts, 1997-1998 and 2005 heavy rainfall periods, the 2009 and 2011 wind storms, and the highest heat waves ever recorded in Zanzibar in 2007.

Understanding climate change and variability, and the way it is interpreted within different cultural groups based on their knowledge and interactions, is crucial in order to develop coping and long-term adaptation strategies that increase resilience amongst different groups within communities, mainly because different groups may have different perceptions of a component of the environment. One of the findings of this study, for example, was that different perceptions amongst seaweed farmers and fishers relating to wind patterns were based on the nature of their interactions. Seaweed farm stability is compromised by both north- and south-easterly wind speed, but the south-easterly wind provides additional cool conditions for sea water which favours seaweed growth. For fishers, the south-easterly wind is not conducive to fishing as it limits fish trips for the majority of the fishers who use local vessels to make fish trips (see Chapter 6) and they perceive it as driving away fish stocks out of the near-shore water.

The findings also revealed the increasing domination of Sea Surface Temperature (SST) and associated El Niño Southern Oscillation (ENSO) events over local events which have shaped local climate patterns for centuries. As SST is strongly linked with human-induced greenhouse gases, Zanzibar should probably expect more abnormality in the future, as its climate is affected at both a regional and global level. Future scenarios have predicted high abnormalities in rainfall, temperature and sea level rise; for instance, models have projected a substantial increase in sea levels in Africa which will have severe impacts in Zanzibar. Being an island with low adaptive capacity, Zanzibar is likely to be vulnerable to further coastal flooding, coastal inundation and salt water contamination. Similarly, with the current nature of the farming systems (rain-fed), future projections of rainfall and temperature should not be ignored. This situation calls for urgent action in improving both physical and socio-economic resilience through policies and development plans for reducing poverty.

Despite the unpredictable nature of the observed variability and local change of climate, especially among farmers, the study found low levels of adoption of seasonal forecasts. The adoption of forecasts appears to be constrained by accessibility and legitimacy. It is obvious that the anticipated changes necessitate addressing the challenges that affect the local peoples’ decisions to be guided by weather forecasts. For

instance, various studies such as Boko *et al.* (2007), Patt and Gwata (2002) and Kalanda-Joshua *et al.* (2011) suggest the need to integrate local knowledge with conventional forecasts to address the issue of legitimacy and credibility for mass adoption of seasonal and marine weather forecasts.

In conclusion, the findings demonstrate that Zanzibar, particularly along the east coasts, is already exposed to increasing variability in climate and sea level. This variability and change is adversely interacting with the existing vulnerability context thus intensifying vulnerability amongst poor households.

CHAPTER 6

LIVELIHOOD RISKS AND IMPACTS ASSOCIATED WITH CLIMATE VARIABILITY AND CHANGE AND OTHER STRESSORS AS PERCEIVED BY EAST COAST FARMERS, FISHERS AND SEAWEED FARMERS

6.1 INTRODUCTION

6.1.1 An overview

Building on (Chapter 5), this Chapter seeks to examine the livelihood impacts of climate variability and change and other stressors as perceived and experienced by farmers, fishers and seaweed farmers. Farming, fishing and seaweed farming are the major sources of income and food across the study sites, but are exposed and sensitive to both climate and non-climate stressors (Chapter 5). This Chapter provides insight into the consequences of this exposure for people operating in these sectors. Specifically, the Chapter aims to (1) explore the nature of production in farming, fishing and seaweed farming to understand the sensitivity of these sectors, and (2) examine local peoples' perceptions of risks related to climate change and other linked stressors on these three important livelihood strategies.

Building on Chapter 5, Chapter 6 starts with an exploration of what it meant by risk perception, which is followed by a review of the large body of literature on known and probable risks and impacts related to climate variability and change on farming, fishing and seaweed farming. This is followed by a section on the methods that shaped data collection and analysis. Lastly, the Chapter presents the results and discussion, followed by a conclusion. The results and discussion section is divided into three sections based on the three sectors under study, namely fishing, farming and seaweed farming. Each section is further divided into three subsections: (1) the existing context of each sector; (2) perceptions of the impacts of climate variability and change on each sector, and (3) perceptions of the impact of other stressors on fishing, farming and seaweed farming.

6.1.2 Understanding risk perceptions

O'Connor *et al.* (1999:462) defined risk perception as “perceived likelihood of negative consequences to oneself and society from one specific environmental phenomenon”. Over the years, various environmental studies have studied human behavioural change in relation to environmental changes and come up with different conclusions. In the view of cultural theory, a risk perception is constructed within social and cultural realms (Rippl, 2002; Steg and Sievers, 2000). Furthermore, Kahan *et al.* (2007) argue that a combination of social culture, value and identity influence risk perception. A study by Kahan *et al.* (2007:498) found that “men and women, whites and minorities, form distinct attitudes toward risk in a manner that protects from interference the activities on which their identities depend”. This means variations in risk perception between people within social systems are not only influenced by the culture

that defines people, but also by the extent to which individuals protect their identity. People may choose to underestimate the risks related to climate variability in order to protect their identity. For example, apart from ambiguity in the likelihood of risks related to climate change, the resistance of a flood-prone community in Mozambique to resettlement was also influenced by the value of local place and associated identity as defined by residents (see Patt and Schroter, 2008).

A study by Nursey-Bray *et al.* (2012:754) shows that risk perception is determined by “(1) the level of knowledge, (2) the probability of harm, (3) the ability to contend with or mitigate the risk and (4) the value of the resources at risk”. With regard to the value of the resources at risk, risk perception may also vary between individuals who have a varied connection to the resources at risk. A seaweed farmer who solely depends on seaweed farming to make a living may have a different opinion about an increase in temperature which affects the growth of seaweed, compared with a seaweed farmer with a diverse livelihood portfolio. Peoples’ perceptions are also informed by direct experience, knowledge of the environment and extreme events such as floods, drought and stronger north or south-easterly winds that operate beyond normal (see Chapter 5).

Based on the review of a large body of literature, I developed the perception model in Chapter 5. The model illustrates how local people’s perception of climate variability and associated risks is influenced by the co-production between climate and their livelihood activities, in this case farming, fishing and seaweed farming. The study argues that perceptions of climate and associated risks as well as acknowledgement (belief) that change is happening is an important step towards sustainable adaptation (see Chapter 5; O’Connor *et al.* 1999; Nursey-Bray *et al.* 2012). This Chapter identifies the risks and impacts of climate variability on farming, fishing and seaweed farming, as perceived by actors. It provides a clearer picture of the extent to which local people and their livelihood activities in both the study sites are exposed and sensitive to impacts of climate variability and future risks related to a changing climate.

6.1.3 Known and probable risks of climate variability and change for farming, fishing and seaweed farming

The findings in Chapter 5 showed that climate variability and coastal floods are already being experienced in Zanzibar and are expected to exert pressure on major rural livelihood activities such as farming, seaweed farming and fishing. The observed warming trend and predicted warming in both atmosphere and sea surface will increase the frequency and intensity of extreme events (floods and droughts) and exacerbate local climate variability, with severe impacts for fishery resources, biodiversity, farming systems and societies in general (Hulme *et al.* 2001; Funk *et al.* 2005; Roessig *et al.* 2004; Boko *et al.* 2007). While erratic rainfall along the east coasts of both major islands (Unguja and Pemba) is not a new phenomenon, there is evidence that increasing frequencies of dry spells have further intensified local food shortages (see

Chapter 4). Chapter 1 presented a broad overview regarding known and probable risks and impacts of climate change on natural capital and livelihood activities in SIDSs, while the introductory section of Chapter 5 provides a general understanding of the linkages between climate and livelihood activities in Zanzibar. Thus, to avoid repetition, in this section I focus on the various risks and impacts of climate change on farming, fishing and seaweed farming, providing a brief but specific overview.

With regard to farming, it is now recognised that high temperatures, extreme drought and floods decrease crop yields, especially in tropical areas (Boko *et al.* 2007; Chapter 1 and 5). The production of rice (the most important staple food in Zanzibar) is threatened all over the tropical world (Peng *et al.* 2004; Mohandarrass *et al.* 1995). Maize, a common crop grown in the study sites, is also sensitive to current variability and future change in climate (Chikozho, 2010; Jones and Thornton, 2003). Events like El Niño and La Niña (see Chapter 5) and general warming will also intensify crop diseases and pests and hence reduce crop yield (Olatinwo *et al.* 2010; Sutherst *et al.* 2011). Additionally the observed coastal floods on arable land in Zanzibar, which are partly attributed to the recent variability in sea level, have affected arable land crops and contributed to food insecurity in the affected areas (Sultan, 2011; Chapter 5). Similar impacts are predicted for other east African coastal areas. For example, it has been estimated that a 1 m sea level rise in Kenya is likely to heavily affect major coastal crops, namely mangoes, cashew nuts and coconuts (Republic of Kenya cited in Boko *et al.* 2007). The projected rise of sea level in Africa (see Chapter 5) would hamper the recent attempts by Zanzibar to extract ground water for irrigation in order to increase rice and other crop production. In terms of fishing, Table 6.1 though not exhaustive, presents climate change risks and the associated impacts on fisheries, particularly on fish abundance and distribution (also see Chapters 1 and 5). Climate change risks such as increasing warming conditions, sea surface temperature changes, extreme regional events such as ENSO, floods, drought and sea level rise are already affecting, or likely to affect the productivity and distribution of fishery resources in both marine and inland waters as well as fishery infrastructure (Table 6.1; Stenevik and Sundby, 2007; Sundby and Nakken, 2008; Miller, 2007; Badjeck *et al.* 2010; Allison *et al.* 2009). Coastal communities that are largely dependent on fishery resources linked to coral reefs and mangrove ecosystems, such as in Zanzibar, are particularly vulnerable as both these ecosystems are highly sensitive to climate change and sea level rise (Cinner *et al.* 2012; Boko *et al.* 2007). With regard to seaweed farming, studies show that sea level rise, increasing sea surface temperature and variable atmospheric temperatures may also affect the growth and yield per seaweed plot (see Chapter 5). A study by Campos (2010) in the Philippines showed that apart from variability of climate, seaweed farming is also affected by increasing congestion of seaweed farmers in a small areas and variability in water level at the intertidal zones. In Zanzibar, a newspaper article (Ussi, 2012) reported the massive effect of warm sea water attributed to high summer temperatures on seaweed in the village of Uroa, in the southern region of the Unguja Island (see Plate 6.2). These reports demonstrate

the sensitivity of seaweed to the variability of both atmospheric temperature and sea surface temperature associated with ENSO events.

Table 6.1: Climate change impact pathways on fisheries

Type of change	Climate risks	Impacts	Potential outcome for fishers and fisheries resources
Physical environment	Warming upper layer of ocean	Warm water species replace cold water species.	Shifts in distribution of plankton, invertebrates, fish, and birds towards the North or South poles, reduced species diversity in tropical water.
		Plankton species move to higher latitudes.	
		Timing of phytoplankton bloom changes. Zooplankton composition changes.	Potential mismatch between prey (plankton) and predator (fish population) and decline production and biodiversity.
	Sea level	Coastal fish breeding and nursery habitats (e.g. mangrove and coral reefs) lost.	Reduced production of coastal and related fisheries.
Fish stocks	High water temperature	Sex ratio changes Spawning time alters Migration time alters. Peak abundance time alters.	Possible impacts on timing and levels of productivity across marine and fresh water.
	Change in ocean currents	Invasive species, disease and algal blooms increase.	Reduced productivity of target species.
		Fish recruitment success affected.	Abundance of juvenile fish affected and thus, production.
Ecosystems	Increase frequency of ENSO events	Timing and latitude of upwelling change. Coral bleaches and dies off.	Changes in pelagic fish distribution.
			Reduced fisheries productivity.
Coastal infrastructure and fishing operations	Sea level rise	Coastal profile change, loss of harbours and homes. Increased exposure of coastal areas to storm damage.	Costs of adaptation make fishing less profitable; risk of damage increases costs of insurance and/or rebuilding; coastal household vulnerability increases.
	Increase frequency of storms	More days at sea lost to bad weather, risks of accident increase.	Risks of both fishing and coastal fish-farming increase, making this a less viable livelihood option for the poor.
		Aquaculture installations (coastal ponds, sea cages) more likely to be damaged or destroyed.	Reduced profitability of large scale enterprises; insurance premiums rise.

Adapted from FAO (2007) and Allison *et al.* (2005)

Although there is a direct relationship between climate and livelihood sectors such as crop farming, livestock keeping, fishing and seaweed farming, the decline in crop and seaweed yield, as well as fish catches cannot be solely linked to a changing climate. For example, food shortages along the east coasts of both islands of Zanzibar (see Chapter 4) cannot be attributed solely to the observed local climate variability but rather a combination of this and various factors such as soil loss, environmental degradation and development challenges such as poverty (Walsh, 2009; Mubaya *et al.* 2012; Boko *et al.* 2007). In this regard, since the Third Assessment Report (AR3) of the Intergovernmental Panel for Climate Change (IPCC), it has been realised that it is necessary to examine vulnerability to climate change impacts in

conjunction with other challenges, both natural and social in a particular locality (IPCC, 2001). However, so far there have been few empirical studies of the livelihood effects of climate change interacting with other stressors. Some studies that have done this include O'Brien *et al.* (2004), O'Brien and Leichenko, 2000; Reid and Vogel (2006), Mubaya *et al.* (2012), McDowell and Hess (2012), Belliveau *et al.* (2006) and Tschakert (2007). Using a four-stage approach, O'Brien *et al.* (2004), for instance, examined climate change impacts and globalisation in India, whereas Reid and Vogel (2006) studied climate change vulnerability in relation to HIV/AIDS. Similarly, Belliveau *et al.* (2006) and Mubaya *et al.* (2012) examined multiple stressors faced by grape growers in the Okanagan Valley in Canada and farmers in Zambia and Zimbabwe respectively. In examining the interaction between climate change risks and existing development challenges in understanding the vulnerability, this Chapter seeks to understand the perceptions of farmers, fishers and seaweed farmers on both climate and non-climate stressors and drivers of change that affect their activities through various impact pathways.

6.2 METHODS

This Chapter combines data from several complementary sources; most of the data were obtained through the sector surveys administered to fishers, farmers and seaweed farmers (see Chapter 2). For more in-depth information and for the purpose of triangulation, various Participatory Learning and Action (PLA) tools such as vulnerability matrices (Appendix III), vulnerability mapping (Appendix II), and storytelling and focus group discussions were used. Additionally, I interviewed key informants; at the district level, this included agriculture and fisheries focal persons. Interviews were also conducted with two key informants from the Department of Fisheries and Marine Resources to establish the validity of the data obtained from the field, based on their experiences of fishing and seaweed farming. Extra comments made by respondents during the survey or during PLA workshops were recorded and used to back-up the quantitative data. Life stories obtained from the field are presented in boxes to provide an in-depth, first-hand understanding of people perceptions. Additionally, related literature was used extensively in explaining the existing context of each sector.

The main areas covered in the perception surveys for each livelihood sectors are outlined below:

a. Part 1: Existing context of the sectors

To understand the existing context of arable farming across the sites, farmers were asked five questions: (1) to identify the nature of their farm plot (coral or deep-soil plots or both); (2) to describe the size of their farm plots; (3) to estimate income received from selling their crops, (4) to indicate whether they had expenses on farming input, and (5) those who answered 'No' to the fourth question were asked to identify sources of inputs used on their farm plots. The percentage of responses in all five questions were then determined.

With regard to fishing, fishers were asked: (1) to identify the type of vessels they used for fishing trips; (2) to identify physical fishing assets they owned; (3) to identify the position they held on the fishing vessels (e.g. member crew, owner of the gear, captain), and (4) to estimate their income per month. The percentage of responses to all four questions were then determined. Additionally, a cross tabulation and bivariate correlation test was performed to determine the relationship between the income of fishers and the ownership of physical fishing assets.

Seaweed farmers were asked three questions to clarify the existing context: (1) to identify the number of seaweed blocks in which they farm seaweed; (2) their expenses for seaweed farming inputs, and (3) to identify their income per harvest season. Again, the percentage of the responses was determined. Further, an independent sample t-test was performed to reveal the difference between sites in relation to the number of seaweed blocks per farmer. A bivariate correlation analysis was performed to explain the relationship between income and the number of blocks owned by the farmers.

b. Part 2: Risks related to climate variability and change and other stressors for farming, fishing and seaweed farming

Respondents were asked to what extent variability in climate is affecting farming (e.g. crop and livestock survival, performance of pasture), fishing (e.g. quantity of fish caught, stock distribution, variability in species caught) and seaweed farming (e.g. growth, yield and seaweed block stability). Respondents were asked to give one of the following responses which included: 1 = high impact, 2 = moderate impact, 3 = low impact and 4 = no impact. In the fishing section additional questions were administered to fishers: they were asked to identify fish species that have declined or disappeared over time. Afterwards the percentage of responses for each question was determined. With regard to other linked stressors and drivers of change, respondents were asked to identify those stressors that they thought were affecting their livelihood activities. The question was open and respondents were free to identify as many stressors as they wanted. Lastly, seaweed farmers were asked if the price given per kg of seaweed was having negative impacts on the development of the sector; if so, they were also asked to rank the impact, as above. Percentages of responses to all these questions were then determined.

6.3 RESULTS AND DISCUSSION

6.3.1 Farming systems: existing context

6.3.1.1 Arable land and farm plots: survey and secondary information

The coral rag landscape which dominates a large part of Kiuyu Mbuyuni, Pemba and Matemwe, Unguja is traditionally used for keeping livestock. Shifting cultivation is used to cultivate crops with long fallow periods because of the low rate of fertility rejuvenation caused by the rocky nature of the soil (see Plate 6.1) and unreliable rainfall (see Chapter 5). The soil is prone to exhaustion even under slight cultivation pressure

and thus, production on coral rag soils is highly dependent on organic matter content generated from leaf litter from natural thicket vegetation (Makame and Kombo, 1998; Salum, 2009). The results of ‘participatory risk mapping’ workshops in both sites showed that even within the sites, local people perceived variation in the suitability of the soil across the landscape. In Matemwe for example, the area in the west is perceived to be more fertile than the rest of the village (see Appendix II).

Farming is performed on small plots acquired mainly through clearing (Singer 1996). Clearing is the most common means of land acquisition in most parts of the east coasts of both major islands (Singer 1996). This was attributed to the fact that land along the east coast was not considered in land redistribution after the 1964 revolution because of the poor soil. Most of the farmers have more than one plot and shifted between these plots to maintain constant production. In examining land tenure in Zanzibar, Singer (1996) found that farmers owned between one and five distinct farm plots in Pemba, while in Unguja, farmers owned between one and three.



Plate 6.1: Rocky nature of coral-rag soils in the areas

It is understood that some farmers in the drier parts also owned deep soil farm plots outside the areas as a response to localised food shortages in the drier parts of the islands. However, the results in Table 6.2 show that 100% of the interviewed farmers in Kiuyu Mbuyuni, Pemba, had only coral rag soil farm plots, while in Matemwe, Unguja 96% of the farmers had plots covered with coral-rag soil and only 4% of the interviewed farmers owned deep-soil farm plots outside the area. The absence of a tarmac surface of the road that links Kiuyu Mbuyuni with district headquarters and long distances from the village to other villages that are on deep soils, as well as the lack of financial assets (see Chapter 4), probably restricts farmers from owning deep soil farm plots outside their area.

Table 6.2 Nature of farm plots in both sites

Type of farm plots	Kiuyu Mbuyuni, Pemba (Nr =48) (%)	Matemwe, Unguja (Nr=51) (%)
Coral rag soil	100	96
Deep soil	-	4

Nr=Number of responses (multiple responses question)

Box 6.1: Life story of a farmer in Matemwe, Unguja

Juma was born at Matemwe and grew up in the same village. He works as a farmer and at the same time, is employed by the Department of Road Construction. After retiring from that department in 1994, he engaged fully in farming and he started growing yams, maize, tomatoes, and cowpeas (*kunde*).

Matemwe was one of the leading villages in Unguja that produced tomatoes, but Juma believed that, apart from unreliability of rainfall and poor soils, many youths, after completing their education don't engage in farming practices such as growing tomatoes, unlike previously. Instead, they become involved in the tourism sector. He himself grew tomatoes on a small scale but this time they didn't grow well because of the dry conditions. In the last season of short-rain season (*vuli*) he grew yams (*viazi vikuu*) but rats tried to destroy them. He also grew cowpeas (about 0.4 hectares), maize (about 0.8 hectares), and tomatoes. Apart from attacks by rats, constant dry conditions in 2010-2011 also seriously weakened the crops. He believes that the land has lost its fertility and thus food security in his household has deteriorated because he is no longer employed. He uses a large piece of land for farming but he harvests little, unlike previous years when he used a small piece of land but harvested a lot. The main problems he experiences in his farming are constant and long-term sun, crop/plant diseases, and rats and livestock which attack crops. He doesn't usually use insecticides for his crops although they are available at the district government. He does however, use poison to control rats. Although rats seriously damage crops, he believes he is fortunate that other destructive animals, such as wild pigs and monkeys have disappeared in their area.

Juma thinks that after an interval of seven years there is a drought and consequently livestock, especially cattle, die and crops are severely weakened and sometimes die. Generally people get seeds from the government, especially maize. This time they have requested some seeds but so far they haven't got anything. Sometimes when they request seeds they get them, but very late. As they are poor they can't buy seeds; and not all beans or maize sold in the shop are suitable for seeds. Seeds are prepared and treated in a special way. He uses short-term maize. From the day they sow the seeds till the time of harvesting maize takes three months. Short-term cowpeas take only two months to harvest from the day of sowing. Apart from using fast-maturing varieties, he also improves soil fertility by leaving grasses and leaves on the land during weeding.

There was plenty of land for farming and it was free for everyone to use. He used to shift from one place to the other in order to cope with poor soil, but not anymore. As the days go by the land becomes occupied by people and thus the tendency to shift from one place to another has decreased. People, who own the land, even though they abandoned it, only allow others to grow short-term crops such as maize, peas, beans, and yams and forbid them to grow very long-term crops like mango trees. All land which is by the sea/ beach has been sold for hotel construction. The demand for land has expanded to agricultural land. He warned people along the shore not to sell the land but they refused and they regarded him as mad. People sell the land which is near the sea and they get money, but after one year they have nothing.

With regard to the size of farm plots owned by the respondents, the results in Table 6.3 show that 4% of the interviewed farmers in Kiuyu Mbuyuni and 27% in Matemwe owned farm plots of between 0.4-0.6 hectares. About 33% in Kiuyu Mbuyuni and 51% in Matemwe owned land between 0.8-1 hectares, while 27% in Kiuyu Mbuyuni and 14% in Matemwe owned between 1.2-1.4 hectares. More farmers in Kiuyu Mbuyuni (29%) owned arable land of 1.6 hectares and above while in Matemwe only 4% did so (Table 6.3). Thus, in Kiuyu Mbuyuni, Pemba, farmers have larger size farm plots than those in Matemwe, Unguja (Table 6.3). A study by Singer (1996) which involved all islands revealed that the size of individual

landholdings was between 0.40 and 8 hectares in Pemba, while in Unguja, it was between 0.40 and 141 hectares. The smaller size of farm plots observed might be influenced by decreasing landholding over time due to increasing population, increasing land value, and the expansion of tourism infrastructure in the case of Matemwe, Unguja as well as other emerging new land uses (e.g. making bricks from underlying rocks in Kiuyu Mbuyuni). Increasing land pressure in Matemwe is also reflected in the life story of a farmer in Matemwe (see Box 6.1).

Table 6.3: Size of farm plots owned by respondents

Size of farm plot (hectares)	Kiuyu Mbuyuni, Pemba (N=49) (%)	Matemwe, Unguja (N=49) (%)
0.4-0.6	4	27
0.8-1	33	51
1.2-1.4	27	14
1.6 hectares and above	29	4
I don't know	8	4

6.3.1.2 Type of crops and methods of farming

At least six seasonal and annual crops are common across the sites: cassava, banana, yams, maize, millets and sorghum. Pumpkin, cowpeas, small peas and pigeon peas were also observed at both sites. In Matemwe, Unguja, vegetables such as tomatoes, pumpkins, cucumbers and yams were observed being intercropped with other crops. Discussions in the vulnerability mapping (Appendix II) and vulnerability matrix workshops (Appendix III) suggested that Matemwe was among the major producers of tomatoes for urban markets during the 1990s, but the combination of diseases and ever more erratic rainfall had tremendously lowered the production of tomatoes in the area (see Box 6.1). With regard to permanent crops, only coconuts are grown in Kiuyu Mbuyuni, whereas in Matemwe, coconut, mango trees and citrus fruits (oranges and lemons) have been observed. However, a large number of coconut trees in Matemwe are now included within tourism hotel compounds or have been cleared for the development of tourism infrastructure. Rice is the most common staple food in both sites, as for Zanzibar as a whole, but it is not grown in these coral rag sites because there are no river valleys associated with both perennial and annual streams (see Chapter 4).

6.3.1.3 Income, availability and usage of farming inputs

Since farming is subsistence and complements fishing and other off-farm activities (Chapter 3), most of the farming produce is for home consumption. The results show that out of 49 interviewed farmers in Kiuyu Mbuyuni only three sold part of their agriculture produce, whereas in Matemwe about 13 farmers out of 49 interviewed sold their produce (Table 6.4). The larger number of farmers who sold their agricultural produce in Matemwe might be a result of greater access to markets due to good roads and tourism demand. Out of the three farmers selling crops in Kiuyu Mbuyuni, three earned between 30,000-50,000 Tanzania

shillings (Tshs), while one earned about Tsh.50,000-100,000 per season (Table 6.4). In Matemwe, Unguja out of the 13 farmers selling crops, four earned about Tsh.30,000-50,000 whereas three earned between Tsh.70,000-100,000 and another three earned above Tsh.100,000 per season. The most-traded agricultural produce included maize and giant yams.

Table 6.4: Income earned by farmers per season by selling produce

Income in Tsh.	Kiuyu Mbuyuni, Pemba (F=3) (%)	Matemwe, Unguja (F=13) (%)
10,000-30,000	-	2
30,000-50,000	67	4
50,000-70,000	33	1
70,000-100,000	-	3
Above 100,000	-	3

Exchange rate in 2011 was 1 USD = 1,600 Tanzanian shillings

Farming systems in the area are characterised by low expenditure on most of the farming inputs, which again demonstrates the subsistence nature of farming systems across the sites. Respondents were asked if they incurred expenses on various farming inputs, and the results in Table 6.5 show a large proportion of the interviewed farmers had no expenses on inputs such as labour, manure, fertilizers, insecticide and pesticides. Approximately 52% of the interviewed farmers in each site were purchasing seeds, while half did not (Table 6.5). Buying or not buying is highly influenced by the variability of rainfall and types of crops involved. Farmers have a tendency to keep part of the harvest as seeds for the next season, but when crops fail there will be no harvest or seeds for the following season, and farmers must find an alternative. The following comment made by a farmer in Kiuyu Mbuyuni, Pemba demonstrates the role of climate in the availability of seeds or cuts of cassava and sweet potatoes for future needs:

“We used to conserve seeds of millet, maize, sorghum for the future or ask from our neighbours, but we buy cassava and sweet potato cuts from other villages, because we can’t keep them for the next season as they will get dry due to declining rainfall and increasing temperature”.

Table 6.5: Expenditure on farming inputs

Responses	Labour (%)		Manure (%)		Fertilizers (%)		Insect/herbicides (%)		Seeds (%)	
	Kiuyu (N=49)	Matemwe (N=49)	Kiuyu (N=43)	Matemwe (N=49)	Kiuyu (N=41)	Matemwe (N=49)	Kiuyu (N=39)	Matemwe (N=49)	Kiuyu (N=48)	Matemwe (N=49)
Yes	4	2	-	4	-	2	-	4	52	49
No	96	98	100	96	100	98	100	96	48	51

Interviewed farmers who had no expenses on inputs were asked to identify the sources of their farming inputs, and the results in Table 6.6 show that family labour in both sites was a major source of labour for farming. While farmers, especially in Kiuyu Mbuyuni, used manure from their animals, about 17% of the interviewed farmers in Kiuyu and 41% in Matemwe did not use manure at all for their farming. This segment of the farmers is probably more exposed to poor soil. Further, the majority of the respondents

across the sites did not use fertilizers, insecticides or pesticides (Table 6.6; Box 6.1). For those who have no expenses for seeds, the results revealed that about 48% of the farmers in Kiuyu Mbuyuni and 80% in Matemwe, Unguja kept their own seeds, while 26% in the Pemba site and 16% in the Unguja site acquired seeds from the district government. District government across the sites often supply seeds, especially after dry spells (see Box 6.1). This is mainly because agricultural failure attributed to erratic rainfall affects the capacity of the farmers to conserve seeds for future needs.

Table 6.6: Sources of farming input

Farming inputs	Kiuyu Mbuyuni, Pemba (%)	Matemwe, Unguja (%)
Sources of labour	(N=47)	(N=48)
Family labour	89	81
Myself	11	19
Sources of Manure	(N=41)	(N=37)
From my livestock	59	40
From neighbour	24	19
Do not use manure	17	41
Source of fertilizers	(N=32)	(N=38)
Do not use fertilizers	100	100
Sources of insect/herbicides	(N=33)	(N=37)
Traditional medicine	12	35
Do not use insect/herbicides	88	65
Sources of seeds	(N=23)	(N=25)
Kept from previous harvest	48	80
From neighbour/relatives	26	4
From district government	26	16

6.3.2 Farmers' perceptions of risks and impacts related to climate variability and change

Farmers across the sites believed that local variability in temperature, rainfall and drought as perceived and observed, impacted their crops and livestock (see Appendix III; Box 6.1. 6.2, 6.4). With this concern, respondents were asked to classify the degree of impact on various farming outcomes. The results in Table 6.7 show that the majority of the interviewed farmers across the sites perceived an impact of climate variability and change on both crops and livestock. However, they differed on the degree to which climate stressors impact farming.

Table 6.7: Perceived climate variability and change risks and impacts on farming and food availability

Extent of perceived impact	Crop survival (%)		Livestock survival (%)		Production/yield (%)		Performance of pasture (%)	
	K (N=42)	M (N=41)	K (N=42)	K (N=37)	K (N=37)	M (N=38)	K (N=37)	M (N=32)
High impact	86	61	27	48	67	68	54	44
Moderate impact	9	32	52	30	20	24	38	25
Low impact	5	7	19	22	13	8	8	31
No impact at all	-	-	2	-	-	-	-	-
Impact score Mean $\pm$SE	1.19$\pm$0.08	1.46$\pm$0.09	1.98$\pm$0.11	1.73$\pm$0.13	1.46$\pm$0.11	1.39$\pm$0.10	1.54$\pm$0.17	1.88$\pm$0.15
Extent of perceived impact	Food availability (%)			Pest and diseases (%)				
	K (N=37)		M (N=36)	K (N=26)		M (N=37)		
High impact	78		64	27		51		
Moderate impact	16		17	27		32		
Low impact	3		19	46		16		
No impact at all	3		-	-		-		
Impact score Mean $\pm$SE	1.30$\pm$0.11		1.56$\pm$0.13	2.19$\pm$0.17		1.65$\pm$0.12		

K=Kiuyu Mbuyuni, Pemba; M=Matemwe, Unguja. The impacts score ranging from 1(high impact) to 4 (no impact).

6.3.2.1 Risks and impacts perceived to affect crops-in the areas

The majority of the farmers interviewed in Kiuyu Mbuyuni (86%) and 61% of those in Matemwe believed the declining rainfall and increasingly warm conditions were having a high impact on the growth and survival of crops (Table 6.7). The mean score shows that the majority of the farmers in Kiuyu Mbuyuni (1.19 $\pm$ 0.08) perceived a higher impact of climate variability on crop survival compared with Matemwe (1.46 $\pm$ 0.09) (Table 6.7). With regards to crop production, 67% of the farmers in Kiuyu Mbuyuni and 68% in Matemwe perceived the impact as high, while 20% and 24% of farmers in Kiuyu Mbuyuni and Matemwe respectively believed that climate variability had a moderate impact on crop production (see Chapter 4). The perceived declining crop production and yield was expressed by a farmer from Kiuyu Mbuyuni in the following quote (also see Box 6.1 and Box 6.4):

“I remember in those early days we planted crops on just a small plot and we used to get better output; but now you can farm one kilometre you will get nothing”.

With regard to food availability, the majority of the respondents across the study sites perceived a high impact on food availability (see Chapter 4). About 16% of the farmers in Kiuyu and 17% in Matemwe perceived the impact on the availability of food in the households to be moderate. Only 3% of the respondents in Kiuyu Mbuyuni perceived no impact of climate variability on the availability of food in the households. Variability in the onset of the rainy season was also perceived to alter the local crop calendar, as articulated by a farmer from Kiuyu Mbuyuni, Pemba:

“We normally plant sweet potatoes during winter; we are now in winter but we can’t plant because there is no rain which normally accompanies winter season, locally known as mchoo”.

Table 6.8 which presents the crop calendar for some common crops on both islands also demonstrates the vulnerability of crops to variability of climate. For example, there are two planting seasons for maize: the beginning of the long-rain season (March) and during the short-rain season (*vuli*) (September-October). Thus, the perceived decline in rainfall during the short-rain season (see Chapter 5) may have significant implications for maize production and food security in both the study sites. In a similar manner, abnormal winters as remarked on by the respondent above, and the short-rain season as perceived in Chapter 5, adversely affect the planting season for other common crops in the areas such as cassava, yams (*viazi vikuu*), sweet potatoes and various types of peas. Therefore, it can be argued that the observed localised food shortage in the area (see Chapter 4) was partly caused by the fact that most of the common crops, such as maize, yams, cowpeas and millet, are grown through two seasons which have been experiencing the most variability (see Chapter 5).

Table 6.8: Seasonal and crop calendar in Zanzibar

Islands	CROPS	SUMMER		LONG RAIN SEASON			WINTER			SHORT RAIN SEASON			
		JAN	FEB	MAR	APRIL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
U	Maize	harvest		plant			harvest				plant		
Pba	Maize	harvest		plant			harvest			plant			
U	Millet	harvest		Plant				Harvest		Plant			
Pba	Millet			plant				Harvest					
U	Cassava				plant		plant				plant		
Pba	Cassava						plant				plant		
U	Sweet potato and Yams						plant		plant				harvest
									Harvest				
Pba	Sweet potato and Yams						plant		harvest				
U	Small pears/Cowpeas						plant		harvest				
Pba	Small pears/Cowpeas	harvest					plant			harvest			harvest
									Plant	plant			

U=Unguja, Pba= Pemba (Modified from KKKUEWZ, 2005)

6.3.2.2 Risks and impacts perceived to affect livestock farming

With regard to livestock survival, the results in Table 6.7 show mixed feelings on the degree of impact. For example, the majority of the farmers interviewed in Kiuyu Mbuyuni (51%) perceived climate variability to have a moderate impact on livestock survival, whereas 48% of the farmers in Matemwe perceived the impact as high. About 2% of the farmers in Kiuyu Mbuyuni perceived no impact of climate variability on livestock survival; however, mean results in both the study sites show that the perceptions of farmers are within the moderate impact range. In terms of performance of pasture, 54% of farmers in Kiuyu Mbuyuni and 44% in Matemwe believed that pasture is highly affected by the perceived variability in climate (Table 6.7). About 38% of farmers in Kiuyu Mbuyuni and 25% in Matemwe perceived a moderate impact on

pasture, while 8% in Kiuyu Mbuyuni and 31% in Matemwe perceived the impact of climate variability on pasture as low.

These results regarding the impact of climate variability on livestock survival and pasture are also reflected in life stories presented in Box 6.1 and 6.2 and in vulnerability matrix workshops findings (Appendix III). For instance the life story teller in Box 6.2 lost about nine cattle and some goats due to drought and diseases triggered by ENSO events. Unlike the responses recorded in Table 6.7, responses from participants of the workshops in both sites found declining rainfall and drought had a significant impact on grazing land and pasture (see Appendix III). The following quote from a respondent in Kiuyu Mbuyuni, Pemba supports the contention that variability in climate and drought has a high impact on livestock and the well-being of households:

“These days availability of pasture has been affected by the variability of rainfall, especially during winter (June-August) and short-rain seasons (October-December). For example, we lost four cattle in 2010 due to poor pasture caused by the 2008-2010 erratic rainfall. All of us in the house cried as if we lost one of our close relatives because those cattle meant a lot to our livelihoods” (Farmer from Kiuyu Mbuyuni, Pemba).

The study also noted that poor pasture resulting from the variability in rainfall forced farmers to untether their cattle and goats and in many cases, the animals risk death from eating poisoned food, plastic and rubbish. Similarly, untethered cattle and goats are likely to destroy other farmers’ crops and hence cause conflict. The comment below from a farmer in Matemwe, Unguja and the life story in Box 6.2 demonstrate other risks to livestock farmers during dry spells and the periods of associated low pasture:

“Cattle and goats died during the bad seasons not only because of the absence of pasture, but also because they ate poisonous food and plastic bags. In most cases cassava, during drought, becomes poisonous” (Farmer from Matemwe, Unguja and Kiuyu, Pemba).

Box 6.2: Life story of a farmer, once a successful livestock keeper

Unanani was born in Matemwe in 1963; he grew up in his elder brother’s house after their parents divorced and he started school in 1976. He assisted his brother to take care of goats and cattle and around the same time he started doing some fishing with friends. In 1982 his family forced him to marry a woman who was previously engaged to his brother, and who cancelled the marriage at the last minute. That marked the end of school because he had to fish in order to earn a living in his new life. After two years of marriage he stopped fishing and became a farmer and livestock keeper; for him fishing was too risky. After a while, apart from being a farmer and livestock keeper, he diversified his livelihood portfolio and became a middleman, trading cattle and goat meat between Matemwe and Zanzibar town. By the early 1990s he was a successful businessman and livestock keeper, already with more than 30 cattle and 20 goats. The 1997-1998 El Niño year, which was accompanied by heavy rainfall, triggered animal diseases and most of his goats died, while in 1999 of the remaining 17 cattle, eight died during the 1999-2000 drought triggered by La Niña events. He was in Dar es Salaam in and around 1999 so when he got back he found only nine cattle remained. He decided to take three of them to his uncle in the central district and he kept six cattle. The drought intensified and most of the livestock keepers responded by untying their animals - he again lost three cattle out of six and he suspected that they probably ate poisonous foods, plastic or honey. Honey is poisonous to cattle so during that time farmers applied honey to their drought-resistant crops like banana and cassava to prevent cattle from eating them. Heavy rainfall during El Niño (1998) and drought during La Niña (1999/2000) crippled his wealth and income and he never recovered.

He was fortunate that in 2002 he had been given dairy cattle from the department of livestock through the ‘land cattle pay back cattle’ scheme and after five years he had four dairy cattle. He was then selling milk and somehow his income improved. However, the area has never been a suitable place for dairy cows because of the unreliable

rainfall, which affects the pasture quality and availability and in 2008 he sold one of the dairy cattle and with the money obtained, made a latrine in his home. During the same time, two of his dairy cattle died and the remaining one he sold at the onset of the 2009/2010 dry spells. Dairy cattle, apart from pasture, need intensive care and it was difficult for him to provide this. During this period he also lost five goats to disease and as a result he lost interest in keeping even locally bred cattle as they are sensitive to dry spells and diseases. Now he has 15 goats and only two cattle. Goats are not affected by drought as they feed from dry bushes or from drought-tolerant bushes.

6.3.2.3 Perceptions of impacts of pests and diseases

The impact of climate variability on the increasing incidence of pests and diseases again showed mixed results (see Table 6.7). Just less than half of farmers in Kiuyu Mbuyuni (46%) believed that declining rainfall and increasing temperature has a minimum impact on the increased incidence of pests and diseases, while the majority of the farmers (51%) in Matemwe perceived the impact of climate variability as high. About 27% in Kiuyu Mbuyuni and 32% of the farmers in Matemwe perceived the impact of varied climate on pests and diseases as moderate. The stories from farmers in Matemwe, Unguja (see Box 6.1 and 6.2) also recounted the increasing incidence of pests and diseases triggered by increasing warming, drying and wetting conditions, caused partly by ENSO events.

With regard to the impact of pests and diseases on crops and livestock, the results of vulnerability matrix workshops (see Appendix III), which tested the perception of participants regarding various risks through ranking, showed that in Kiuyu Mbuyuni, participants ranked pests and diseases fourth after drought, human actions and temperature variability. By contrast, in Matemwe participants ranked pests and diseases as risk number three, after drought and variability in wind patterns (see Appendix III). It seems that farmers in Matemwe are more affected by these risks compared with Kiuyu Mbuyuni, Pemba. As the prevalence of some pests, insects and diseases is influenced by climate, future predicted changes in climate are very likely to increase the incidences of pests and diseases not only to crops and livestock, but also to humans.

6.3.3 Farmers' perceptions of risks and impacts related to other linked stressors and drivers of change on agriculture

The most cited non-climate stressors that affect farming included poor soil, poverty, deforestation and continuous farming (Table 6.9). About 41% of interviewed farmers in Kiuyu Mbuyuni and 36% in Matemwe believed that soil is adversely affected by variable rainfall which further intensifies the sensitivity of the farming system (see also Appendix II). On the other hand, 15% of interviewed farmers in Kiuyu Mbuyuni and 14% in Matemwe believed that poverty also affects their farming activities, because poverty reduces access to important farming inputs and also natural and physical assets related to farming (Table 6.9). This situation is explained by an agriculture official at district level in Pemba:

“There are a number of insects that destroy millet and maize, but farmers have no financial capacity to buy insecticides. Like last year 2010 we had large stock of insecticides here at the district office at a low price, but very few came to buy them”.

About 11% of the interviewed farmers in Kiuyu Mbuyuni and 16% in Matemwe believed that pests and diseases affect their crops and livestock. This problem of plant and animal diseases and pests has also been vividly depicted in stories in Boxes 6.1 and 6.2. Furthermore, about 6% of the farmers in Kiuyu Mbuyuni and 11% in Matemwe believed that deforestation has also impacted farming. People believe that because of the nature of their land, leaves and branches from forests are crucial for the rejuvenation of their soils. This is reflected in the following comment made in Matemwe by a farmer:

“Big trees that normally produce the leaves that increase the fertility of our soils have gone because of the demand for firewood, lime and stones. Now our soil doesn’t gain fertility”.

An interview with the leaders of an environmental NGO in Matemwe revealed that the forest in their area has been completely destroyed for various reasons; now many people have to buy firewood and pegs for seaweed farming. This has huge implications for households which already experience low savings, low investment, poverty and seasonal food insecurity (Chapter 3 and 4). Similarly, scarcity of fuel wood and lack of locally available pegs for seaweed is likely to threaten the nearby conserved forest as locals seek other supplies (Kiwengwa-Pongwe Forest Reserve). An interview with NGO’s leaders also revealed that the organisation attempts to win the local leaders’ support to establish planted forest plots as in Kiuyu Mbuyuni but faced a strong challenge from local leaders which may be linked to the increasing value of land in the area.

With regard to continuous farming in one place, 10% of the farmers in Kiuyu and 13% in Matemwe believed that this tendency affects their production and yield. Farmers believed that the land contains small amount of nutrients and thus becomes exhausted under minimum pressure. Increasing population and demand for land for other land uses, coupled with the small size of plots has forced farmers to abandon their traditional shifting-cultivation to cope with poor soil (see Box 6.1). Indeed, the combination of land degradation, population increase and the expansion of tourism have reduced the size and number of farm plots per household. And under the current farming trend, further fragmentation of the land will intensify food insecurity, as farmers are forced to farm constantly on plots with diminishing nutrients. Given the low input nature of the farming systems (Table 6.9 and 6.3.1) it appears that continuous farming has had a significant impact on food production and food security as a whole. The impacts of human activities on resources such as land also emerged in vulnerability matrix workshops in both sites (Appendix III), however with significant difference between sites. While participants in Kiuyu Mbuyuni ranked human action on resources as second after drought, in Matemwe they ranked it sixth (less impact on resources) (Appendix III). The other stressor that affects farmers and farming systems in both sites was theft of both crops and livestock.

Table 6.9: Perceptions of farmers on other linked stressors that interact with climate variability

Other linked stressors	Kiuyu Mbuyuni (Nr=151) (%)	Matemwe (Nr=177) (%)
Poor soil	41	36
Lack of input	9	4
Poverty	20	14
Continuous farming	10	13
Crop and livestock theft	2	6
Pests and diseases for crops and livestock	11	16
Deforestation	7	11

Nr=Number of responses (multiple responses question)

Given the rain-fed nature of the farming, it appears that farming in the areas is vulnerable to the variability of temperature and frequency of dry spells as observed at the end of the last decade (see Chapter 5). Farmers perceptions of the impact of climate variability on crops and livestock in Zanzibar mirror those from other studies in many parts of the world (Nyanga *et al.* 2011; McDowell and Hess, 2012, Mubaya *et al.* 2012; Marin, 2010; Roudier *et al.* 2011). For instance, although it was difficult to quantify the contribution of climate and non-climate stressor impacts on farming, farmers in Zimbabwe and Zambia perceived that climate variability was affecting their livestock and crops (Mubaya *et al.* 2012). Similarly, pastoralists in Mongolia perceived the significant impacts of climate variability on pasture and quality of livestock production (Marin, 2010). In examining the impact of climate change on livestock and livestock systems in developing countries, Thornton *et al.* (2009) contend that climate change, apart from reducing the quality and quantity of pasture, is also likely to increase the incidence of livestock diseases and pests.

The findings revealed that non-climate stressors and associated risks exert high pressure on farming and farming systems as well. Some of the farmers interviewed believed that non-climatic stressors such as decreasing landholding and increasing incidences of animal and plant diseases have more impact on farming and livelihoods than variability in climate. This is to say, the perceived variability in climate is adversely interacting with existing stressors, making farming as well as livelihoods more vulnerable. The perceptions of farmers on non-climate stressors on farming have also been observed both within and beyond the continent (see Mubaya *et al.* 2012; McDowell and Hess, 2012; Belliveau *et al.* 2006; Reid and Vogel 2006). For instance, apart from climate variability, small-scale farmers in Kwazulu-Natal, South Africa were also exposed to HIV/AIDS that affected the quality of human capital (Reid and Vogel, 2006). In Zambia and Zimbabwe, farmers mentioned a wide range of stressors that were thought to interact with climate change, these included HIV/AIDS, lack of capital, bad roads, limited access to credit, financial capital to buy inputs, lack of improved cattle breeds, poor irrigation infrastructure, and lack of agricultural inputs, amongst others (Mubaya *et al.* 2012).

6.3.4 Fishing and fisheries: existing context

6.3.4.1 Scale, technology and ownership of vessels and gear

Table 6.10 shows that the majority of the interviewed fishers across the sites go out fishing in small vessels such as outrigger and dugout canoes (see Table 6.11 for the description of various types of vessels). As expected, because of lack of financial services and assistance, only 4% of the fishers in Kiuyu Mbuyuni and 10% in Matemwe use motorised boats. About 34% in Kiuyu Mbuyuni and 8% in Matemwe do not use vessels but fish by wading into the water and walking to the reef. This again may be attributed to low access to livelihood assets including financial services (see Chapter 3). The results match the district data obtained from the Department of Fisheries and Marine Products (DFMR, 2012) based on the summary of a fisheries survey (2010). The report shows that Micheweni, Pemba in which Kiuyu Mbuyuni is located, had 4,825 fishers and 1,017 foot fishers, whereas North ‘A’, Unguja, in which Matemwe is located, had 5,370 fishers and 1,164 foot fishers. Across the sites there are few motorised boats (also see Lange and Jidawi, 2009), most of which are supplied either by the Tanzania Social Action Fund (TASAF) or the Department of Fisheries in order to improve the income and sustainability of the fishery resources. Fishing in the areas is also characterised by unsophisticated gear. This includes various types of nets (dominated by gill nets), lines, spears (mainly targeting octopus and big fish) and traps (large and small traps, fishing weir fence). The sophisticated fishing nets, locally known as *jarife*, which target certain species, are mostly found in TASAF-funded boats.

Table 6.10: Types of fishing vessels used in the study sites

Types of vessels	Kiuyu Mbuyuni, Pemba (n=50 (%))	Matemwe, Unguja (n=48) (%)
Outrigger canoes (<i>Ngalawa</i>)	32	77
Dug-out canoes (<i>Mtumbwi</i>)	26	4
Sailing boats (<i>Mashua</i>)	4	-
Motorised boats (<i>Boti</i>)	4	10
On foot	34	8

Table 6.11: Description of the common vessels available in the areas

Types of vessels	Description
Outrigger canoes (<i>Ngalawa</i>)	Length up to 6 m; draft to 0.5 m. The hull is basically a dugout canoe, often with an upwardly-curved and fanned bow and a pointed stern where the rubber is fixed. Two stabilising outriggers are attached to poles fixed inside the hull. The short mast, supported by movable stays, carries a spar (often bamboo) and a lateen sail.
Dug-out canoes (<i>Mtumbwi</i>)	Length up to 3 m, rarely more; draft to 0.5 m. The most basic and probably the oldest water craft in the western Indian Ocean region. The hull is carved out of a single tree trunk (mango trees being popular in some areas).
Sailing boats (<i>Mashua</i>)	Length up to 10 m; draft to 0.6 m. A smaller version of the dhow (<i>Jahazi</i>). Many carry outboard petrol engines as well as or instead of sails.
Motorised boats (<i>Boti</i>)	Looks like a sailing boat but always carries outboard petrol engines

Description of outrigger, dug-out canoes and sailing boats adapted from Richmond, (2010). Description of motorised boat is my own.

Given that ownership of fishing assets is important for fishing activities (see section 6.3.4.2 below), fishers were asked if they personally owned various types of gear and vessels. The results in Table 6.12 show that only 17% and 26% of the interviewed fishers in both Kiuyu and Matemwe respectively owned fishing vessels and most of these vessels were small, such as dugouts and outrigger canoes. This result tallies with a study by Lange and Jidawi (2009) which showed that more than half of the vessels used for fishing in Zanzibar are dugout canoes. A large number of fishers across the sites owned fishing lines, but only 1% in Kiuyu Mbuyuni owned refrigeration (see also Chapter 4). The overall results in Table 6.12 demonstrate the low physical capital of the fishers. This is probably attributable to poor saving of the income obtained from fishing caused by the increasing frequency of agriculture failure across the sites as commented on by one fisher from Kiuyu:

“We earn very little from fishing and almost all of our earnings is used for buying food (rice)”.

Low physical capital may reduce fisher’s resilience to climate change risks. For instance, fishers may sometimes land large amounts of fish that exceed the demand of the market, but most of them are forced to sell their catch at cheaper prices as they do not have electricity, let alone refrigerators to keep them until the next day (see Chapter 3). In this context, remote landing sites like Kiuyu Mbuyuni are more vulnerable.

Table 6.12: Ownership of fishing physical capitals

Physical capital	Kiuyu Mbuyuni, Pemba (Nr=78) (%)	Matemwe, Unguja (Nr=87) (%)
Vessels	17	26
Various lines	33	37
Various fishing nets	6	25
Traps	9	6
Engine boat	1	2
Refrigerator	1	-
Spear gun	22	1
Nothing	10	1

Nr=number of responses (multiple responses)

6.3.4.2 Income and markets

In addition to selling their catch, fishers also supply fish to their homes for food (see Chapter 4; Lange and Jidawi, 2009). However, the group discussions revealed that the amount, size and types of fish supplied for home consumption has changed tremendously over time. Because tourism has expanded within and outside the country and increased the demand for fish in towns, high-quality fish and seafood, such squid and octopus, are out of reach of the majority (see Chapter 4). In Kiuyu Mbuyuni, Pemba there are no tourism hotels, but big fish (e.g. tuna), squid and octopus were observed to be locally exported to Mombasa, Kenya or Unguja Island by middlemen. Most of the fishers perceived a decline in the fish stocks, though they earn more money than before because of the high demand, as a fisher from Matemwe, Unguja observed:

“I remember in those days we landed many fish but we earned a little; but now we land less fish but we earn more”.

The income of fishers was highly dependent on the position of a fisher on a vessel and ownership of physical capital. The cross tabulation result in Table 6.13 shows that a large proportion of the respondents who own the vessels, and at the same time are the captain, earned higher incomes (Tsh. 70,000-100,000 and above 100,000) than just crew members without assets. A Pearson correlation test also revealed a significant correlation between income and position held in the fishing vessels. The result demonstrates that the majority of the fishers are relatively vulnerable as many of them do not own physical assets such as vessels and fishing gear. Furthermore, the income of the fishers is also sensitive to the wind patterns because of the small size of the vessels used (see Chapter 5) and the unreliable nature of fishing as articulated by a fisher from Matemwe:

“During north easterly wind (kaskazi) I may earn more than Tsh.200,000 per season, while during south eastern wind (kusi) I earn as little as Tsh.10,000 as outrigger canoes limit us from fishing far from the shore where the fish stock is very high”.

North-easterly winds, apart from helping small vessels sail back from a fishing trip, are also perceived to drive fish stocks close to the shore as they blow toward the shore, whereas south-easterly wind are considered risky as they blow away from the coast and perceived to chase away the fish stocks (see Chapter 5; Feidi, 2005).

Table 6.13: Income and position in the fishing boat

Positions in fishing boat	Income per month (%)				
	10000-30000 (N=5)	30,000-50,000 (N=14)	50,000-70,000 (N=27)	70,000-100,000 (N=24)	100,000 and above (N=15)
Gear owner/big traps	20	7	7	4	-
Crew member	60	57	52	33	20
Captain	20	-	15	-	8
Vessel owner and captain	-	14	22	54	68
Vessel owner and assistant captain	-	7	-	-	-
Both gear owner and captain	-	-	4	-	7
Both crew and vessel owner	-	14	-	8	-
Pearson correlation	P=.01*				

*Significant correlation between income and position of a fisher in fishing boat (Exchange rate in 2011 was 1 USD = Tsh.1,600)

Almost all the fish caught across the sites are sold locally at the landing sites within the village or neighbouring villages and mostly through auctions. There were also those who sell their catch at the village market in retail fashion; most of the fishers who fall in this category were foot fishers. On the other hand octopus, squid and lobster are often sold outside auctions using weights measured on a scale (Crona *et al.*

2010). Although most of the fishers do not have complaints about the auctions, they do not trust the process entirely as fishers from Kiuyu Mbuyuni and Matemwe respectively commented:

“Auctions have many tricks, sometimes the auctioneer may influence price to favour a buyer whom he knows, but sometimes we take back our fish if we are not satisfied with the price”.

“We are not always content with the price at the auction, but we have to accept because we have no freezers for storing fish to sell them the next day”.

Middlemen also play a major role in fishery businesses all over Zanzibar, and coastal Tanzania and Kenya (Crona, *et al.* 2010). Due to the limited availability of micro-credit, both from banks and government institutions that could assist poor fishers to acquire assets such as vessels and fishing gear (Mohamed 2003; Chapter 3), fishers in most cases acquire this from middlemen, who in return secure priority access to the fish catch. This reciprocal agreement between fishers and middlemen is likely to influence price and income of the fishers in the long-run (Crona *et al.* 2010). In Pato Lagoon, Brazil, middlemen were also found to control the price of the catch in return for their assistance to fishers, including lending money (Kalikoski *et al.* 2010).

Although the nature of artisanal fisheries may vary from country to country, they are mostly considered as having poor resilience. Because they are characterised by the small size of vessels, poor technology, low physical capital, poor market systems, over-dependency on fishery resources for income and food, the sector is very sensitive to climate change, and other interacting stressors such as over-fishing, conflicts and socially-constructed stressors (DuBois and Zagrafos, 2012; Kalikoski *et al.* 2010; Allison and Ellis, 2001; Badjeck *et al.* 2010).

6.3.5 Fishers’ perceptions of risks and impacts related to climate variability and change

Although over-fishing and illegal fishing may have the upper hand in the vulnerability of marine ecological niches (Boko *et al.* 2007), climate change has also significantly influenced the sensitivity of physical and biological processes at various scales (Allison *et al.* 2009; Boko *et al.* 2007; Barros *et al.* 2009; Nagy *et al.* 2009a). A large proportion of the respondents across the sites believed that the perceived variability in climate (see Chapter 5) had an impact on the quantity of fish landing, quality and size of fish, stock distribution, species and breeding grounds (Table 6.14). The results tally with those from the vulnerability matrix workshops (Appendix III); these workshops revealed perceived impacts of variability of wind and temperature on coral reefs and on fishery resources.

Table 6.14: Perceived risks and impacts of climate variability and change on fishing

Response s	Quantity (%)		Stock distribution (%)		Species caught (%)		Breeding ground (%)	
	K (N=44)	M (N=41)	K (N=44)	M (N=36)	K (N=33)	M (N=26)	K (N=31)	M (N=24)
1	64	68	41	64	9	46	29	63
2	11	15	30	14	12	12	19	8
3	23	17	30	22	76	42	52	29
4	2	-	-	-	3	-	-	-
Impact score Mean±SE	1.64±0. 138	1.49±0. 122	1.89±0.127	1.53±0.140	2.73±0.11 7	1.96±0.18 8	2.23±0.15 9	1.67±0.187

K=Kiuyu Mbuyuni, Pemba, M=Matemwe, Unguja. 1=high impact, 2=moderate impact, 3=low impact, 4=no impact.

6.3.5.1 Perceived risks and impacts of climate variability and change on the quantity fish landed

About 64% of interviewed fishers in Kiuyu Mbuyuni and 68% in Matemwe perceived the impact of climate change on the quantity of fish caught per fish trip to be high (Table 6.14). About 23% of the fishers in Kiuyu Mbuyuni and 17% in Matemwe believed that the impact is very low. Moreover, 2% of the fishers in Kiuyu Mbuyuni perceived no impact of climate variability and change on the quantity of fish caught. Despite the fact that fishing is controlled by seasonality, the majority of the fishers believed that even during a good fishing season the amount of fish caught has declined over time. Quotes in Box 6.3 also support the perception of fishers regarding the decline in fish catch. A story in Box 6.3 also highlight the perceived declined of fishery resources particularly in Kiuyu Mbuyuni, Pemba. However, it is also possible that the decreasing fish catch might be attributed to depleted fishery resources close to the shore. A large number of foot fishers and a dominance of small vessels (see Table 6.10) in the fishing system, means a concentration of fishers very close to the shore for decades. Although fishery resources are dynamic this concentration might have depleted the resources and thus affected fish catch per fisher.

Box 6.3: Fishers comments on variations in fish quantity in the areas

<i>"Our parents used to fish along the ridge very close to the shore (within a kilometre in both sites) and they used to land large catches of fish of varying species, but now we reach as far as close to Mombasa, Kenya looking for fish".</i>
<i>"You can't compare north-easterly season (locally known as kaskazi, a good season for fishing) for these days and kaskazi in those years. In those previous years we used to land a large amount of fish during kaskazi".</i>
<i>"Although generally the fish catch declined over time, I remember during El Niño year 1997-1998 we used to land a large amount of fish".</i>
<i>"Impacts only affect shallow water areas close to the shore. If we would get big fishing vessels with modern gear we would fish a lot out there".</i>

Box 6.4: Life story of a fisher, who is also doing some farming and seaweed farming

Said was born at Kiuyu Mbuyuni in 1968 and grew up in the same village. In 1975, when he was seven years old, he started school. In 1985 he completed Form Three and unfortunately, he did not continue to study further. He started his own life by engaging in livestock keeping, especially cattle, and fishing activities. His father was a fisherman and at the same time, held various government and party responsibilities. His parents used to fish in the shallow sea because they lacked advanced technology. Fortunately at that time, fish were plentiful. But now if people don't go further out to sea, they can't catch fish. Even crabs were plentiful, but nowadays they are very scarce. When he was young in 1972, at the time Karume was ruling the country, there was famine. When the rain started during that time, his father sailed to a small uninhabited island not far from the village and established a
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new farm plot by the slash and burning method. Although the island is located very close to the village, people were afraid to shift their farming there as they believed there were devils there. Said and his parents dared to defy the belief to cope with land exhaustion and famine. Since then people have continued to go to that small island to farm as there were no cattle to destroy their crops. They used to get good rain but the amount diminished as people constantly cut down the trees. People believed that the 1972 famine was a punishment from God because during the Zanzibar Revolution (1964) people were guilty of a lot of injustice.

When he started life on his own, Said was doing well, in both farming and fishing. But things have changed. With regard to farming, there is no surplus to store as their harvests are small. Actually, the land is exhausted so they farm on the places they used to keep cattle to increase fertility. With regard to fishing, fish catches declined and were not reliable. In order to improve food security in his household, at one time he moved to Tanga and then to Dar es Salaam (Tanzania mainland) where he stayed for some years. He struggle with life there and then he went back to Kiuyu Mbuyuni to start farming and fishing again, but this time added seaweed farming.

However, farming and keeping livestock still face challenges such as the increasing frequency of dry spells. Water availability is not bad, though the water is a bit hard but people drink it as do their animals. During the sunny season, the hardness of the water increases. One thing that went right upon his return was in fishing. With government support through TASAF, their fishing co-operative group managed to acquire a big motorised boat with modern gear. Their co-operative has 30 members; whatever they get, they share. However, their co-operative has made no progress in fishing; possibly because of the unreliable nature of fishing, so they have decided to shift to seaweed farming. Essentially, he has been growing seaweed for a long time to diversify his livelihood portfolio, but he was doing it on and off because of the disappointing price offered by the seaweed buyers; he considered it too much investment in time and energy. His inconsistency was also influenced by participating in many activities at once.

The fisher's comment on increased fish catches during El Niño year of 1997-1998, which was characterised by heavy rainfall and warm temperature, is supported by a study by Feidi (2005) who noted that fish catches in Zanzibar increase with increasing rainfall, because high run-off brings nutrients from the land which attracts fish close to the shore. Elsewhere in the world, warmer conditions caused by ENSO events produced mixed results (see section 6.3.4.1). Although local fishers perceived a decline of fish in their territorial water, which affected their catch over time, the analysis of data obtained from the Department of Fisheries (Figure 6.1) shows a significant increase in the artisanal fish landing in Zanzibar from just 8,851 tons in 1990 to 28,759 tons by 2011. In-depth interviews with key informants revealed that the low fish catch landed in the 1990s could be attributed to poor data collection at landing sites, while the significant rise in the 2000s can be attributed to the improvement of data collection methods, increased number of motorised boats that can fish off-shore, the use of gear that targets certain species, and the introduction of a protected marine area. Whatever the case, it seems that the amount of fish landed through artisanal fishing is increasing toward what the FAO calls a 'sustainable potential yield limit' (Mkenda and Folmer, 2001).

Based on the potential yield for various fishing grounds available in Zanzibar (reefs, coral reefs, mangrove ecosystems, continental shelves and continental slopes) including pelagic fish, the potential yield was estimated at 25,000 to 30,000 metric tons per year (FAO, 1991 cited in Mkenda and Folmer, 2001). Given the constant increase in the tons of fish landed recently (Figure 6.1), the 30,000 ton limit as suggested by the FAO will be exceeded within the next two or three years. The constant increase is probably caused by the influx of more fishers, attributed to increasing population, agriculture failure, lack of alternative sources

of income in coastal villages, and an increasing demand for fishery products in the urban and tourism sectors. For instance, the number of fishers increased from 2,373 in 1997 to 34,571 in 2010, whilst the number of vessels jumped from 5,149 to 8,639 in the same period (Figure 6.2).

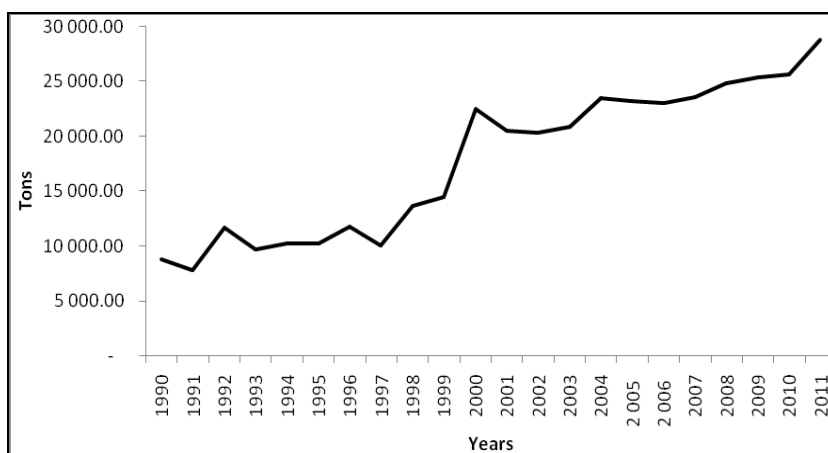


Figure 6.1: Fish landed by artisanal fishers (source of data: DFMR 2012)

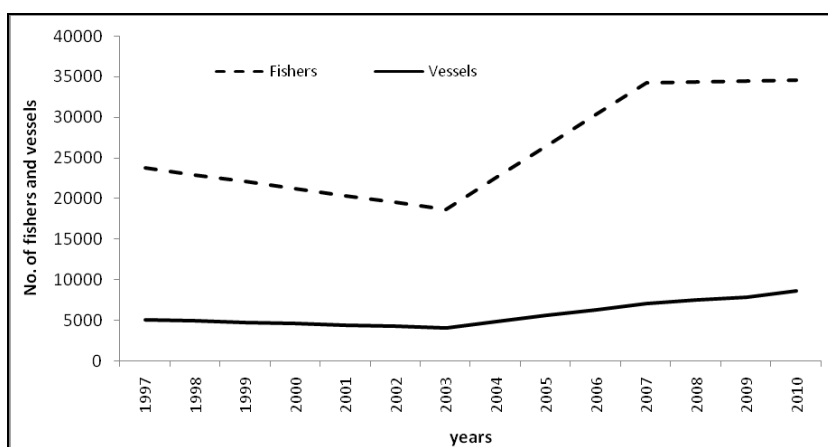


Figure 6.2: The number of fishers and vessels (source of data: DFMR 2012)

6.3.5.2 Perceived risks and impacts of climate variability and change on species caught

With regard to the species caught, the results in Table 6.14 again show some variation in the perceptions of fishers on this. About 76% of interviewed fishers in Kiuyu Mbuyuni believed that the impact on the types of species caught was low, while 46% of the fishers in Matemwe perceived the impacts to be high. This means there are some species that are no longer caught or that have declined over time. Three percent of the interviewed fishers in Kiuyu Mbuyuni perceived no impact on the type of species landed. Mean results show that the perception of the fishers in Kiuyu Mbuyuni (2.73 ± 0.117) falls at 3 (low impact) whereas, in Matemwe (1.96 ± 0.188) this falls at 2 (moderate impact) (Table 6.15). Although the results revealed a difference in perception across the sites, fishers in both sites identified various species which had either declined or disappeared over time. This decline however, may not necessarily be caused by climate change.

A wide array of species that had declined was mentioned, but the study selected only those species which scored a high frequency (see Table 6.15).

Table 6.15: Fish species which perceived to have declined over time by fishers

Common name	<i>Chanos chanos</i> /milk fish	Bluefin trevally	Indian mackerels	Anchovies	Spangled emperors	Sharks and Rays	Spine foot	Goat fish
Local name	<i>Mwatiko</i>	<i>Kolekole</i>	<i>Vibua</i>	<i>Dagaa</i>	<i>Changu</i>	<i>Papa and taa</i>	<i>Tasi</i>	<i>Kundaji</i>
Kiuyu Mbuyuni, Pemba (N=50)	54%	20%	14%	12%	-	-	-	-
Matemwe Unguja (N=46)	-	-	-	-	33%	26%	24%	17%

Some of the species identified by the fishers (Table 6.15) were also identified as threatened in both Zanzibar and at a global level. A study by Crona *et al.* (2010) categorised Spangled Emperors (*changu*) that were cited as declining in Matemwe, Unguja as having medium and high vulnerability in Kenya and Zanzibar. Emperors are in high demand in both local and tourism markets. The decline of sharks may be partly linked to the increasing popularity of shark fin soup in south East Asia (also see Richmond, 2010). Other species cited in Matemwe, Unguja, such as blue rays and goat fish, were also perceived to have disappeared in Chwaka Bay, Unguja (Muhando, 1995). However, Muhando (1995) attributes the disappearance of these species to overfishing.

The perceived decline of Indian mackerel and anchovies in Kiuyu Mbuyuni, Pemba, may be partly associated with the observed variability of rainfall which reduced run-off to the ocean mainly because plankton, the main food of Indian mackerel (see Richmond, 2010), feeds off nutrients which are largely brought to the sea by rainwater run-off. It has been shown in section 6.3.4.1 of this Chapter that the abundance of fish in Zanzibar is partly influenced by rainfall which brings nutrients crucial for fish feeding down to the sea. In an interview with a key informant it was noted that these two species are seasonal, small pelagic species, so it is possible that during the field survey, they were out of season. However, it is also possible that the changing characteristics of the seasons caused by climate variability and other climate-related factors may have influenced the abundance of these species (see Allison *et al.* 2009). For example, studies by Sun *et al.* (2006) and Avaria *et al.* (2000) cited in Badjeck *et al.* (2010) show that the landing of mackerels fell nearly 50% in Taiwan and 70% in Chile in the aftermath of the 1997-1998 El Niño events.

Mangrove ecosystems are among the most common habitats for both *chanos chanos* (*mwatiko*) and bluefin trevally (*kole kole*) (Richmond 2010). Thus their disappearance or decline as perceived by fishers in Kiuyu Mbuyuni may be linked to habitat degradation through human-induced activities. Climate variability may

have a stake too as mangroves are considered an ecosystem vulnerable to climate change and sea level rise (see Nicholls *et al.* 2007). During a group discussion at the Pemba site, one participant also commented that the decrease in the number of people using the mangrove forest as a toilet may also be reducing the number of fish in their territorial waters because the supply of nutrients has decreased. A study by Muhando (1995) cited in Mkenda and Folmer (2011), also recorded that fishers observed that *chanos chanos*/milk fish had disappeared in Chwaka Bay, Unguja which had experienced massive mangrove deforestation through the urban demand for firewood and poles. A study by Bagarinao (1991) of the life of *chanos chanos* shows that, despite variability and regional extreme events such as ENSO, the climate of the sea water in Zanzibar still offers favourable conditions for the survival of *chanos chanos*, based on their temperature and salinity tolerance levels. Their decline therefore, may be either caused by over-fishing or habitat loss attributable to both human-induced actions and climate change (see for example Mkenda and Folmer, 2001).

6.3.5.3 Perceived risks and impacts of climate variability and change on fish stock distribution and breeding grounds

About 41% of interviewed fishers in Kiuyu Mbuyuni and 64% in Matemwe perceived high levels of change in the distribution of fishery resources, while about 20% in Kiuyu Mbuyuni and 22% in Matemwe perceived the impact of climate change on the distribution of the fishery resources in territorial water as low (Table 6.14). On the other hand, the results in Table 6.14 show that the majority of the interviewed fishers in Kiuyu Mbuyuni (52%) perceived the impact of climate variability and change on breeding grounds such as coral and mangrove ecosystems as low. By contrast, 63% of the interviewed fishers in Matemwe, perceived the impact as high, while only 29% of the interviewed fishers in Kiuyu Mbuyuni shared this perception. The mean results of fishers' perceptions regarding the impact on breeding grounds were 2.23 ± 0.159 (moderate impact) in Kiuyu Mbuyuni and 1.67 ± 0.187 (high impact) in Matemwe (Table 6.14).

With regard to fish stock distribution, most of the fishers believed that wind direction influences the movement of the fishery resources. As discussed in section 6.3.4.2 north-easterly winds (*kaskazi*) indicate a good fishing season since they bring more fish into the near-shore water, while south-easterly winds (*kusi*) chase fish into deeper water (also see Chapter 5). In examining the potential for new investment for the fisheries of Zanzibar, Feidi (2005) commented that north-easterly winds with short spells of rain attract more pelagic migratory fish species into territorial water. This is to say the variability of wind as perceived by seaweed farmers and fishers in Chapter 5 may have some implications for the distribution of fish resources in the areas. Apart from seasonal distribution resulting from seasonal variation in winds, disturbance of the distribution of fish resources may also be the result of the destruction of breeding grounds and habitat. The use of GPS by fishers, especially in the Unguja site to locate the position of the fish (see Chapter 7) may reflect the changing patterns of the distribution of the fish resources. This is highlighted by the following comment made by a fisher in Matemwe:

“In those early years, we used to know in this place we can trap which type of fish species and in that place which type of species. But now things have changed”.

As discussed earlier in section 6.3.5.2 mangrove and coral reefs are among the important breeding grounds for fishery resources in Zanzibar (Mkenda and Folmer, 2001). However these ecosystems are under pressure, not only from climate change and sea level rise but also from human-induced activities. In Kiuyu Mbuyuni, mangrove forests are an important source of fuel wood and live wood pegs for seaweed farming. Similarly, participants in the vulnerability matrix workshop in Kiuyu Mbuyuni (see Appendix III) indicated that, apart from variability in winds and storms, human activities significantly affect the forests. It is worth noting that in Matemwe there are no stands of mangrove forests. Similarly, a large numbers of in-shore pools which act as breeding and habitat grounds for fish species have been buried by massive sand deposits attributed to variability in winds (see Chapter 5), thus reducing the quantity and distribution of fishery resources close to the shore (see Box 6.3). Some fishers in Matemwe, Unguja, however, associate deterioration of in-shore breeding and habitat grounds with seaweed farming (also see Richmond, 2010).

In terms of coral reefs, participants of the vulnerability matrix workshop (see Appendix III) in Kiuyu Mbuyuni, Pemba perceived no impact of temperature on coral reef ecosystems. However, they believed that human activities such as the use of illegal fishing methods like spear guns, are moderately affecting the reefs. In a similar manner, participants in Matemwe perceive the impact of human activities on coral reefs as moderate. Despite the variations in the perceptions between sites, it is widely understood that coral reef ecosystems, which act as a safe haven for the majority of the fish species, are sensitive to global warming (Obura, 2005; Boko *et al.* 2007; Nicholls *et al.* 2007). Coral reefs have become one of the first of the earths’ ecosystems to directly suffer large-scale mortality from climate change (Ateweberhan and McClanahan, 2010). In Zanzibar, coral ecosystems are highly vulnerable to extreme regional events such as ENSO. For example, during the 1997-1998 El Niño, coral ecosystems in Zanzibar experienced massive bleaching which extensively affected the tourism industry and fishery resources as well (see Boko *et al.* 2007). The findings therefore tally with Table 6.1, which indicates that the variability of sea surface temperature, storms, sea level rise and ENSO events have a large impact on species distribution, the abundance of juvenile fish and on off-shore fishing grounds (also see Cinner *et al.* 2012; Allison *et al.* 2009; Miller, 2007; Boko *et al.* 2007).

6.3.6. Fisher’s perceptions of risks and impacts related to other linked stressors and drivers of change on fishing and fisheries

Fishers across the sites were asked to identify non-climate drivers or stressors that they thought affect fisheries and fishery resources. The four most cited stressors across the study sites were: increased numbers of fishers, the use of illegal methods of fishing, increased demand for fishery products, and Allah’s will (Table 6.16). Other stressors that emerged here but are related to climate change or are already discussed in

the previous section, included deterioration of coral reefs, changes in the ocean and the increased duration of south-easterly winds (Table 6.16). In addition, a small number of fishers across the sites identified the Indian Ocean tsunamis of 2004, the use of nets and foreign fishing fleets as stressors for fisheries and fishery resources. Stressors that were identified only in Matemwe, Unguja by a few fishers include pollution, and conservation practices such as the Marine Protected Areas (Table 6.16), which was seen to limit fisher's access to fishery resources.

Table 6.16: Perceived other linked stressors and drivers of change on fishing and fishery resources

Stressors on fishing and fishery resources	Kiuyu (Nr=144) (%)	Matemwe (Nr=136) (%)	Stressors on fishing and fishery resources	Kiuyu (%)	Matemwe (%)
Illegal methods	10	22	God's will	15	3
Change in the sea	17	7	Foreign fishing fleets	1	6
Increased numbers of fishers	22	18	Low temporal migration system (<i>dago</i>)	1	1
Increasing demand for fishery products	13	7	Pollution produced by vessels	-	1
Long duration of south-easterly wind (<i>kusi</i>)	8	11			
Conservation practices	-	7			
Deterioration of coral reef	7	10	Fish stock escaped to off-shore sea	3	1
Last Indian ocean tsunamis	3	6			

Nr=Number of responses (multiple responses question)

With regard to the increasing number of fishers, about 22% of the interviewed fishers in Kiuyu Mbuyuni and 18% in Matemwe believed that increasing numbers of fishers as a result of population increase has caused the decline in catch per fisher over time (Table 6.16). Decreasing fish catch means reduced access to food (Chapter 4) as well as reduced saving capacity at both individual and households levels (Chapter 3). Their perceptions tally with the results in Figure 6.2 which show that, even at national level, the number of fishers and vessels has increased tremendously. The increased number of fishers is attributed to the lack of alternative sources of income among youth who either completed or dropped out from schools. Illiteracy, low skills related to tourism and the perceptions of the hotel owners about the capacity of the local people to participate in tourism-related work exclude most of the youth from the tourism sector (see Chapter 3). Similarly, most young males regard seaweed farming as a job for females. This is to say that fishing is the only available option for the majority of people and this puts more pressure on fishery resources. In other parts of the world, the problem of increasing pressure on fisheries resources has also been observed. For example, Kronen *et al.* (2010) found that the lack of income diversification in increasing populations of the Pacific fishing community has resulted in high pressure on fishery resources.

In terms of illegal methods of fishing and the increasing demand for fish products, the results in Table 6.16 show that about 10% of the interviewed fishers in Kiuyu Mbuyuni and 22% in Matemwe believed that

illegal fishing methods affected fishery resources. On the other hand, 13% of the interviewed fishers in Kiuyu Mbuyuni and 17% in Matemwe believed that the increasing demand for fishery products also increased pressure on fishery resources. The increased demand for fisheries products caused by expanding tourism and the increase of an affluent population in urban areas threatens the resilience of the fishery resources and may cause extinction of the desired species (see Crona *et al.* 2010). Given the low technology involved in fishing (see section 6.3.4), coupled with low access to modern equipment (see section 6.3.6.1), increasing demand is likely to encourage the use of illegal techniques of fishing such as spears guns, beach seining nets, small-eye nets and dynamite.

With regard to God's will, about 15% of the interviewed fishers in Kiuyu Mbuyuni, Pemba and 3% in Matemwe, Pemba believed that declining fish stocks and fish species was a result of God's will (Table 6.16). It was very difficult to establish the exact reasons why more people in Kiuyu Mbuyuni attributed God with fishing problems compared with Matemwe, Unguja. Attributing declining fish catch to God's will is highlighted by the comment made by a fisher in Matemwe during the survey:

"God used to bring to the ocean one basket of fish in a day of rainfall, that can be used for 15 years for the whole world, so we have nothing to worry about".

This perception may affect both fishery resources and coping strategies as fishers believe that everything resolves itself and therefore they would be reluctant to conserve or respond to the perceived and observed risk related to climate change. This perception may also influence the use of illegal methods that could further affect the ecological resilience.

Furthermore only 7% of the interviewed fishers in Matemwe believed that conservation practices through marine protected areas (MPAs) affect their fish catch and livelihoods as it reduces access to key fishing grounds. This claim came up more strongly in the discussions during the PLA workshops in Matemwe. Their perceptions, however, differ from the general understanding that MPAs help to revive the health of coastal and marine ecosystems and improve local livelihoods (see Warner and Pomeroy, 2012). Local people believe that the introduction of protected coral reef patches off Mnemba islet (see Chapter 3) limits local fishers' fishing activities in the area and ultimately impacts on their income. During the vulnerability matrix workshop in Matemwe, Unguja, participants claimed that they had not benefitting from the money paid by tourists who dive and snorkel on the coral reef inside the MPAs. For instance, they claimed that they received only Tsh.1000000 ten years ago, which was used to build toilets in their schools. Restricted access to fishing grounds associated with MPAs as stressor was only depicted in Matemwe, Unguja because in Kiuyu Mbuyuni, Pemba there is no nearby MPA.

Other identified drivers of change in the fisheries systems were the last Indian Ocean tsunamis (3% Kiuyu Mbuyuni and 6% Matemwe) and a decrease in temporal migration amongst fishers (*dago*) (1% in both

Kiuyu Mbuyuni and Matemwe). The results show that more people cited tsunamis in Matemwe compared with Kiuyu Mbuyuni, probably because the aftermath temporary effects of tsunamis such as waves were stronger in Matemwe, Unguja than in Kiuyu Mbuyuni, Pemba. Fishers believed that the Boxing Day tsunami, which occurred on Sunday 26th December 2004, triggered by the Sumatra-Andaman earthquake also contributed to the decline of fish across the sites. Local fishers believed that the tsunami had disturbed fish breeding grounds and habitats and thus fish migrated to the other areas as the comment by a fisher from Kiuyu Mbuyuni, Pemba shows (see also Chapter 5)

“We know the local habitat of certain species in the ocean but since the 2004 tsunami some of the species migrated from one place to the other; probably their habitat was affected by the tsunami”.

The decrease in temporal migration of fishers was also mentioned as a stressor on fisheries resources (Table 6.16). This decrease may be influenced by the expansion of the tourism industry and conservation practices through MPAs to the tiny islets off major islands (Unguja and Pemba). Most of these islets were previously used as fishing camps when fishers engaged in short-term migration within the islands. The migration of fishers between islands or to the coast of mainland Tanzania has also declined over time (see quote below). Temporal migration of fishers can potentially improve an ecosystem’s health at the origin but is likely to increase pressure and conflicts at the destinations. In West and Central Africa both spatial and temporal migration of various kinds was employed by the fishers to cope and adapt to declining fish stocks and climate change (Njock and Westlund, 2010).

“Myself I think the abandonment of the seasonal fishing camp outside Matemwe has contributed to the decline of fish resources in our area. I remember we used to migrate to Pemba, south of Unguja, and sometimes within North of Unguja, but now we have concentrated in our area throughout the year”.

6.3.7 Seaweed farming: existing context

6.3.7.1 Seaweed farming and seaweed plots: survey and secondary information

After several trials since 1984, commercial seaweed farming started in Zanzibar in the beginning of the 1990s (Msuya, 2011). Since then the number of people (mostly women) who are engaged in seaweed farming has increased tremendously (Jiddawi and Khatib, 2007). Low input requirements coupled with lack of diverse sources of income among women probably influenced the amazingly high rate of seaweed farming uptake in Zanzibar (Eklund and Petterson, 1992; Lange and Jiddawi, 2007). By 2010, the number of seaweed farmers in Zanzibar was 21,969 (DFMR, 2012). Although the majority of seaweed farmers are female, the number of male farmers is rising due to agriculture failure, especially along coral rag zones, and the uncertainty of fishing (see profile of the respondents in Chapter 5). The increase in the number of male seaweed farmers might also be influenced by the lack of alternative sources of income. Culturally, men are obliged to cover all household expenditure (Eklund and Petterson, 1992). Nevertheless, in some cases and households, income earned by women, mainly through seaweed and handcraft work, is also used to cover household expenses (Wallevik and Jiddawi, 1999).

A total of 13,193 metric tons of seaweed, worth USD 3.5 million, were produced during 2011 (DFMR 2012). Although an attempt to produce products from seaweed has begun (e.g. seaweed bar soap and seaweed body creams), most seaweed produced in Zanzibar is exported to the world market (Lange and Jiddawi, 2009; Msuya, 2011). The seaweed species farmed in Zanzibar are *Euchuema cottonii* and *spinosum* (Lange and Jiddawi, 2009; Msuya, 2011). *Spinosum* is very common across the sites and in Zanzibar in general, compared with *Euchuema cottonii*. For instance, *Euchuema cottonii* contributed only 0.5% of the total production for the year 2011 (DFMR, 2012). Climate and sea levels play a major role in seaweed production which makes the sector extremely sensitive to observed variability and future changes (see Chapter 5). Based on the seaweed farmers' narratives, seaweed growth needs relatively cool seawater and should remain under water to avoid exposure to direct sunlight. That is why most seaweed farmers perceived winter (June-August) and the short-rain season (October-December) as the best seasons for seaweed growth (see Chapter 5).

Seaweed farming occurs within the intertidal zones (see Plate 5.1), making it prone to conflict with other users of the zone, especially the tourism sector. An interview with a key informant at North 'A' district government offices revealed that in Matemwe, Unguja, conflict between seaweed farmers and hotels owners is common, as hotel owners want a clear and safe zone in front of the hotels for the tourists to swim and play in, whilst seaweed farmers want to plant seaweed for their survival. In Kiuyu Mbuyuni, Pemba, despite having a wide and excellent beach, so far the inhabitants have managed to resist tourism in their area. Seaweed is planted in under-water blocks (Lange and Jiddawi, 2009; Eklund and Petterson, 1992), of no distinct length and width, though most of the farmers assert that a block is about 15 m long and 14 m wide. As for land, seaweed farmers across the sites owned more than one block in order to increase their income (Table 6.17). An independent sample t-test revealed a significant difference in the number of blocks owned by the seaweed farmers between the sites. Seaweed farmers in Kiuyu Mbuyuni owned more blocks (5-6 blocks) than seaweed farmers in Matemwe (3-4 blocks).

Pressure exerted by tourism in Matemwe probably pushed seaweed farmers into a smaller area and thus has reduced the number of blocks per farmer. It was noted during an interview with an informant that hotel owners used to pay seaweed farmers small amounts of money around USD 40 in order remove their blocks in front of the tourism hotels. The number of blocks may also be determined by labour availability within the household, and the household members' ages. Having a husband or children who are willing to help in various stages of seaweed farming is likely to help farmers to farm more blocks (see Msuya, 2011).

6.17: Number of seaweed blocks per farmer in coastal Zanzibar

Number of seaweed blocks	Kiuyu Mbuyuni, Pemba (N=50) (%)	Matemwe, Unguja (N=50) (%)
1-2	6	54
3-4	18	30
5-6	38	10
7-10	20	4
11-15	18	2
Mean±SE	3.26±.161	1.70±.135
t-test	(t=7.426 df= 98 p.<.001)*	

The number of weed blocks ranges from 1 (1-2 blocks) to 5 (11-15). * Significance differences

6.3.7.2 Seaweed farming methods and inputs

Across the sites, seaweed farmers used traditional methods for seaweed farming in which nylon ropes with seaweed branches tied to them are fixed between wooden pegs (obtained from either mangroves, planted or natural forest) and arranged in lines of approximately 50 lines per block, which allows for growth under water in the intertidal zones for six weeks before harvest (Plate 5.1; Msuya, 2011; Richmond, 2010; Eklund and Petterson, 1992). However, according to farmers, the duration between planting and harvest may be shorter, depending on the season. During winter, the cooler seawater allows for faster growth compared with other seasons, particularly summer. After the harvest, seaweed is exposed to the sun for about three days before being taken to the selling point or it is stored for future sale. As most of the areas close to the shore in Unguja are now covered by tourism infrastructure, seaweed farmers have to carry their harvest and dry it in front of their homestead. By contrast, in Kiuyu Mbuyuni, where there is no tourism infrastructure, farmers dry seaweed close to the shore and sell from the same point.

Rope, pegs, seaweed branches and labour are important inputs for seaweed farming. Respondents were asked whether they have expenses as a result of these inputs. Results in Table 6.18 show that, as expected respondents have no expenses on seaweed branches as they keep these from the previous harvest. A large proportion of the respondents (52% in Kiuyu Mbuyuni and 80% in Matemwe) indicated that nylon rope was an expense, whereas 48% in Kiuyu Mbuyuni and 20% in Matemwe had no expenses. There are nine companies buying seaweed from farmers, either directly or indirectly through middlemen. These companies differ in terms of their strategies when it comes to the issue of farming inputs. Some companies do offer inputs, especially ropes, but then the farmer is obliged to sell his/her weed to that company. If farmers carry their own expenses then they can sell to anyone.

The results show a big difference regarding availability of wooden pegs across the sites. In Kiuyu Mbuyuni, Pemba 96% of respondents said pegs were not an expense, while in Matemwe 68% did (Table 6.18). This is probably influenced by the fact that Kiuyu Mbuyuni has many sources of wood (mangrove and patches of planted trees) while Matemwe has none. Kiwengwa-Pongwe Forest Reserve is located in the neighbouring

village and local residents are only allowed to collect dry twigs. Pegs need to be made of strong green wood. Thus, farmers in Matemwe could be more sensitive to climate and a lower small price given per kilogram of weed (see section 6.3.7.3), since they are forced to buy most of their inputs, as illustrated by the following quote:

“We don’t have forest in Matemwe, and I am scared to cut pegs from the reserved forest. So all these days I buy those pegs and it costs me approximately Tsh. 5,000 per bundle and they don’t last long” (Exchange rate in 2011 was 1 USD = 1,600 Tanzanian shillings).

This suggests that as the number of seaweed farmers and blocks per farmer increases due to the uncertainty of fishing and agricultural, the demand for wooden pegs will expose the forests to yet another stressor. But it also offers an income opportunity for those selling the pegs.

Table 6.18: Expenses on seaweed farming inputs

Responses	Rope (%)		Wooden pegs (%)		Weed branches (%)	
	Kiuyu Mbuyuni (N=50)	Matemwe (N=50)	Kiuyu Mbuyuni (N=50)	Matemwe (N=50)	Kiuyu Mbuyuni (N=50)	Matemwe (N=49)
Yes	52	80	4	68	-	-
No	48	20	96	32	100	100

6.3.7.3 Income and markets for seaweed

The results in Table 6.19 show that a large proportion of the seaweed farmers in Kiuyu Mbuyuni, Pemba (62%) earn between Tsh.70000-100000 per harvest season, while in Matemwe, Unguja only 28% earn this much. The majority of the seaweed farmers in Matemwe earn between Tsh.10000-50000 per season (Table 6.19). The difference in income between sites could be attributed to the number of blocks per farmer. A bivariate correlation analysis was done and the results revealed a high relationship between income per season and the number of blocks farmed (Table 6.19). It has been noted earlier that the small number of blocks per farmer in Matemwe is the result of the pressure exerted by other users of intertidal zones, especially tourism. This again suggests that the observed and predicted variability of climate and sea level will likely exert more pressure on seaweed farming in Matemwe than in Kiuyu Mbuyuni, Pemba, as the sector is already disadvantaged by limited access to suitable seaweed farming areas. Apart from tourism, farmers also need to confront other users of the intertidal zones, such as fishers and their vessels. Success is therefore highly dependent on how seaweed farmers manage to operate under those unavoidable conditions. Seaweed farming is also particularly vulnerable to a market system which is controlled by the world market. For instance in June 2013, the Minister of Industry, Business and Markets in Zanzibar was reported by the daily news paper as saying that the demand for seaweed in the world market is continually declining due to increasing production in Zanzibar and other seaweed producing countries in both Africa and Asia which has flooded the market (Sadallah, 2013).

Table 6.19: Income per harvest (time between planting and selling approximately 2 months) and Person correlation between income and number of blocks owned by seaweed farmers

Income	Kiuyu Mbuyuni, Pemba (n=50) (%)	Matemwe, Unguja (n=50) (%)
Tsh.10,000-30,000	2	32
Tsh.30,000-50,000	16	26
Tsh.50,000-70,000	20	14
Tsh.70,000-100,000	62	28
Person correlation	P=.001*	

Exchange rate in 2011 was 1 USD = 1,600 Tanzanian shillings *significance correlation

Across the sites, seaweed farmers used to sell seaweed at Tshs. 250/kg (USD 0.16/kg) but in the middle of my survey in Kiuyu Mbuyuni, Pemba, the price rose to Tshs. 450/kg (USD 0.28/kg). The increase which started to be paid by one company caused conflicts and debates among buyers. Even this current price is not accepted as fair by the farmers due to the energy needed and resulting health consequences (Fröcklin *et al.* 2012). But farmers have no option as one can see from a testimony from Kiuyu Mbuyuni, Pemba:

“The price we are getting from selling our seaweed is very small and we are not content with it, but we have no option”.

In most cases, all nine companies that buy seaweed from farmers or middlemen set their own fixed price. Farmers are not organised to fight for better prices and they are thus forced to accept the price set by the buyers. Unlike cloves, so far there is no specific institution responsible for providing market information to producers. However, Lange and Jiddawi (2009:527) argue that, “Neither farmers nor exporters in Zanzibar have the capacity to influence world market prices”. Being a small producer, Zanzibar is unable to compete with other producers, particularly in Asia and thus has limited capacity to dictate the price (Lange and Jiddawi, 2009)

6.3.8 Seaweed farmers’ perceptions on risks and impacts related to climate variability and change for seaweed farming

It has been seen from the above section that, even without climate variability and change, seaweed farming is exposed to its own set of threats and limitations. Thus, without adaptation to climate variability, the future of the sector will be highly compromised. Seaweed farmers were asked to explain the degree to which the observed variability of climate and sea level (see Chapter 5) impacted the ability of seaweed to survive and yield and also seaweed block stability. The result in Table 6.20 shows that all respondents across the sites perceived an impact on seaweed, but they do differ on the degree to which local climate variability and sea level affects their seaweed blocks. The mean results fall between high impact and moderate impact.

Table 6.20: Climate variability and change risks and impacts on seaweed as perceived by seaweed farmers

Degree of impact	Seaweed survival/growth		Yield/production		Seaweed stability	
	Kiuyu (N=44)	Matemwe (N=44)	Kiuyu (N=43)	Matemwe (N=43)	Kiuyu (N=23)	Matemwe (N=36)
High impact	12	48	16	51	13	28
Moderate impact	77	43	63	42	74	53
Low impact	11	9	21	7	13	19
No impact at all	-	-	-	-	-	-
Impact score Mean±SE	2.00±.073	1.61±.099	2.05±.094	1.56±.096	2.00±.109	1.92±.115

The degree of impact ranges from 1 (high impact) to 4 (no impact)

6.3.8.1 Climate variability and change risks and impacts for seaweed survival

Across the sites the observed variability of temperature in both summer and winter, and sea level decline (see Chapter 5), was perceived to affect the capacity of the seaweed to survive and grow. About 12% of the interviewed seaweed farmers in Kiuyu Mbuyuni and 48% in Matemwe perceived the impact of variability in climate on the seaweed as high, while 77% of the seaweed farmers in Kiuyu Mbuyuni and 43% in Matemwe perceived this impact as moderate (Table 6.20). The mean score was 2.00±.073 for Kiuyu Mbuyuni and 1.61±.099 for Matemwe. What appear to be declining sea levels within intertidal zones (where seaweed farms are located) are in fact caused by sand deposition, which farmers attribute to the domination of the south-easterly winds over north-easterly winds (see Chapter 5). For better growth and health, seaweed should remain under water at both high and low tides. In both the study sites, lower water levels in this zone, exposes seaweed to direct sunlight and the higher temperatures of shallow sea water, which affects the growth of seaweed, as a seaweed farmer from Matemwe commented:

“Massive sands have covered my seaweed blocks; as a result, the water level has fallen and thus seaweed is exposed to sunlight and warm water”.

A laboratory-based study to test the growth rate of two main species of seaweed grown in Zanzibar (*spinosum* and *cotonii*) in relation to temperature showed that the growth for *cotonii* was higher at 26°C and lower at 30°C (Sheikh *et al.* 2012). Plate 6.2 below shows bunches of *spinosum* seaweed affected by temperature during last summer (2012) in the southern region of Unguja. This demonstrates the fact that ENSO events, which are associated with the variability of sea surface temperature (SST), and variability in summer temperature as perceived by fishers, seaweed farmers and farmers (see Chapter 5) have significant impacts on the seaweed survival and growth.



Plate 6.2: Minister of Industry, Business and Markets together with a group of seaweed farmers in Uroa village (central district-North region of Unguja Island), showing bunches of seaweed that have changed colour to dark green, possibly as a result of increasing warming conditions during the previous summer (source: Ussi, 2012)

6.3.8.2 Risks and impacts of climate variability and change on seaweed blocks stability and production/yield

About 13% of the interviewed seaweed farmers in Kiuyu Mbuyuni and 28% in Matemwe perceived the variability in wind speed and direction to have had high impacts on the stability of the seaweed blocks. The mean score fell around 2 (moderate impact) in both sites (see Table 6.20). Seaweed farmers in both sites believed that both major wind patterns in Zanzibar (south- and north-easterly winds) at their peaks are capable of cutting seaweed branches and destroying the seaweed farms/blocks. With regard to seaweed production/yield, the majority of the seaweed farmers interviewed in Matemwe (51%) perceived the impact of climate variability on production as high, while only 16% in Kiuyu Mbuyuni did. The mean score was 2.05 ± 0.094 for Kiuyu Mbuyuni and 1.56 ± 0.096 for Matemwe. In reality, seaweed yield and production is highly dependent on seasons. The winter season locally known *mchoo* in Pemba and *pupwe* in Unguja (June-August), and associated south-easterly winds (*kusi*) produces favourable conditions for better yields and production. The comment from a Matemwe seaweed farmer supports this view:

“The intensity of wind during the winter season can wash away the seaweed branches, but this period (winter) is good for seaweed yield and production as temperatures become low”.

Apart from high yield, the winter season was also perceived to reduce the harvesting period, as demonstrated by the following testimony from Matemwe:

“During winter (kusi) we can harvest after just three spring tides (bamvua), but during summer we normally harvest after four spring tides or more”.

Across the sites, north-easterly winds (*kaskazi*) which blow toward the shore and are associated with warm conditions, are perceived to impact the growth of the weed as a seaweed farmer from Kiuyu commented:

“Apart from the heavy waves [they create] which cut and wash away seaweed, north-easterly winds are associated with warm conditions which affect the growth. We actually normally earn more money during the south-easterly wind season and associated cold than a north-easterly season and associated warm conditions”.

Unlike fishers, seaweed farmers want the domination of south-easterly winds (*kusi*) in wind patterns and associated winter weather (Chapter 5). It can be argued that the observed increase in temperature during winter and the predicted changes in both temperature and wind (see Chapter 5) are likely to affect this sector. The majority of the seaweed farmers interviewed in Matemwe perceived a greater impact of climate on production than those in Kiuyu, Pemba. In contrast, some Kiuyu Mbuyuni seaweed farmers believed that their production per block had increased tremendously after shifting from the area which was affected by declining sea levels due to sand deposition. This is highlighted in the following comment by a seaweed farmer in Kiuyu Mbuyuni:

“Previously we used to get a small amount of seaweed because most of our blocks were exposed to the sun due to deposition, but now we have moved into a bit deeper water and production has increased compared with those days”.

Figure 6.3 shows the fluctuation in overall production of seaweed in Zanzibar, with some relationship to the number of seaweed farmers. For example, in 2009 the total production declined although the number of the seaweed farmers increased in this period. By contrast, the production in 2010 was high with an increase in the number of seaweed farmers (Figure 6.3). A study by Msuya *et al.* (2007) cited in Lange and Jiddawi (2009) revealed that the average of production declined from 1.5 tons per farmer in 1991 to 0.5 tons in 2007. Given the observed high variability of temperature, rainfall, wind and sea level during the late stage of the last decade (Chapter 5), it appears that the observed increase in production in 2009-2010 may well be related to increasing numbers of seaweed farmers (Figure 6.4).

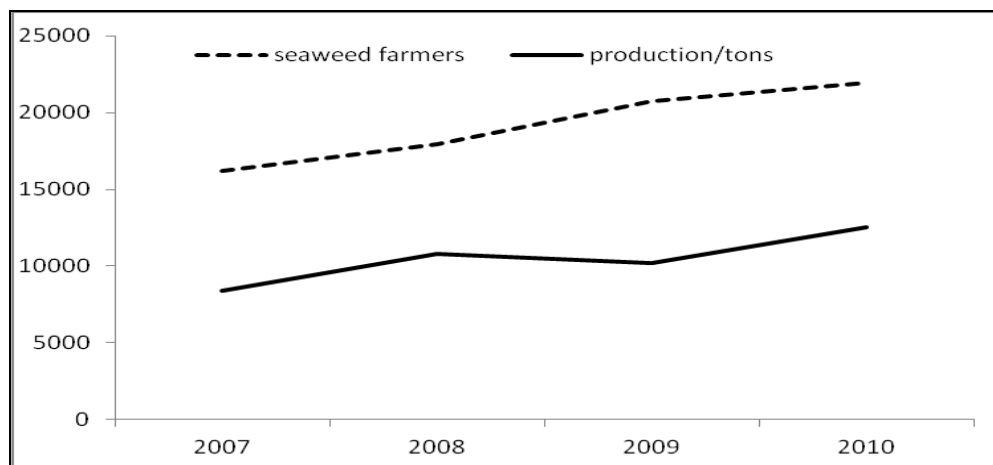


Figure 6.3: Relationship between seaweed production and seaweed farmers per year

6.3.9 Seaweed farmers' perceptions of risks and impacts related to other linked stressors and drivers of change on seaweed farming

Like fishing and farming, seaweed farmers also believed that the seaweed sector is exposed to both climate variability and other interacting stressors. The most cited stressors in both sites included low prices paid by the buyers, seaweed diseases and marine organisms, constant use of the same seaweed for planting, and constant farming (Table 6.21). Other stressors included lack of inputs, poverty, large number of farmers for the available area, tourism, and God's will.

With regard to the low price paid by the buyers, a large proportion of the seaweed farmers interviewed in Kiuyu Mbuyuni (38%) and Matemwe (33%) believed that the price of seaweed per kilogram (see section 6.3.7.3) constrained the development of the sector. Price was also ranked as a high-impact stressor in the sector (Table 6.22). As seaweed is considered an alternative source of income particularly among women, this globally influenced stressor impacts both households' economy and livelihoods. In fact, seaweed farmers considered price as more of an obstacle to seaweed farming than changing climate or sea level rise, as shown in this testimony from Matemwe, Unguja (also see section 6.3.7.3):

"We continue to plant seaweed only because we don't have options; the price is relatively small compared with the complex nature of the work" (see also section 6.3.7.3 for a detailed discussion of price).

About 25% of the interviewed seaweed farmers in Kiuyu Mbuyuni and 19% in Matemwe believed that seaweed diseases and marine organisms also affect seaweed. Some species of fish, such as spine foot (locally known as *tasi*) feed on seaweed, while green algae (locally known as '*mwani wa kijani*') covers seaweed blocks and disturbs the flow of air and light which are necessary for the successful growth of the seaweed. Green algae also affect seaweed farmers as it causes irritation when skin comes into contact with the algae. An interview with a key informant revealed that seaweed is also affected by epiphytes, especially in those areas close to the river streams that flow into the ocean because epiphytes thrive in areas with moderate salinity. In examining the adaptation of coastal communities to climate change in the Philippines, Campos (2010) found that in addition to climate variability, algae and epiphytes are additional stressors that affect seaweed farming.

Apart from marine organisms, constantly using the same seaweed for planting the next season was perceived to decrease yield in the long run. An interview with a key informant revealed that the perception of the farmers may be real as they have been using the same seaweed since its introduction in early 1990. Key informants who deal with marine products argue that, poor selection of seaweed cuts and extending the harvest period may result in low quality seaweed cuts for planting. With regard to constant farming, about 8% of the seaweed farmers interviewed in Kiuyu Mbuyuni and 16% in Matemwe believed that constant farming also affects the growth and the production of the seaweed. As on the farm-land, seaweed farmers believe that constant farming in one place also causes the fertility to deteriorate through sand deposition,

and the accumulation of sea grass and green algae. However, the increased number of seaweed farmers due to the lack of alternative sources of income (see Chapter 3), coupled with tourism pressure in the case of Matemwe, reduces land holding for underwater blocks, and thus farmers are forced to concentrate in one area for a longer period. About 10% of the respondents in Matemwe believed that tourism is a stressor for their seaweed activities and thus their livelihoods. As underwater seaweed blocks occupy the intertidal zones, the conflicts between seaweed farmers and hoteliers are common, section 6.3.7.1 of this Chapter clearly demonstrates the impact of tourism on seaweed farming in Matemwe. In Kiuyu Mbuyuni Pemba, 14% of the interviewed seaweed farmers perceived the increasing in their numbers which resulting in overcrowding between seaweed blocks as stressors for seaweed farming; this, situation was also observed by Campos (2010) in the Philippines.

Table 6.21: Perceived other linked stressors and drivers of change on seaweed farming

Stressors	Kiuyu Mbuyuni, Pemba (Nr=88) (%)	Matemwe, Unguja (Nr=145) (%)
Seaweed diseases and other organisms	25	19
Constant farming	8	16
Large number of farmers and closeness of the blocks	14	-
Lack of inputs and poverty	5	6
Low price of seaweed	38	33
God's will	-	1
Constant use of the same seaweed for planting	10	15
Tourism-related activities	-	10

Nr=Number of responses (Multiple-response question)

Table 6.22: The extent in which seaweed price affects seaweed farming

Stressor	Impact rank	Kiuyu Mbuyuni (N=42) (%)	Matemwe (N=24) (%)
Price/market failure	Rank 1	90	100
	Rank 2	10	0
	Rank 3	-	-

Rank 1 (high impact), rank 2 (moderate impact) and rank 3 (low impact)

6.4 CONCLUSIONS

This Chapter has explored the impacts of climate variability and change and other stressors as perceived and experienced by farmers, fishers and seaweed farmers on their activities. The findings correspond with similar findings in the region and at global scale that demonstrate that the most important sources of cash and food in the coastal areas, namely fishing and farming, are sensitive to the impacts of climate variability and other interacting stressors. This Chapter has clearly shown the impact of varying climate, particularly in temperature and sea level at the intertidal zones, on seaweed farming.

The results also illustrated that the existing context of these activities demonstrates the fact they are sensitive to their own set of characteristics. For example, low ownership of important assets such as vessels and gear was found to be one of the major sources of vulnerability among the fishers. The study found that income increased with increased ownerships of assets. Additionally, the size of the vessels used is also a source of vulnerability. Because of the small size of the vessels, fishing activities are controlled by the seasonality of winds patterns (north- and south-easterly winds) and fishing activities are limited to short distances. This adds more pressure to in-shore fishery resources and causes overfishing. With regard to farming, the findings show that the low input characteristics of rain-fed farming systems across the sites made farming particularly vulnerable to climate variability. Climate variability, which is associated with increased incidence of diseases and pests, negatively interacts with the low input nature of farming systems and causes high damage to livestock and crops. However, the low input character of farming across the sites may also be correlated with poor extension services and poverty. In terms of seaweed farming, the findings show that the small-scale and dynamic nature of intertidal zones where it is carried out influences sensitivity. Perhaps the most important characteristic of seaweed farming that affects the sector is the global nature of the seaweed business, which influences price; currently the price for seaweed paid by the buyers is too low for the complexity of the work involved.

With regard to climate variability and change, all three sectors (fishing, seaweed farming and farming) are influenced or controlled by the climate. Therefore, any variability would have a significant impact on these activities. A further decline in rainfall along the east coasts, particularly in the short-rain season and in winter, and an increase in warm conditions during summer and winter have compromised the ability of crops and livestock to survive, the performance of pasture, and production per farm plot. The variability in climate is also perceived to influence the incidence of pests and diseases that affect crops, animals and availability of food in the households (also see Chapter 3). Increasing deposits of sand in-shore, increasing warming conditions, coupled with human activities that threaten fishery habitats and breeding grounds, are perceived to have a great impact on the quantity of fish, fish stock distributions, and the types of fish caught. Species such *chanos chanos*/milk fish, bluefin travally, Indian mackerel, anchovies in the case of Kiuyu Mbuyuni, and spangled emperors, sharks and rays, spine foot and goat fish in Matemwe were perceived to have declined over time due to changes in the ocean attributed to both climate variability and human actions. In a similar manner, variability in temperature, falling seawater levels at the intertidal zones and the increasing intensity in wind patterns were found to impact seaweed survival and stability, growth, and production.

Furthermore, similarly to other studies the findings show that impacts from climate variability interact negatively with non-climate stressors, many of which operate beyond the control of the coastal communities and thus intensify their sensitivity to changes in climate. Even without climate variability,

stressors such as poor soils, lack of farming inputs, lack of support (e.g. means for tapping water for garden irrigation; livestock loans schemes), low access to soft loans and other financial capital, global market land fragmentation and increasing land value due to population increase and development are all heavily affecting farming systems, food security and livelihoods on the east coasts of both islands. With regard to fishing, stressors such as illegal methods of fishing, the increasing number of fishers, increasing foreign fishing fleets and increasing demand attributed to expansion of tourism and a growing middle class population, intensify the sensitivity of the fishery resources and fishers themselves. Furthermore, seaweed farming is already affected by constant farming attributed to the increasing a number of farmers, close proximity of the seaweed blocks, diseases and marine organisms. Tourism activities and low prices given to the farmers have been singled out as stressors with huge impacts on seaweed farming, households' savings and livelihoods across the sites.

However, it is important to note that there were varying perceptions related to variability in climate and sea level (Chapter 5) and perceptions of their associated risks and their interaction with other non-climate stressors (Chapter 6). As perceptions and knowledge are the biggest influencers of coping and adaptation, this variation is likely to trigger variations in adaptation and adaptation behaviours between individuals. Although the majority have perceived variations and associated risks, they lack a bigger picture of the situation and understanding of the root causes of variations in climate (Chapter 5). This again may present a barrier to adaptation and may result in only small behaviour changes within social system related to adaption.

The findings substantiate the fact that these three sectors are already vulnerable to a wide range of stressors, and, without adaptation, future climate change will intensify the situation and affect peoples' efforts to graduate from poverty. Current localised food shortages on the east coasts of both islands are associated with the sensitivity of fishing, farming and seaweed farming to multiple stressors because these activities are the sources of food and income, as activities beyond fishing and farming remain out of reach for the majority (see Chapter 3).

CHAPTER 7

COPING AND ADAPTIVE RESPONSES AMONGST EAST COAST FARMERS, FISHERS AND SEAWEED FARMERS TO CLIMATE VARIABILITY AND CHANGE AND BARRIERS TO RESPONDING

7.1 INTRODUCTION

7.1.1 An overview

Although seasonality and variability in climate is not a new phenomenon along the east coasts of both islands, the findings in Chapter 5 and 6 reveal that the variability in rainfall and sea level has intensified for at least the last decade, threatening coastal livelihoods. Thus, building on the previous two Chapters (5 and 6), this Chapter seeks to examine how farmers, seaweed farmers and fishers respond to the perceived risks and impacts of both climate and other interacting stressors. The Chapter also examines barriers to responses both within sectors (e.g. adjustments within fishing, seaweed farming and farming) and outside these sectors (e.g. alternative strategies). Lastly it examines where and why there has been discontinuance in some coping and adaptive strategies.

The Chapter starts with an overview of the concepts of coping and adaptation, followed by a focus on responses to climate change in farming and pastoral systems, fisheries and seaweed farming. This is followed by a discussion on what constitutes a barrier to adaptation. This preliminary overview provides a clear understanding of the concepts under discussion, which are elaborated on in a conceptual model developed to guide this Chapter. The second section deals with the specific methods used for data collection for this Chapter. The results and discussion section is divided into two main parts. The first part deals with the various coping and adaptation strategies used by farmers, fishers and seaweed farmers and the barriers that constrain adaptation at sector and household levels. The second part focuses on reasons for the discontinuance of adaptive options which were previously adopted by farmers, fishers and seaweed farmers to cope with climate variability and change and other stressors. The Chapter ends with a conclusion that summarises the major findings in relation to the literature.

7.1.2 Thinking about adaptation to climate variability and change and other linked stressors

Throughout human history, individual and local communities have coped and adapted to resource and climate irregularities (Adger *et al.* 2009; Orlove, 2005). Various empirical studies, including IPCC reports AR3 and AR4, show that current and future climate change impacts on fishing and agriculture can be significantly minimised through adaptation and taking advantage of the opportunities offered by a changing climate. Understanding how farmers and fishers cope and adapt to climate variability is crucial in order to develop intervention options that could assist them to graduate from vulnerability (Below *et al.* 2012) and build resilience to future changes in climate.

To understand adaptation processes at different levels of decision-making (e.g. individual, group and institution), various scholars working in climate change adaptation have tried to classify adaptation in various ways (see Chapter 1). For example, in terms of duration, adaptation can be either anticipatory also called strategic or reactive also known as tactical. Tactical adaptations are short-term strategies (the same as coping strategies) that are meant to solve the problem at that particular time, whilst strategic adaptation is a long-term strategy that can sustainably solve the problem in the future (Belliveau *et al.* 2011). For instance, planting and conserving fodder for livestock to be used during drought would be strategically adaptive, while moving livestock herds outside the grazing land to search for pastures in each and every dry spell could be called a reactive or tactical adaptation (see Box 7.1). Adaptation can also be either planned or autonomous in terms of management (Jones and Boyd, 2011; Belleveau *et al.* 2006; Grothmann and Patt, 2005; Orlove, 2005), and it also can be categorised based on the actors involved, such as private or public adaptation (Box 7.1; Table 7.2).

Box 7.1: Typology of adaptation

Anticipatory adaptation: Adaptation that takes place before impacts of climate change is observed; also referred to as proactive adaptation
Strategic: Long-term strategies that are meant to solve the problem permanently
Autonomous adaptation: Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems; also referred to as spontaneous adaptation
Planned adaptation: Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that the action is required to return to, maintain, or achieve a desired state
Private adaptation: Adaptation that is initiated and implemented by individuals, households or private companies; private adaptation is usually in the actor's rational self-interest
Public adaptation: Adaptation that is initiated and implemented by governments at all levels; public adaptation is usually directed at collective needs
Reactive adaptation: Adaptation that takes place after impacts of climate change have been observed
Tactical: Short-term responses that are meant to solve the problem at that particular time

Source: IPCC (2001), adapted from Huq *et al.* (2004:31) and Belliveau *et al.* (2011)

Furthermore, adaptation involves mental preparations (Grothmann and Patt, 2005; Kuruppu and Liverman, 2011) and a belief in climate risks (Blennow and Persson, 2009); it also involves utilisation of resources (Thornton and Manasfi, 2010). Indeed, the ability of any decision unit to adapt is influenced to a large extent by existing capital stocks and access to these (see Chapter 3; Adger, 2003; Islam *et al.* 2011). Using case studies from south-east Asia and the Caribbean, Adger (2003) found that social capital (collective actions) in both private and public institutions of coastal and marine resources management is crucial in building adaptive behaviour and resilience in the face of climate change risks. Adaptation of a community or an individual in response to climate variability is a dynamic process which involves a set of diverse and intersecting factors that may take place autonomously or through planning (Thornton and Manasfi, 2010). For example, mental preparation and belief in risks alone may not be enough to motivate adaptation if there

are no means to do this. A fisher would not shift from foot fishing to vessel fishing if there are no resources to acquire a vessel, even if he perceived a decline in the fish catch in the area close to the shore (see section 7.1.3).

7.1.2.1 Responses in farming and pastoral systems

Small holder farmers and livestock keepers are constantly affected by a wide range of climate variability impacts and extreme weather but they often adapt to manage the resulting impacts (Morton, 2007; Chapter 6). In the Niger Delta, which is exposed to both climate variability and environmental degradation as a result of the oil and gas industry, farmers were found to delay their planting time and grow fast-maturing varieties of maize and cassava to cope with declining rainfall and variability (Uyigue and Agho, 2007). In the Sahel part of Nigeria, farmers increased livestock-crops (mixed farming) integration, increased farming inputs (including labour), and diversified their livelihoods as responses to increasing variability in climate (Mortimore and Adams, 2001). In Kenya, small-scale farmers changed crop varieties and planting dates, planted trees, decreased the number of livestock, implemented soil water management and changed fertilizer application in order to cope and adapt to climate variability and other stressors (Bryan *et al.* 2010). Similarly, proactive adjustments like planting trees, soil conservation, changing planting dates, and irrigation were observed in South Africa and Ethiopia (Bryan *et al.* 2009) and other parts of the developing world (Morton, 2007).

In temperate and cooler regions, farmers adopt various strategies to adapt to variability and extremes. Table 7.1, adapted from Belliveau *et al.* (2011) shows some examples of adaptations by grape farmers in the Okanagan Valley in Canada, which range from tactical to anticipatory responses. Probably the most strategic option identified by Belliveau *et al.* (2011) is insurance to cope with crop damage as the result of fire and extreme frost. However, crop insurance to manage the ex-post impact of climate variability and hazards is not common in Africa. A study by Notenbaert *et al.* (2010) in the Great Horn of Africa, argues that apart from livelihood diversification, livestock insurance would also be viable as it offers an opportunity for protecting assets.

In a typical pastoral environment in Sahel Africa, pastoralists have had to cope and adapt to the increasing variability of rainfall and expansion of arid conditions. Morton (2006) cited in Morton (2007) identified the various coping strategies employed by pastoralists in northern Kenya and southern Ethiopia during recent droughts. These included mobility; herd accumulation; keeping multiple species with varying resilience through different ecological niches; informal savings; use of supplementary feed, and livelihood diversification (also see Notenbaert *et al.* 2010). In small island developing states (SIDSs) where water is always scarce, farmers and households used various adaptation measures to cope with variability. For example, in Kiribati (Pacific Island), rainwater harvesting is widely used to cope with declining rainfall

(Kuruppu and Liverman, 2011), while at national level, land-use planning is practiced in SIDSs to cope with climate change coupled with population pressures.

Table 7.1: Adaptations employed by grape framers to manage risks identified in bad years

Type of adaptation	Source of risks both climatic and non-climatic	Example of adaptation
Tactical, reactive	Cold, wet season	Thin fruit or 'drop crops' ; lighten canopy to dry; make sparkling wine; drop the price of the wine
	Frost and winter	Claim crop insurance
	Smoke damage (forest fire)	Claim crop insurance Reverse osmosis
	Low tourism	Sell more aggressively in other market channels
Tactical, anticipatory	Frost	Turn on wind machine
	Winter	Irrigate the vineyard
	Extreme heat	
	Powdery mildew	Spray routinely with sulphur
Strategic, reactive	Technological failure	Replace manual water pump with automatic pump
Strategic, anticipatory	Frost	Select of early maturing variety Select site; purchase crop insurance
	Winter pests	Purchase crop insurance Integrate pest management Plant varieties on grafted rootstock

Adapted from Belliveau *et al.* (2006:371)

7.1.2.2 Responses in fishing and seaweed farming

Fisheries and seaweed farming are also exposed to variability in climate, seasonality and extreme events (Chapter 5 and 6), and fishers and seaweed farmers must adapt and manage the impact both in the field and at household level. With regard to fishing, a study by Nagy *et al.* (2009b) showed that fishers in the Rio de la Plata, South America, used a wide range of coping strategies ranging from reactive to planned private strategies, such as long-term migration to cope with declining fish catches attributed to ENSO events. In a similar manner, in west and central Africa, small-scale fishers tend to migrate from one village to the other in response to coastal and marine changes (Njock and Westlund, 2010). Temporary migration, locally known as *dago*, within islands or to the mainland coast is also common in Zanzibar, in order to cope with the normal variability of wind patterns and reduced yield. Fishers' mobility in response to declining to fish catches has also been observed in the islands of Indonesia (Musa *et al.* (nd) cited in Allison and Ellis, 2001) and African inland fisheries (Sarch and Allison, 2000).

Like small-scale farmers, fishers also diversify their livelihood portfolio to cope with seasonality or declining catches. For example, in Patos Lagoon, Brazil, livelihoods diversification amongst fishers during bad seasons is a major adaptation measure used by small-scale fishers (Kalikoski *et al.* 2010). According to Kalikoski *et al.* (2010), fishers who managed to diversify their portfolio during unfavourable seasons or exit fishing for off-fishing activities as suggested by FAO (2008) (Table 7.2), were better off than those fishers who did nothing. In the Lake Victoria region a combination of fishing, farming and livestock rearing is a common adaptive strategy to cope with the trends and seasonality across these sectors (Geheb *et al.* 1997

cited in Allison and Ellis, 2001). Furthermore, despite being itself prone to sea level rise and local variability, aquaculture as a strategic adaptation has the potential to improve the livelihood status of coastal communities all over Asia (Minh *et al.* 2009), and at the same time, reduce the pressure on marine resources. In the Pacific, studies have shown that the sustainability of coastal and marine resources can only be achieved through diversification of livelihood portfolios to reduce the pressure exerted by an increasing population which depend solely on utilisation of these resources (Kronen *et al.* 2010). Drawing from numerous studies, FAO (2008) suggested several potential public and private adaptation measures to deal with climate change and other linked stressors such as increasing population. These include livelihood diversity, increased efforts (e.g. time spent, modern gear), and improved vessels, weather warning systems and exiting fishing (looking for an alternative source of income) among others see Table 7.2. To exit fishing is not an easy process for anyone as this is affected by multiple factors at varying scales (Daw *et al.* 2012; Cinner *et al.* 2008; Coulthard, 2012). Daw and colleagues, in their extensive study in Kenya, Tanzania, Seychelles, Mauritius, and Madagascar which examined the willingness of fishers to leave fishing, found that only fishers with high livelihood diversity in their household were willing to exit fishing. Additionally, fishers characterised by low value fish catches were also willing to exit fishing and find alternatives (Daw *et al.* 2012).

Table 7.2: Examples of potential adaptation measures in fisheries

Impact of climate change on fisheries	Potential adaptation measure	Responsibility	Reactive/anticipatory
Reduced yield	Access higher value markets/ fishing target species Increase efforts Diversify livelihood Exit fishery	Public/private Private Private Private Private	Either Either Either Either Either
Increased variability of yield	Diversify livelihood portfolio Insurance scheme	Private Public	Either Anticipatory
Reduced profitability	Exit fishery	Private	Either
Changes in distribution of fisheries	Migration of fishing efforts/ strategies and processing/distribution facilities	Private/public	Either
Increased danger of fishing	Establish weather warning systems Invest in improved vessels Ensure stability/ safety/ communication	Public Private	Anticipatory Anticipatory
Influx of new fishers	Support existing local management institutions/ diversify livelihood portfolio	Public	Either

Source: FAO (2008)

Very little has been written on the vulnerability and adaptation of seaweed farmers to climate variability and other stressors. Like aquaculture, seaweed farming is viewed as a means of livelihood diversification and one which reduces pressure on marine resources (Sievanen *et al.* 2005; Marschke and Berkes, 2006). However, as discussed in the previous chapters the sector itself is vulnerable to variability in sea surface temperature, atmospheric temperature, wind and rainfall (see Chapters 5 and 6), and linked stressors such as low price and reliable market (de la Torre-Castro and Lindstrom, 2010; Sadallah, 2013), intertidal property

right problems caused by increasing numbers of farmers and the expansion of tourism activities (Mohammed and Jiddawi, 1999), low access to both formal and informal financial services (Eklund and Patterson, 1992) and seaweed diseases (Ronnback *et al.* 2002). In examining how coastal communities in the Philippines adapted to the impact of climate change (Campos, 2010) identified various adaptation strategies used by seaweed farmers to adapt to both climate and non-climate factors. These include removing algae, epiphytes and mud that can cause seaweed diseases and shifting their seaweed plots from crowded to less crowded zones where water moves freely. Other options include “harvest plants as soon as diseases occur” and lower the ropes further down “from the water surface to prevent too much exposure to sunlight, especially during low tides” (Campos, 2010).

7.1.3 Understanding barriers to adaptation

During the second half of the last decade, a number of researchers questioned why some people do not adapt when they may have everything (technology, institutions, technology, human capital etc.) that could help them to adapt. In answer to this question, various studies revealed that individual motivation to adapt is influenced by a wide range of factors, ranging from financial and social capabilities to cognitive and physiological factors (see Grothmann and Patt, 2005; Adger *et al.* 2009; Gifford, 2011). These factors are collectively termed limits and barriers to adaptation (Adger *et al.* 2009; Jones, 2010; Jones and Boyd, 2011; Nielsen and Reenberg, 2010). Limits are defined as obstacles that tend to be obsolete in the real sense and constitute thresholds beyond which existing activities, land uses, ecosystems, species, sustenance, or system state cannot be maintained, not even in a modified fashion (Nielsen and Reenberg, 2010 cited in Moser and Ekstrom, 2010: 1), whilst barriers are defined as obstacles that can be overcome with a concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc. (Moser and Ekstrom, 2010:2).

In examining social barriers in western Nepal, Jones and Boyd (2011) identified three main categories of limits and barriers, namely social, natural, and human-informational. This Chapter focuses on social and human-informational barriers as this study is centred on the human side of coupled human-environmental systems (see Chapter 1). Social barriers are endogenous to societies and are related to individual and social factors that may hold back or delay the decision of an individual or community to adapt to climate change. These include cognitive factors, institutions, individual characteristics, perceptions of risk, culture and beliefs, and ethics (Jones and Boyd, 2011; Nielsen and Reenberg, 2010; Adger *et al.* 2009). A study by Adger *et al.* (2009) also shows that social barriers such as culture, ethics and knowledge among others, also constrain decisions to adapt (Chapter 1; also see Bunce *et al.* 2010; Jones and Boyd, 2011). For example, unwillingness to deviate from culture has constrained local people in northern Burkina Faso to diversify their livelihoods through actions like migration to cope with declining rainfall (Nielsen and Reenberg,

2010), while in Nepal, discrimination through the caste system has reduced access to important assets for adaptation amongst the discriminated segment of the population (Jones and Boyd, 2011).

With regard to cognitive factors, it is now recognised that adaptation can also be constrained if, for example, an individual or community does not perceive the risk as great enough to their livelihoods (Jones and Boyd, 2011; Adger *et al.* 2009; Nurse-Bray *et al.* 2012; Grothmann and Patt, 2005; Kuruppu and Liverman, 2011). Similarly, if an individual farmer or fisher associates climate variability risks with the power of God he may also lack the motivation to respond. Furthermore, Gifford (2011) produced a wide array of what he called “psychological barriers” that hold back a decision unit (e.g. farmer, seaweed farmer, fisher and household) from changing their behaviour. These include limited cognition (e.g. ignorance, environmental numbness, and uncertainty), ideologies, comparison with others (e.g. social comparisons, social norms and networks), discredence (e.g. denial and mistrust) and perceived risks.

Human-informational barriers include financial costs of adaptation, development, diffusion and adoption of technologies, lack of or low levels of information amongst policy and decision makers, and uncertainty around climate change (Jones and Boyd 2011; Jones, 2010; Huang *et al.* 2011). Indeed, ambiguity and uncertainty of weather predictions particularly in developing countries is a major barrier. For instance, Patt and Gwata (2002) found that the legitimacy and credibility of the seasonal forecast among local farmers had declined to the lowest level due to the frequency of inaccurate predictions in rural Zimbabwe. This is quite challenging as the financial capacity of these countries to invest in high quality technology for weather forecast and predictions is very low.

Other studies showed a wide range of barriers ranging from financial to social that hold back fisher’s and farmer’s motivation to adapt. Anwar *et al.* (2012) identified barriers such as “misinformation about climate change, lack of coordination in forging partnerships, farmer’s reluctance to adopt climate change, and uncertainty of effective solutions to climate change”. Barros (2009) in the Pampas belt of Argentina found that low awareness regarding rainfall and precipitation trends, attributed to the slow nature of seasonal and decadal variability, acted as a barrier for the farmers to adapt. Further, using the sustainable livelihood framework (SLF), Osman-Elasha *et al.* (2009) identified various barriers that constrain adaptation in the north Kordofan state of South Sudan. These included conflicts over resources, lack of financial resources, civil war, social conflicts and brain drain amongst others. In the Lake Victoria regions especially in Tanzania, a study by Yanda *et al.* (2009) found that absence of adequate early warning systems and the lack of people’s awareness to climate sensitive diseases such as cholera and malaria constrained adaptation strategies. With regard to fishing, a study by Nagy *et al.* (2009b), showed that fisher’s migration (seasonal, relocation of fishing sites and spontaneous) as a coping strategy for ENSO events and other trends is constrained by climate uncertainty.

The foregoing discussion demonstrates the fact that the motivation and decision of an individual and household to adapt to climate change is influenced not only by adaptive capacity (e.g. technologies, economies, knowledge, capital stocks and capital access), but also by social and cognitive factors (Grothmann and Patt, 2005; Adger *et al.* 2009; Gifford, 2011). This is mainly because social and cognitive factors interact with other factors such as technology, capital stocks and access (see Chapter 3) to facilitate the adaptation processes. It can be argued therefore, that the degree to which an impediment to adapt becomes either a limit or a barrier, will vary between individuals and within communities. Vulnerability levels between farmers, seaweed farmers and fishers will vary as well, depending on the capacity of an individual or society to overcome these barriers through enough political will, social support, resources, social learning and effort.

7.1.4 Adaptation framework

Drawing on various literatures, I have developed an explanatory framework (Figure 7.1) to help explain adaptation amongst farmers, seaweed farmers, fishers and households to climate change and other linked stressors. This framework is extended from the conceptual model introduced in Chapter 1 and only conceptualises the adaptation components. The model shows that coastal and marine resources and associated livelihoods (B) are exposed to climate variability and change, and other linked stressors (A). The decision of a decision unit (C) (crop and livestock farmers, seaweed farmers, fishers and households) to cope and adapt to the risks related to climate change and other linked stressors (see Chapters 5 and 6) is influenced by barriers. Individuals or households need to overcome these barriers designated as D1 and D2. D1 comprises barriers such as social, cognitive and human informational whereas D2 involves capital stocks and access to these. The latter relates to the extent an individual or household is able to access and utilise various capitals (natural, social, financial, human and physical) (see Chapter 3).

The successful coping and adaptation to multiple stressors is influenced by the degree into which a decision unit manages to overcome the barriers and the outcome of this is designated by (E1, E2, E3, E4 and E5). E1 represents successful long term adaptation. Most of the carefully planned strategic adaptation falls under this category. For example with regard to fishing, strategic adaptation such as increasing physical capital ownership of vessels can be considered as a long term adaptation. E2 represents short term adaptation or coping. For example harvesting seaweed once affected by diseases or collecting pasture from different localities to cope with unexpected dry condition can fall under this category. E3 represents local responses that should be long term but are discontinued after being affected by barriers or other factors such as loss of assets forcing adopters to discontinue the adopted option. E4 represents maladaptation. Some adaptive strategies, such as illegal methods of fishing to cope with declining fish stock or inavailability of proper fishing gear and quarrying on farm lands to cope with poor yield can be considered to be maladaptive as they may compromise the sustainability of resources on which future adaptations are based. Outcome E5

represents “do nothing”. Failure to overcome barriers (D1 and D2) is likely to generate a ‘do nothing’ response in a segment of the population. This outcome is attributed to the lack of means to adapt or poor understanding of the dynamic nature of the risks faced from both climate and non-climate stressors.

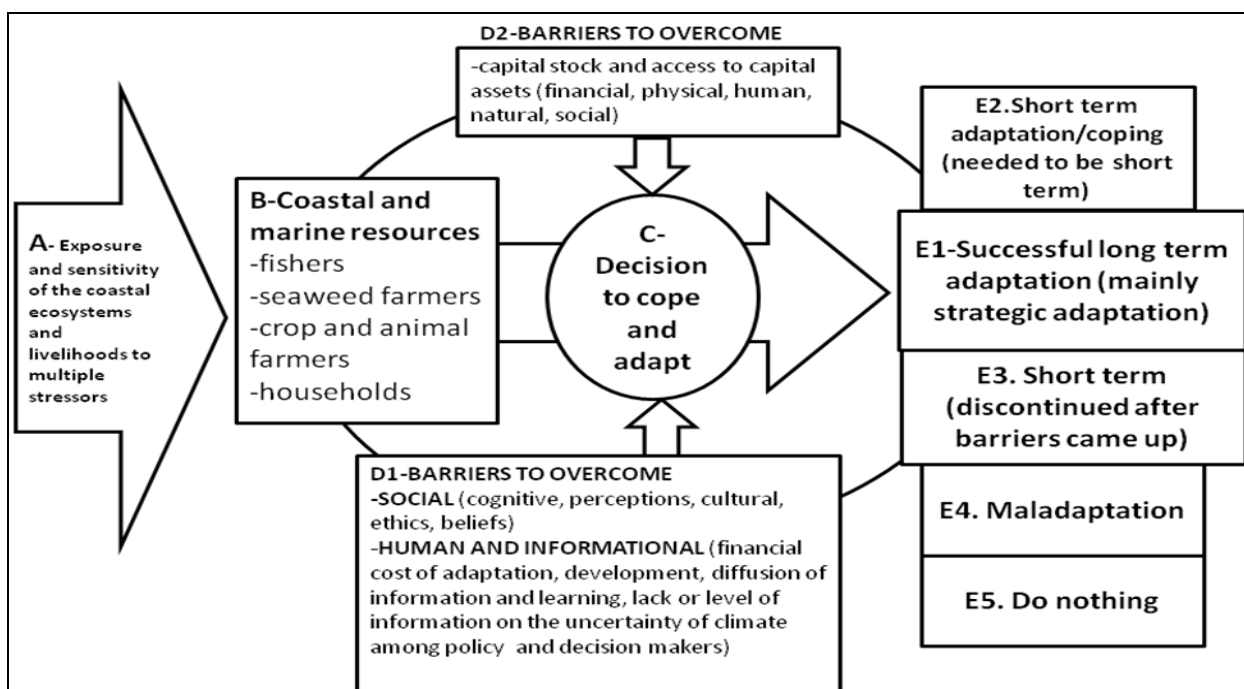


Figure 7.1: Adaptation framework

7.2 METHODS

As in Chapters 5 and 6, this Chapter combines data from various sources. A major source of information was a perception and adaption survey which consisted of three sets of interviews with farmers, fishers and seaweed farmers. Other data were obtained through (PLA) (see Chapter 2 for the detailed description of techniques used in PLA) and key informant interviews.

In the survey, three major areas were explored to demonstrate the nature of coping and adaptation to perceived climate variability and change and other linked stressors across the sites. These were: identification of coping and adaptation strategies for each sector (farming, fishing and seaweed farming), the barriers blocking adaptation responses within the sector and at household level, and the reasons for discontinuing particular adaptation actions. With regard to adaptation, farmers, fishers and seaweed farmers were asked to identify actions and strategies used to cope with a wide range of climate and non-climate stressors. The percentage of respondents mentioning specific strategies across the study sites and sectors was determined. In terms of barriers to adaptation, respondents were asked two questions: firstly, whether there were adaptive options at both sector and household level that they would wish to adopt; and secondly, they were asked to identify barriers that constrained them from adopting these responses. The percentages of responses to both questions were determined.

With regard to discontinuing adaptation, respondents across the study sites and sectors were also asked two questions; firstly, whether they had discontinued any previously adopted adaptation options; secondly, respondents who answered “yes” were asked to identify the strategies that they had discontinued and the reasons for the discontinuance. The percentages of the responses were determined. Furthermore, like in other chapters additional comments given by respondents during the administration of the survey, interviews and PLA workshops were used as quotes to explain some of the findings.

7.3 RESULTS AND DISCUSSION

7.3.1. Coping and adaptation in the farming sector

The adaptive options cited in Table 7.3 ranged from tactical-reactive to strategic adaptation (see Box 7.1) and included the use of fast-maturing crop varieties, intercropping and mixed farming. About 18% of farmers in Kiuyu Mbuyuni and 22% in Matemwe used fast-maturing varieties of maize; cowpeas and millet to cope with dry spells and variability in the onset of the rainfall season (see Chapter 5 and 6). It was reported during PLA workshops for example, that farmers used maize seeds that can be harvested after 90 days and cowpeas after 60 days. With regard to mixed farming, 38% of interviewed farmers in Kiuyu Mbuyuni and 28% in Matemwe used mixed farming to cope with poor soil quality. Mixed farming in this context involves a combination of livestock and crops and is a common method along the east coasts of both islands (see Chapter 6). About 30% of the farmers interviewed in Kiuyu Mbuyuni and 22% in Matemwe indicated that within the farm plot, they planted many types of crops with varying resilience to pests, diseases and rainfall, to ensure a constant flow of food.

Furthermore, 10% of the interviewed farmers in Kiuyu Mbuyuni and 15% in Matemwe still used shifting cultivation to cope with low quality soil, while 6% used crop rotation for similar purposes and to deal with variable rainfall. In the past, shifting cultivation was a common method of farming along the east coasts of both islands due to low population and poor soils (Singer, 1996). However, as population increased, villages expanded and the demand for land increased, partly due to the expansion of the tourism industry, shifting cultivation has been discouraged (see Chapter 6; Box 7.2). Other adaptive strategies to cope with dry spells cited only in Matemwe included the use of irrigation using water from stand pipes (cited by 3% of the respondents), dumping food-related waste on the homestead garden plots to increase soil fertility and “do nothing” (6%). The use of irrigation was only cited in Matemwe, probably due to the fact that farm plots are located very far from settlement in Kiuyu Mbuyuni where stand pipes are available, whereas in Matemwe some farm plots are located close to the homestead and thus had access to the piped water. However, using water from stand pipes to irrigate home gardens has been banned by the authority responsible for water supply in both islands. Similarly, dumping food waste on the farm plots to increase fertility is only cited in Matemwe where some of the farm plots are close to the settlement. This is possible in Matemwe, because of scattered nature of the settlement. The “do nothing” responses may be influenced

by lack of knowledge (Gifford, 2011) or because they do not believe that the climate is varied (see Figure 7.1). For decades, farmers along the east coasts of Zanzibar have coped and adapted to the double difficulties of variable rainfall and poor soil quality (see Chapters 5 and 6). As a result, the most-cited adaptive strategies meant to cope with these two variables were autonomous-strategic (Table 7.3 and Figure 7.1).

Table 7.3: Adaptation strategies identified by farmers

Coping and adaptation	Kiuyu Mbuyuni, Pemba (n=47) (%)	Matemwe, Unguja (n=47) (%)
Fast-maturing crops	18	22
Intercropping	30	22
Mixed farming	38	28
Irrigation	-	3
Shifting cultivation	10	15
Crop rotation	6	6
Do nothing	-	6
Dumping food waste on the homestead garden plot	-	1

Adaptive strategies not cited in Table 7.3, but observed and cited during the various workshops, included the use of baobab leaves as fodder, collecting grass outside the area, migrating with animals to look for pasture, and planting trees with leaves suitable for fodder. These are strategies used to respond to climate variability which adversely affects the local pasture (also see Chapter 6). This is also demonstrated in the following comments made by livestock keepers in Kiuyu Mbuyuni, Pemba:

“I have never sold or lost my cattle due to dry spells which adversely affect grazing land in our area. My cattle survived various dry spells before, because I used to go out of this area by bicycle to the areas which experience rainfall regularly to collect fodder for my cattle”.

“During drought, livestock suffered a lot due to lack of grass. Some of the livestock keepers go to other places to collect grass for their cattle. Some people perform a short-term migration with their cattle to the west or central corridor where rainfall is readily available until the situation becomes better. To migrate is not the only solution for me. I have planted indigenous trees (locally known as mkone) with edible leaves for cattle”.

Baobab trees are a common tree species across the sites and are little affected by declining rainfall or drought. Across the sites, the majority of the baobab trees had their branches lopped, which demonstrates the use of their leaves as fodder during dry spells. Another tactical strategy used by livestock keepers in response to the increasing salinity content in the caves and wells during dry spells was to use tap water where available (see Chapter 3). On the other hand, local farmers believe that the problem of rats intensifies during dry spells as wild food for rats is also affected (see Chapter 6). As a result farmers, particularly in Matemwe, use poison and traps to fight rats which affect crops such as yam (*viazi vikuu*), cassava and maize. These two strategies can be classified as short-term or tactical-reactive and are only used when the

problem occurs (Figure 7.1). Furthermore, although both sites traditionally experience low rainfall, and despite the current observed variability of rainfall, especially during the short-rain and winter seasons (Chapter 5), it is possible to harvest rainwater during the long rain season. However, local communities have no means of capturing rainwater for farming (see Chapter 4). The findings also demonstrate the problem of lack of support, which participants from all three sectors identified as a barrier to adaptation (see section 7.3.2). The situation was stated like this by a farmer from Kiuyu Mbuyuni:

“If the government brings water to our fields we would be able to cultivate vegetables and increase our income”.

Some of the findings mirror those of other studies conducted in Africa and other developing countries (see section 7.1.2.1; Roncoli *et al* 2001; Bryan *et al.* 2010; Lacy *et al.* 2006; Reenberg *et al.* 1998; Reenberg, 1994; Thomas *et al.* 2007; Bryan *et al.* 2009). Additionally, in response to changing precipitation trends in South Africa, farmers reduced cropping efforts and concentrated on livestock (Thomas *et al.* 2007). Since COP 15 in Copenhagen, micro-insurance for local adaptation has been considered as a potential adaptation option, but whether it can be applied to the poor farmers in the south with high levels of climate uncertainty is still uncertain (Suarez and Linnerooth-Bayer, 2010). According to Suarez and Linnerooth-Bayer (2010), few pilot projects of micro-insurance funded by the World Bank have started in Africa. Although financial capital is not the only thing that determines successful long-term adaptation (see Figure 7.1), farmers in the developed world are expected to have a higher adaptive capacity than the poorest farmers in the developing world, including Zanzibar.

7.3.2 Barriers to adaptation inside and outside of the farming sector

Respondents were asked if there were other options they would like to adopt both at the farm and household levels in order to cope and adapt to climate variability and other stressors but were prevented by barriers. The results in Figure 7.2 show that 38% of the interviewed farmers in Kiuyu Mbuyuni and the majority of the respondents in Matemwe answered “yes”. The difference between sites could be influenced by a limited options and lack of awareness on what else people can do to adapt particularly in Kiuyu Mbuyuni. Being a typical remote rural village, Kiuyu Mbuyuni had less options compared to Matemwe which has good transport networks (roads) and options within the tourism sector. Indeed if the two islands are compared, Unguja is more developed than Pemba Island.

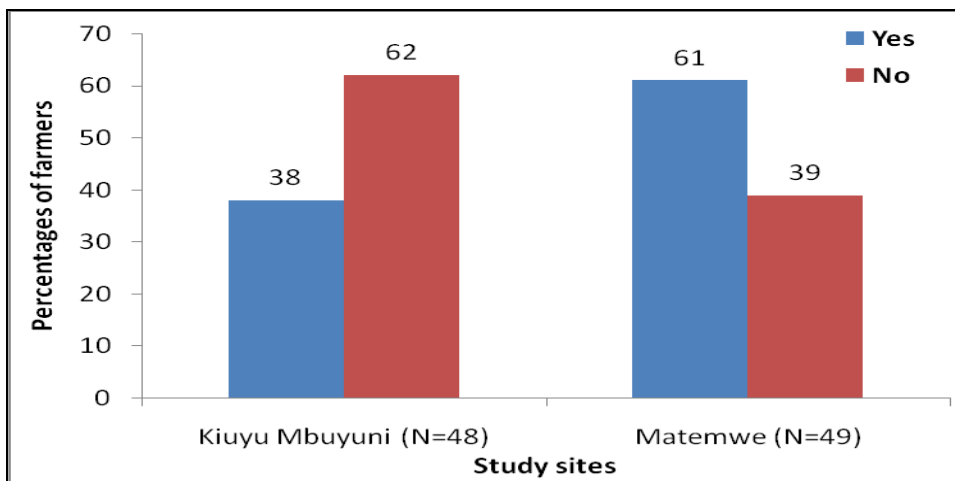


Figure 7.2: Percentages of farmers responding to a question whether there is an adaptive option on- and off- the farming sector they would wish to adopt to cope with climate variability and linked stressors

Amongst farmers who answered “yes”, 33% in Kiuyu Mbuyuni and only 4% in Matemwe wished to plant trees, but were prevented from doing so because seedlings were unavailable (Table 7.4). The big difference between sites is probably influenced by the fact that in Kiuyu Mbuyuni people are more aware of the benefits of trees as they already enjoy many of these (firewood, seaweed pegs, and alternative fodder) from the planted trees outside the village. This difference may also be influenced by the fact that in Kiuyu Mbuyuni, leaves of some planted trees are used as alternative sources of fodder for livestock (see Section 7.3.1). Another adaptive option cited in both sites is irrigation to cope with dry spells and variability in rainfall. This option was mentioned by 7% of the respondents in Kiuyu Mbuyuni and 20% in Matemwe. However, barriers such as low levels of assistance, poor water supply infrastructure (Chapter 4) and the lack of rural electrification bar farmers from adopting an irrigation system for their farming activities. Local people believe that some of the coral caves contain available water with a low salinity content that can be used for irrigation. In areas with unreliable rainfall and with soils with a low capacity for water retention like these, support in the form of rainwater harvesting, access to irrigation facilities (drip system of irrigation), and agricultural inputs would help to increase farming resilience. It has been indicated that the survival of the farming groups, especially those related to vegetable farming, are threatened by unreliable rainfall coupled with lack of access to technologies or mechanisms that will help farmers to tap other sources of water. The results corroborate the findings in Chapter 4 (water security section) which showed that access to water for both households and farming needs is constrained by poor rural electrification, among other things. People across the sites are certain that the availability of water to irrigate their gardens would improve their food security.

Table 7.4: Potential adaptation options that farmers would like to adopt inside and outside of the farming sector, and barriers to this

Adaptations	Kiuyu Mbuyuni (N=15) (%)	Matemwe (N=26) (%)	Barriers
Tree planting	33	4	No seedlings for trees
Irrigation farming	7	20	No assistance, poverty, no rural electrification
Small business	40	23	Capital
Sea weed farming	13	19	Old age, social status
Cutting firewood	7	-	Conservation
Use of fertilizers/insecticides	-	20	Poverty
Keeping livestock and poultry	-	8	Initial capital, poverty,
Employment	-	8	No opportunities, education

Other farming-level adaptation options which were only cited in Matemwe, were using fertilisers, pesticides and insecticides (20%) to cope with declining fertility, and keeping livestock (8%) to increase capital stocks and to access manure, crucial to improve soil fertility (Table 7.4). However, these farmers identified barriers to these options such as poverty for the former and lack of initial capital and poverty for the latter. Regarding the use of fertilisers, pesticides and insecticides, results in Chapter 6 revealed that, even with subsidies, farmers could not afford to buy these important farming inputs.

At the off-farm level, farmers wished to diversify their livelihood portfolio but again, to do this, they would have to overcome a wide range of barriers. The results in Table 7.4 show that 32% of the respondents in Kiuyu Mbuyuni and 41% in Matemwe wished to establish small businesses but they were constrained by lack of capital and business skills. Lack of initial capital could be linked to low access to cash due to low savings and low participation in cooperative and saving groups (see Chapter 3). Since seaweed farming is viewed as an alternative source of income along the coast in Zanzibar, 13% of the respondents in Kiuyu Mbuyuni and 19% in Matemwe wished to engage in seaweed farming. Old age (individual factor) and social status were cited as barriers to this. Since its inception in the early 90s, seaweed farming in Zanzibar has been viewed as a woman's occupation. Despite increasing popularity of seaweed farming among males due to unreliability of other livelihoods (farming and fishing), some respondents were still unwilling to cross this social norm. A further 8% of the respondents in Matemwe wished to look for formal employment in order to cope with variability in climate and unreliability of fishing and farming, but a lack of job opportunities and illiteracy barred them from finding employment. Across the sites, illiteracy was found to be high (see Chapter 3) which diminished a persons' opportunities for employment in both the formal and informal sectors.

Generally, the findings show that more farmers in Matemwe, Unguja wished to adopt various adaption options (on- and off-farm) than in Kiuyu Mbuyuni, in order to adapt to climate variability and other linked stressors, but were restricted by a number of barriers. Low capital stocks, access to financial assets and lack of support made it difficult to adapt (Chapter 3 and Figure 7.1). As a result, local people diversify more within natural resource-based activities rather than outside of these (see Chapter 3), which makes them susceptible to the predicted changes in both climate and sea level (see Chapter 5). A study by Bryan *et al.* (2009) revealed that the decisions of farmers to adapt were hindered by poverty and a lack of access to credit, extension services, climate information, government support and access to fertile land. In Zanzibar a study by Mohamed (2003) found an inadequate flow of credit to the smallholder farmers and artisanal fishers from the existing banking system, while micro-credit through government institutions was not sufficient (also see Chapter 3).

7.3.3 Coping and adaptation in the fisheries sector

About one third of fishers across the study sites were doing nothing to respond to the perceived decline of fish catches (see Chapter 6). About 34% of the respondents in Kiuyu Mbuyuni and 37% in Matemwe were found to be unwilling to adapt or did not know how to adapt (Table 7.5). However, ‘do nothing’ is a choice that an individual makes and in this study is categorised as one form of response (Figure 7.1). Apart from doing nothing responses, Table 7.5 presents various adaptive options. The most common options included the use of a variety of fishing methods, changing to different fishing grounds, and shifting to motorised boats. About 32% of respondents in Kiuyu Mbuyuni and 17% in Matemwe used a variety of methods during a single fishing trip or shifted from one method to another, based on the season, to maximise their catch. About 14% of the fishers interviewed in Kiuyu Mbuyuni and 2% in Matemwe regularly changed fishing grounds. The small number of fishers in Matemwe who regularly change fishing grounds may be caused by the existing marine conservation area nearby which seriously reduced their access to key fishing grounds (see Chapter 6). Furthermore, about 6% of fishers in Kiuyu Mbuyuni and 2% in Matemwe (Table 7.5) shifted from either foot-fishing or small vessels (outrigger and dugout canoes) to motorised boats to increase the ability to reach distant off-shore sites. Such a move demonstrates that the fishing grounds in-shore have already deteriorated and the majority of foot fishers would wish to obtain vessels that will take them off-shore. Similarly, about 4% of the fishers in Kiuyu Mbuyuni and 2% in Matemwe collectively pooled their resources and built their own vessels. This again demonstrates the power of social capital in influencing the access to other capitals. It is evident that increasing ownership of fishing assets such as vessels is likely to increase disposable income amongst fishers. All these adaptive strategies were autonomous; i.e. they were fishers’ own attempts to cope with the perceived decline of fishery resources (see Box 7.1).

Table 7.5: Adaptation strategies identified by fishers

Adaptation strategies	Kiuyu (N=50) (%)	Matemwe (N=46) (%)
Do nothing	34	37
Increase the number of hooks per line	-	6
Use GPS	-	6
Use a variety of methods	32	17
Change fishing grounds	14	2
Change to motorised boat	6	2
Change to octopus catching	4	2
Use refrigeration	-	2
Build own dhow with fellow fishers	4	2
Increase depth for walking fishers	4	2
Change fishing time (from day to night)	2	-

Other strategic-autonomous adaptations included targeting certain species that are in demand and command a high price at the market. In this regard, about 4% of the respondents in Kiuyu Mbuyuni and 2% in Matemwe have turned to octopus fishing to maximise their income. Octopuses are highly marketable sea products in Zanzibar and other tourist destinations along the coast, such as Mombasa (see Chapter 4). Furthermore, about 4% of the fishers interviewed in Kiuyu Mbuyuni and 2% in Matemwe have collectively pooled their financial capital and built their own vessels (Table 7.5). Foot-fishers were also found to be adapting to the decline of fishery resources close to the shore by increasing distance and depth covered in order to maximise their fish catch.

An adaptive option cited only in Kiuyu Mbuyuni was to change the fishing time from day to night (Table 7.5). This move was meant to target small pelagic species such as anchovies and mackerel which are normally caught at night and in most cases, in large schools. Adaptive strategies unique to Matemwe included increasing the number of hooks per line (6%), using GPS to locate fish stocks (6%), and refrigerating the catch, mentioned by 2% of the fishers in Matemwe (Table 7.5). The use of GPS to locate fishing grounds corroborates the perception of fishers in Chapter 6 that the location and distribution of fish stocks are unpredictable. The use of GPS also demonstrates that some fishers are now going beyond their territorial water to the off-shore waters to cope with the decline in stocks. Normally fishers use signs on the shore like telephone towers and tall trees as well as stars to locate fish stocks at sea, but as some have increased the distance offshore, these signs can no longer be seen. However, poor fishers cannot afford any of these adaptive options; thus, poverty, and sometimes lack of knowledge of these technologies, becomes a barrier to adaptation.

Although no one mentioned aquaculture (crab farming) in Kiuyu Mbuyuni, it has been noted that there are some people engaged in crab farming in addition to other activities, in order to increase their income and

improve livelihood security. Kiuyu Mbuyuni, with its massive mangrove ecosystem, is an ideal spot for the future development of aquaculture. Increased participation of local communities in crab farming may have a significant impact on their livelihoods as crab and other aquaculture products such as shrimps, are in high demand in urban and tourist markets (Paul and Vogl, 2011; Hishamunda *et al.* 2009). For example, a study by Sheriff *et al.* (2008) in southern Thailand found that aquaculture is not only a potential alternative source of income but also a means of reducing pressure on scarce marine resources (Minh *et al.* 2009).

Similarly across the sites, no one mentioned temporary migration (locally know as *dago*) as a strategy to adjust to the variability of winds or other climate elements. However, although *dago* is practiced among fishers, its intensity has declined over time. Elsewhere migration, both long- and short-term are common adaptive options for coping with seasonality and extreme events such as ENSO (see section 7.1.2.2; Njock and Westlund, 2010; Nagy *et al.* 2009b). Other findings, such as using a variety of methods and targeting certain species, have also been found in other studies, including a study by Kalikoski *et al.* (2010) and FAO (2008) (see Table 7.2). For example in Brazil, fishers were targeting unexploited species such as crustaceans (crabs) and abundant species in high demand such menhaden (*Brevoortia spp.*) to adjust to variability in the marine environment triggered by a variable and changing climate (Kalikoski *et al.* 2010). Fishers were also reported to be increasing their efforts by spending more time fishing and using a variety of gear, as well as using big nets (Kolikoski *et al.* 2010).

7.3.4 Barriers to adaptation inside and outside of the fishing sector

The results in Figure 7.3 show that the majority of the respondents (74% in Kiuyu Mbuyuni and 76% of the interviewed fishers in Matemwe) answered “yes” to the question on whether there are some adaptive options they wished to adopt in order to cope with changing climate, but their ability to adopt those adaptive measures is restricted by a number of barriers.

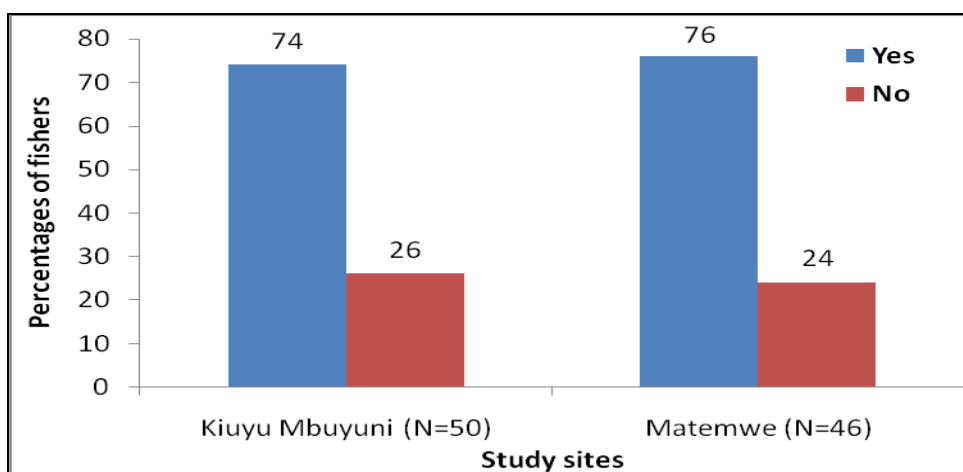


Figure 7.3: Percentage of fishers responding to a question on whether there are on- and off-fishery sector adaptive options they wish to adopt to cope with climate variability and linked stressors

Significant percentages of fishers across the sites (46% in Kiuyu Mbuyuni and 64% in Matemwe) wished to own motorised boats for fishing (Table 7.6). However as already mentioned, barriers such as initial capital, savings, poverty and lack of support were found to inhibit fishers from owning motorised boats and modern gear. The few motorised boats found across the sites were financed by the Tanzania Social Action Fund (TASAF) or the Department of Fisheries. This is an example of planned adaptation that is facilitated by the state to improve the well-being of the poor and reduce pressure on the marine protected areas. This is also made clear in a comment by a fisher in Matemwe where some fishers, through cooperative groups, have been given motorised boats in order to reduce pressure in and around protected areas (also see Box 6.4). In Pato Lagoon, Brazilian small-scale fishers were also assisted by the government in various ways in order to improve their resilience (Kalikoski *et al.* 2010). However, building the capacity of the local people to access livelihood capital would have a more profound impact on building social resilience, than simply providing low-level of assistance for a few fishers (Chapter 3). Given the low degree of support towards provision of modern gear and vessels, improved access to financial assets would be the only option that could help fishers to access these assets (e.g. vessels and gear) on their own. Therefore, the observed low access to modern vessels and gear may push fishers into the use of illegal methods that could further weaken ecological resilience, as this comment by a fisher in Matemwe shows:

“We are forced to use them [illegal fishing methods] because we had no means of getting legal gear”

Indeed, a study by Jiddawi (1990) shows that for quite some time, the Zanzibar government subsidised fishing gear through tax exemption, but it seems that most of the gear remains out of financial reach of the majority of rural fishers. Studies such as that by Cinner (2010) in Kenya and Tanzania, and Jiddawi and Ohman (2002) in Tanzania also attribute the use of illegal gear (e.g. seine nets) mainly to poverty and lack of access to legal gear.

The remaining adaptive options indicated were not directly related to fishing, but were rather aimed at diversifying the livelihood portfolio to cope with the perceived decline of fish. The common adaptive options in this category mentioned in both sites included starting a small business, seaweed farming, and joining savings groups. About 22% of respondents in Kiuyu Mbuyuni and 3% in Matemwe wished to embark on small businesses, but faced barriers such as a lack of initial capital. I observed few activities going on in Kiuyu Mbuyuni due to its remoteness and small economy. This probably influenced the above results which show more people would wish to establish small business in Kiuyu Mbuyuni compared with Matemwe. Further, 8% of the respondents in Kiuyu Mbuyuni and 3% in Matemwe wished to join saving groups in order to increase access to financial capital, but their low income from fishing barred them from participating in these groups. Participation in savings groups requires a constant contribution on either a weekly or monthly basis (see Chapter 3). Because of the seasonal nature of fishing and decreasing income (see Chapter 6) participation in these groups/clubs is sometime restricted for the majority of fishers.

About 5% of fishers interviewed in Kiuyu Mbuyuni and 16% in Matemwe wanted to start participating in seaweed farming. Despite the fact that the fishers see this as an activity for women, the number of male participants in seaweed farming is increasing particularly in Pemba (see Chapter 6). Adaptive options that were only cited in Kiuyu Mbuyuni, Pemba included stone brick quarrying (3%), becoming middlemen (3%), owning deep-soil farm plots outside the area (3%) and aquaculture (farming crabs and shrimps) (11%). No-one in Matemwe mentioned owning deep-soil farm plots in addition to coral-rag farm plots as many already own such plots within reasonable distance in the nearby villages. Similarly, no one mentioned aquaculture in Matemwe because it has no favourable conditions for aquaculture of this kind in contrast with Kiuyu Mbuyuni. Once again, poverty and lack of initial capital prevented fishers from becoming middlemen, whereas distance and lack of a means of transport such as a motorbike, scooter or reliable public transport inhibited local fishers in Kiuyu Mbuyuni from establishing farming on deep soil outside the area. With regard to aquaculture, fishers are constrained from adopting this option by a lack of skills and knowledge.

Table 7.6: Potential coping and adaptation strategies that fishers would like to adopt inside and outside of the fishing sector, and barriers to this

Adaptation strategies	Kiuyu Mbuyuni (N=37) (%)	Matemwe (N=35) (%)	Barriers
Seaweed farming	5	16	Social and cultural
Owning motorised boat with modern nets	46	64	Initial capital, poverty, saving, lack of support
Vegetable farming	-	9	Unreliable rainfall, diseases and pests
Starting small business	22	3	Savings, capital
Quarrying bricks	3	-	Banned by government
Tourism related	-	6	Access to education, perception of the investors on local community
Farming shrimps and crabs (aquaculture)	11	-	Skills and knowledge on how to do it
Joining savings groups/clubs	8	3	Low return from fishing
Becoming middlemen	3	-	Initial capital, poverty
Farming outside village /deep soil	3	-	Distance, transport

Adaptive options cited only in Matemwe included vegetable gardening (9%) and employment in the tourism-related activities (6%). No one mentioned tourism-related activities in Kiuyu Mbuyuni because nothing is going on that are related to tourism. The decision of fishers to plant vegetable gardens in order to diversify income and food sources is inhibited by uncertainty of rainfall, diseases, and pests, and probably, the accessibility of underground water and the technology for rainwater harvesting. Furthermore, access to education and perceptions of investors regarding local community members restrict fishers from being

engaged in tourism. Generally, tourism-related jobs in Zanzibar remain out of reach for the majority of rural communities. An interview with an informant from an NGO revealed that, in addition to the villager's low level of education, hotel owners have a bad perception of their capacity; the informant reported that only two hotels out of 14 in Matemwe, Unguja employ about 10 villagers. Recently 70 local villagers trained and graduated through a local empowerment scheme run by an NGO, but none had been employed so far. It seems that the success of this type of planned adaptation depends on the extent to which hotel owners are included in this process as a way of changing their perceptions of the local community.

Findings, such as the unwillingness of some fishers to participate in seaweed farming to increase their income, mirror results of other studies within Africa. For example, a study by Nielsen and Reenberg (2010) found that the local people's perceptions of emerging job opportunities such as migration labour, acted as a barrier towards them embarking in these new jobs. Across the sites, fishers would like to quit fishing outright, as suggested by FAO (2008) and embark on other activities, but their motivation is affected by a wide range of factors: poverty, low access to capital assets such as education, skills, knowledge, finance and social limitations.

7.3.5 Coping and adaptation in the seaweed farming

Unlike fishers, seaweed farmers produced a short array of strategies used to adapt to the variability of local climate and other stressors (Table 7.7). The most common adaptation options used included shifting to deeper water, increasing the number of seaweed blocks and shifting cultivation (move from one place to the other). About 27% of the respondents in Kiuyu Mbuyuni and 13% in Matemwe shifted their seaweed plots to cope with the perceived decline of sea water level within the intertidal zones (see Chapter 5). In Kiuyu Mbuyuni, Pemba, for example, some seaweed farmers believe that moving their plots to deeper water to avoid exposure had increased yield per block and their income. About 23% of the seaweed farmers interviewed in Kiuyu Mbuyuni and 11% in Matemwe shifted their seaweed blocks from one place to another to cope with perceived decline in fertility. More seaweed farmers in Kiuyu Mbuyuni opted to shift their seaweed plots because they still have room to do so. This is contrary to Matemwe where tourism activities in the intertidal zones and insensitivity of the hoteliers push seaweed farmers into small areas that do not permit movements.

About 22% of the seaweed farmers in Kiuyu Mbuyuni and 5% in Matemwe added a number of seaweed plots to their area per season to cope with both natural variability and the low price paid by seaweed buyers (see Chapter 6 for the description of seaweed plot). The difference in responses between the two sites may be influenced by the limited intertidal space available for seaweed farming in Matemwe as explained above (also see section 6.3.7.1). Another strategic adaptation measure identified in Kiuyu Mbuyuni only, was looking for and using new seaweed cuts for planting. Farmers believed that planting seaweed from seaweed

cuts obtained from the previous harvest reduced the yield over time. An interview with a key informant agrees to some extent with the seaweed farmers' argument, as seen below:

“It is true that seaweed cuts used came to Zanzibar in 1989; farmers continue using seaweed cuts from their harvest; so far we don't have the capacity to produce new seed out of it”.

One reactive, short-term coping strategy identified was replanting seaweed after the damage caused either by wind and wave intensity or temperature variability. Furthermore, 10% and 52% of the respondents in Kiuyu Mbuyuni and Matemwe respectively were doing nothing in response to the perceived decline in sea water level, the price of seaweed and increasing intensity of winds and temperature. The observed difference in response to the “do nothing” category between sites is probably influenced by the fact that seaweed farmers in Matemwe are deeply discouraged by the pressure on space. Tourism expansion in terms of infrastructure has robbed farmers of the areas previously used for drying seaweed, while increasing tourism activities within the intertidal areas confine farmers to smaller areas (see Chapter 6). Not knowing what to do may be another factor influencing a lack of response. Since seaweed remains an important livelihood strategy, knowledge of climate change impacts and adaptation options for this sector should be extended to coastal communities to enhance responses to the unavoidable adverse effects of climate change to all sectors.

Table 7.7: Coping and adaptation strategies identified by seaweed farmers

Adaptation	Kiuyu Mbuyuni, Pemba (N=49) (%)	Matemwe, Unguja (N=50) (%)
Shift to deep water	27	13
Add more blocks	22	5
Do nothing	10	52
Shift cultivation	23	11
Replace after damage	11	19
Find new seaweed branches for planting	7	-

7.3.6 Barriers to adaptation inside and outside of the seaweed farming

Figure 7.4 shows that 46% of the seaweed farmers interviewed in Kiuyu Mbuyuni and 68% of the respondents in Matemwe, said that there are adaptive options they would like to adopt. But their decisions to embark on these adaptive options are constrained by a number of barriers. A similar argument as presented in sections 7.3.2 and 7.3.4 can apply here to explain the difference in responses between the sites. Matemwe seems to have more livelihood options as it more urbanised, well connected to other part of the islands and loaded with tourism activities that can indirectly offer opportunities for the local people.

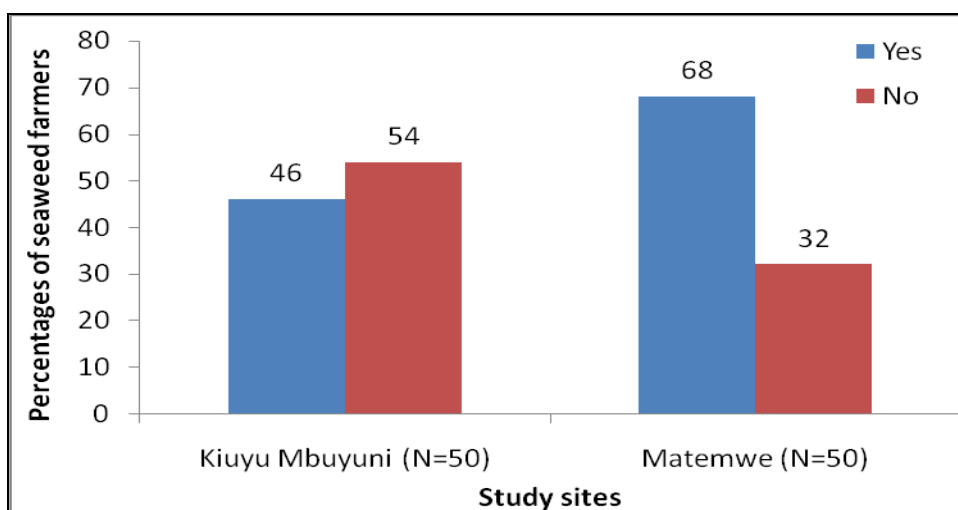


Figure 7.4: Percentages of fishers responding to a question whether there are adaptive options on- and off-seaweed farming they would wish to adopt to cope with climate variability and linked stressors

About 13% of the respondents in Kiuyu Mbuyuni and 3% in Matemwe who would like to shift their seaweed plots seaward to avoid exposure are constrained by their ages (Table 7.8); they are too old to be able to work in that environment as it needs extra strength. In other cases, this was due to lack of space as already discussed. In fact most of the adaptation strategies that seaweed farmers are interested in are related to diversifying their livelihood portfolios, rather than strategies within the sector itself (Table 7.8). The most popular options, also identified by fishers and farmers, included starting a small business and irrigation for gardening. About 36% of the seaweed farmers in Kiuyu Mbuyuni and 50% in Matemwe would like to establish a small business (small food store, ready-made garment store, bread store, among others) but were restricted by initial capital, business skills and a market. Like farmers and fishers, about 10% of the respondents in Kiuyu Mbuyuni and 18% in Matemwe would like to establish irrigated vegetable gardens in order to diversify their sources of income and food, but they are also held back by the lack of support, poverty and limited rural electrification (see section 7.3.2 and 7.3.4).

Adaptation strategies, only cited in Matemwe included keeping poultry (9%), keeping dairy cattle (9%) and tourism-related activities (12%). No one mentioned keeping poultry in Kiuyu Mbuyuni because small scale poultry keeping is already a common practice compared with Matemwe. With regard to dairy cattle, Kiuyu Mbuyuni is very dry compared to Matemwe, thus dairy cattle is not valid option there. A lack of skills on how to keep small-scale commercial poultry was found to constrain some seaweed farmers from establishing poultry projects. Indeed gender, which has cultural roots, constrained some seaweed farmers from keeping dairy cattle. Keeping dairy cattle is seen as a very demanding task, especially for women, in a situation where grazing is not easily available during the dry season (see Chapter 6); as a result, many husbands would not allow their wives to participate in this business. Apart from a lack of education and the perceptions of tourism investors in the coastal community (see Table 7.6) women were also often barred

from participating in tourism-related work for social and religious reasons. In many rural areas in Zanzibar, tourism related work is perceived to be immoral, especially for women. It should be noted here that all seaweed farmers interviewed in Matemwe were female (see Chapter 5).

Adaptive options identified only in Kiuyu Mbuyuni, Pemba, included aquaculture (13%) and keeping goats (Table 7.8). As amongst fishers (see section 7.3.4), the decisions of the seaweed farmers to adopt aquaculture in order to diversify their livelihood portfolio has been held back by a lack of skills and knowledge. With regard to keeping goats, both sites are suitable for goat keeping; goats resist drought as they graze on drought resistance bushes and require less water; but due to social and superstitious beliefs, none in Kiuyu Mbuyuni, Pemba dares to keep goats. They believe that goats cannot survive in their areas as they will be killed by an unknown power. Interestingly, in a neighbouring village (Kiuyu Maziwa Ng'ombe) with same cultural, religious and agro-ecological context people do keep goats. An interview with a key informant from the district government revealed that there is no scientific proof for what local people claim regarding the survival of goats in the area.

Table 7.8: Potential adaptations that seaweed farmers would like to adopt in both seaweed and at household level, and barriers to this

Adaptation	Kiuyu Mbuyuni (N=24) (%)	Matemwe (N=34) (%)	Barriers
Start small business	36	50	Initial capital, business skills and market
Irrigation	10	18	Lack of support, poverty, rural electrification
Move to deeper water to reduce exposure	13	3	Old age
Aquaculture	13	-	Skills, involves difficult work
Keep goats	30	-	Perceptions, superstitions
Keep poultry	-	9	Skills
Keep dairy cattle	-	9	Gender roles
Tourism-related activities	-	12	Social, cultural, gender roles

7.3.7 Discontinuance of adaptation strategies

In this study, ‘discontinuance’ is defined as the breaking off (temporarily or permanently) of certain coping and adaptation strategies. Discontinuance may be influenced by the declining capability of the actor to take up the strategy or the failure of the strategy to meet the desired outcome. Since local people across the sites have coped and adapted previously to erratic rainfall, variations in weather and winds, fishing seasonality and poor soil, respondents were asked if they had discontinued any strategy that helped them to cope in the past. The results in Figure 7.5 show that 27% of the farmers interviewed in Kiuyu Mbuyuni and 43% in Matemwe answered “yes”. With regard to fishers, 44% in Kiuyu Mbuyuni and 45% in Matemwe

discontinued adopted adaptation strategies. Similarly 35% of the seaweed farmers interviewed in Kiuyu Mbuyuni and 33% in Matemwe had done the same (Figure 7.5). More than 50% of the respondents across the sites and categories did not experience any discontinuity. This shows that discontinuity does not happen to everyone; an individual or household that can overcome barriers in various stages of their strategies are likely to successfully adapt in longer term (Figure 7.1). This high percentage can also be attributed to the idea that most of the farmers, fishers and seaweed farmers probably only adapt within their sectors and thus continued to pursue the adapted options to cope with multiple stressors (see Chapter 6) as these activities form the backbone of their livelihood.

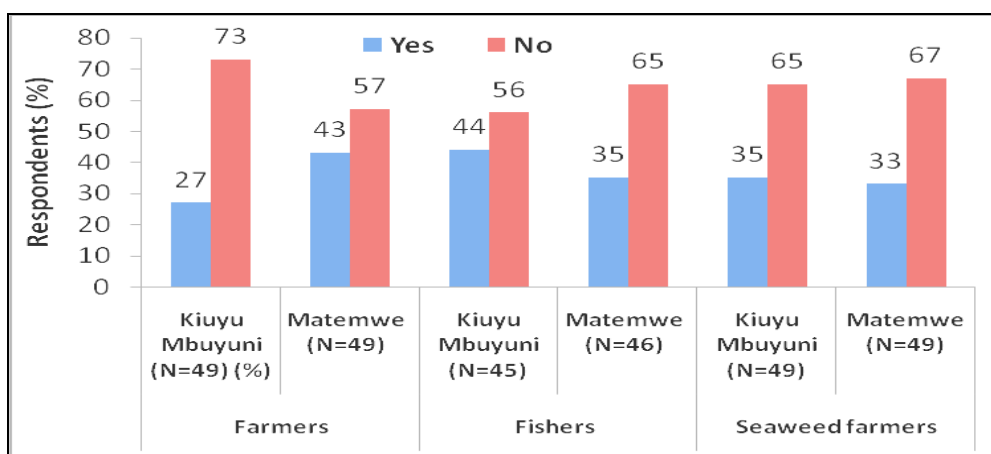


Figure 7.5: Percentage of farmers, fishers and seaweed farmers, responding to a question whether they had discontinued various adaptive options

The most prominent adaptation strategies that had been discontinued across the sites included small businesses, livestock and poultry keeping and participation in cooperative and saving groups. The results show that between 11% and 46% of farmers, seaweed farmers and fishers had discontinued involvement in small businesses in both the study sites (Table 7.9). Lack of enough capital and unpaid loans were cited as reasons for this. Unpaid loans, especially food loans, were said to be particularly responsible for the demise of established small businesses in the neighbourhood. Poverty and low returns from natural resource-based activities means that some people fail to repay their loans to food stores. The findings in both livelihood categories show that more people have discontinued small business in Kiuyu Mbuyuni Pemba compared with Matemwe, Unguja. This justifies the argument presented earlier (see section 7.3. 2 and 7.3.4) that Kiuyu Mbuyuni is more remote; less connected to other areas and thus has the smaller economy.

With regard to livestock and poultry keeping, the results show that amongst fishers 19% in Kiuyu Mbuyuni and 13% in Matemwe had discontinued taking part in livestock keeping and poultry. Similarly, 32% and 48% of farmers in Kiuyu Mbuyuni, Pemba and Matemwe, Unguja did the same. The results show that more fishers in Kiuyu Mbuyuni and more farmers in Matemwe had discontinued these activities. The reasons for discontinuation included drought, diseases that affect livestock and poultry, theft, and failure to recover

from the previous loss of livestock and poultry. Discontinuation of livestock and poultry keeping may have serious implications for the well being of the households because livestock and poultry act as a live bank, a reserve for contingencies, and a source of manure to cope with poor quality of soils (see Chapters 3 and 6). The increasing frequency of dry spells and declining rainfall adversely affect grazing land in terms of grass quality and quantity. The variability in climate also affects water availability and influences the occurrence of climate-related pests and livestock diseases. A combination of these factors, as well as the capacity to recover from shocks due to poverty, is responsible for discontinuance. The results corroborate with the life histories (Box 6.1 and 6.4 in Chapter 6) which show how people are constantly changing their strategies.

In terms of discontinuation in cooperative groups and saving groups, the results show that 16% of the seaweed farmers interviewed in Kiuyu Mbuyuni and 19% in Matemwe stopped participating in the women's cooperative group. Similarly, 10% of the fishers interviewed in Matemwe also suspended their participation in the fishing cooperative group; the reasons cited for discontinuing were mainly related to financial issues and trust amongst members. The low participation in both cooperative and saving groups across the sites (see Chapter 3), and the observed withdrawal from these groups underscores the management problems in these groups. In many parts of the developing world, participation in these groups has increased savings and access to capital assets (e.g. land) and thus increased resilience (see Chapter 3), but these groups may need capacity building to improve their performance and cope with internal conflicts.

Specific adaptive options discontinued by farmers included shifting cultivation and seaweed farming. About 15% of the farmers interviewed in Kiuyu Mbuyuni and 17% in Matemwe have stopped carrying out shifting cultivation (Table 7.9; Chapter 6). The testimony below from Matemwe demonstrates this withdrawal:

“Not long ago we used to conduct shifting cultivation. We just slashed and burned and started planting and when land was exhausted we used to shift from one place to another, nobody cared or asked. Now shifting is not possible because a piece of land is owned by someone and you have to ask permission to use it. The number of people has increased tremendously, we are more than a million now in Unguja, not including about migrants. The demand and the value of land have increased over the years. I can see after ten years or so some people will not be able to find a place to build a house. I think if this island were a dhow it would have already capsized”.

Furthermore, 23% of the farmers in Kiuyu Mbuyuni and 10% in Matemwe discontinued seaweed farming, citing reasons such as the low price per kilogram of seaweed paid by the buyers. Specific adaptive options discontinued by fishers included acting as middlemen and using illegal methods of fishing, such as spear guns and beach seine (Table 7.9). About 14% of fishers in Kiuyu Mbuyuni, and 12% in Matemwe discontinued as middlemen for fish products between their villages and neighbouring villages or town centres, giving lack of enough capital as the reason. In Kiuyu Mbuyuni, 14% of fishers and 32% in Matemwe decided to quit using several fishing methods (small-eye nets, beach seine and spear guns) due to

restrictions imposed by the authorities. These methods could be considered as maladaptive as they destroy coral reef ecosystems. This clear difference between sites is probably associated with more awareness regarding illegal fishing methods amongst fishers in Matemwe, Unguja than in Kiuyu Mbuyuni, Pemba.

Table 7.9: Discontinued adaptation strategies

Fishers			
Discontinued strategies	Kiuyu Mbuyuni (N=22) (%)	Matemwe (N=16) (%)	Reasons for discontinuance
Middlemen	14	12	Loss, not enough capital
Small business	46	44	Loss, capital, loans
Small-eye nets and beach seine and spear guns	14	32	Banned methods of fishing
Livestock and poultry keeping	19	13	Drought, failure to recover from previous loss of cattle, theft, disease
Cooperative fishing group	10	-	Conflicts within the group, trust
Seaweed farmers			
Discontinued strategies	Kiuyu Mbuyuni (N=17) (%)	Matemwe (N=16) (%)	Reasons for discontinuance
Hand-work	23	19	Market
Poultry	26	-	Diseases, theft
Small business	35	13	Loss, market
Seaweed shifting cultivation	-	19	Tourism
Tourism related	-	31	Marriage
Women's cooperative groups	16	19	Conflicts on financial issues
Farmers			
Discontinued strategies	Kiuyu Mbuyuni (N=13) (%)	Matemwe (N=18) (%)	Reasons for discontinuance
Dairy cattle	-	6	Drought, diseases
Small business	30	11	Loss, market
Seaweed farming	23	10	Low income compare with the nature of work, social status
Shifting cultivation	15	17	Scarcity of land
Livestock and poultry keeping	32	48	Diseases, drought, theft and failure to recover from previous loss of livestock and poultry
Small restaurant	-	6	Low profit

With regard to specific adaptive strategies discontinued by seaweed farmers, Table 7.9 shows that 23% of seaweed farmers in Kiuyu Mbuyuni and 19% in Matemwe discontinued handcrafts such as making handbags, mats and other items. The lack of a reliable market for their products has discouraged many women from making these products. In examining the challenges facing women entrepreneurs in Pemba Island, Issa (2012) found that poverty, poor transportation infrastructure and services in rural areas limit access to potential markets, especially tourism hotspots. In Matemwe, 31% of the seaweed farmers

(women) discontinued working in tourism hotels due to social reasons. Some of them drop-out from working in tourism sector after being married. In the seaweed sector, 19% of the seaweed farmers in Matemwe discontinued shifting their seaweed plots from one place to another.

The preceding discussion demonstrates that there are many challenges involved in maintaining adaptation strategies within and outside of farming, seaweed farming and fishing. Even when an individual or household manages to overcome barriers and adapt, they still face problems that could force them to discontinue these strategies. For example, the success of a small business and entrepreneurship is not only determined by the capacity of local people within the villages to purchase, but also by access to urban markets and outside competitors with the same commodities. Success in livestock keeping depends on the extent to which a farmer is able to cope with shocks and recover livestock stocks. Perhaps the most interesting result in this section is the observed discontinuation of some local people from seaweed farming. This is interesting mainly because seaweed farming is considered the most achievable alternative source of income along the coast of Zanzibar compared with other activities such as fishing and farming which need high investments (see Chapter 6). Similarly, some people point out that since they have started engaging in seaweed farming their food security status has at least improved. However, it is evident that the price paid for seaweed is very low compared to the nature of the task involved. Apart from price, a recent study by Fröcklin *et al.* (2012) showed that seaweed farming has significant health implications. The health problems seaweed farmers' face includes "fatigue, musculo-skeletal pain, hunger, respiratory problems, eye-related problems, injuries from hazardous animals and sharp shells in the water, and allergies" (Fröcklin *et al.* 2012:30).

7.4 CONCLUSIONS

This Chapter examined the responses of farmers, seaweed farmers and fishers to the perceived risks and impacts of both climate and other interacting stressors. Since humanity has coped and adapted before to various risks, the findings are in line with similar findings elsewhere, although some of the observed responses are unique to these areas. The findings revealed that at sector level (seaweed farming, fishing and farming), local people have made various adjustments to cope and adapt to variability in climate and other linked stressors as observed in Chapter 6. Some did nothing. This is attributable to lack of both global and local knowledge related to variability and change in climate and ability to overcome barriers which include awareness of 'what to do' to cope with stressors. Few, however, have been able to embark on strategic adaptations. In fishing, for example, strategic adaptation such as increasing ownership of physical assets such as vessels and outboard engines and the use of GPS have been used to cope with the perceived decline and instability of fish stock. Findings in Chapter 6 show a direct relationship between physical assets and income in fishing activities. Similarly, changing fishing time and increasing distance and depth for foot fishers were used for the same purposes. Other adaptive options used and common to other literatures

included the use of varieties of methods, changing fishing grounds and associated short and long term migration (*dago*) and targeting species with high value.

In seaweed farming some farmers have increased their number of seaweed blocks to cope with low price given and stronger winds which cut seaweed branches before harvesting. Moving seaweed blocks/plots to deeper water was used to cope with exposure to sunlight attributable to the perceived decline in sea water level at the intertidal zones and increasing temperature, whereas shifting cultivation was used to cope with concentration of mud which retard the growth of seaweed branches. In the Philippines a study by Campos (2010) showed that seaweed farmers lower the rope further down from the water surface to avoid exposure instead of moving the entire plot to deeper water. Probably, in the Philippines the intertidal zone does not experience much deposition that lowers water depth in the intertidal zones.

With regard to farming, most of the adaptive options cited such as shifting cultivation, mixed farming, intercropping and crop rotation have long been practices in these communities, because farming in the areas has long been performed over poor soils and under low rainfall. Planting fast-maturing crops as adaptive option is very new and it has been also reported by other studies in Africa (see Boko *et al.* 2007; Bryan, 2010). Furthermore, to cope with increasing variability in rainfall a few farmers, particularly in the Unguja sites, are using piped water to irrigate their gardens plots. However, the use of piped water for irrigation is not legally allowed in Zanzibar and may have long term maladaptive consequences. With regard to livestock, adaptive options such as using baobab leaves as fodder, collecting grass outside the area, migrating with animals to look for pasture and planting trees with leaves suitable for fodder, were used. While migration among the livestock keepers to look for pasture and water is common in literature (see Mortimore and Adams, 2001), the use of baobab trees as adaptive option to the scarcity of pasture is not reflected in other studies.

Although many of the respondents across the sites and sectors have perceived variability in climate (see Chapter 5) and impacts on their traditional activities (see Chapter 6), some of them were doing nothing to respond to the perceived impact. This may be linked with the fact that some have associated local climate variability with God's will. Apart from this, the following were other factors mentioned that prevented farmers, seaweed farmers and fishers from adopting various activities to diversify their livelihood portfolio outside their core activities: social-cultural norms, low access to credit, lack of support, low savings, low skills in aquaculture and business, low access to capital, few or no job opportunities.

Despite the fact that many local people are restricted from participating in activities outside their traditional activities that could improve their livelihood, the study found that even those who had succeeded in adapting were still affected by difficulties (barriers) and many were forced to discontinue. Some of these

barriers operate beyond their control. For example Government has made some effort to support livelihood diversification of the coastal communities to reduce the reliance on ecosystems through the Zanzibar Strategy for Growth and Reduction of Poverty, in order to build social resilience to poverty. However, most of the strategies adopted like creating vegetable gardens, livestock and poultry keeping, are also sensitive to climate variability. Most of the groups formed to work in these areas disintegrate within a short period due to lack of proper capacity building, scarcity of water, and no means of harvesting rainwater or no easy way of drawing underground water.

The general picture that emerges out of this demonstrates that, although local people have adapted to variability before particularly within the sectors, adaptation to the current variability in climate through diversifying the livelihood portfolio is still challenging. Since adaptation involves various sub-processes, Moser and Ekstrom (2010) argue that successful adaptation needs systematic identification of barriers to adaptation in each process. According to these authors the “refined ability to identify where the most challenging barriers might lie affords the opportunity to better allocate resources and strategically design processes to overcome them” (Moser and Ekstrom, 2010:22031). Indeed, the findings correlated with the model suggested in Figure 7.1. Unlike the study by Ospina and Heeks (2012) and Clarke (2012) that categorised responses into two categories such as positive and negative (maladaptation), this study went beyond this understanding and found a set of five outcomes of responses (Figure 7.6). These included successful long-term adaptation (mainly strategic), short-term adaptation or coping strategies (needed to be short-term), short-term adaptation that were discontinued when barriers came up, maladaptation and do nothing (see section 7.1.4 for more discussions of these responses).

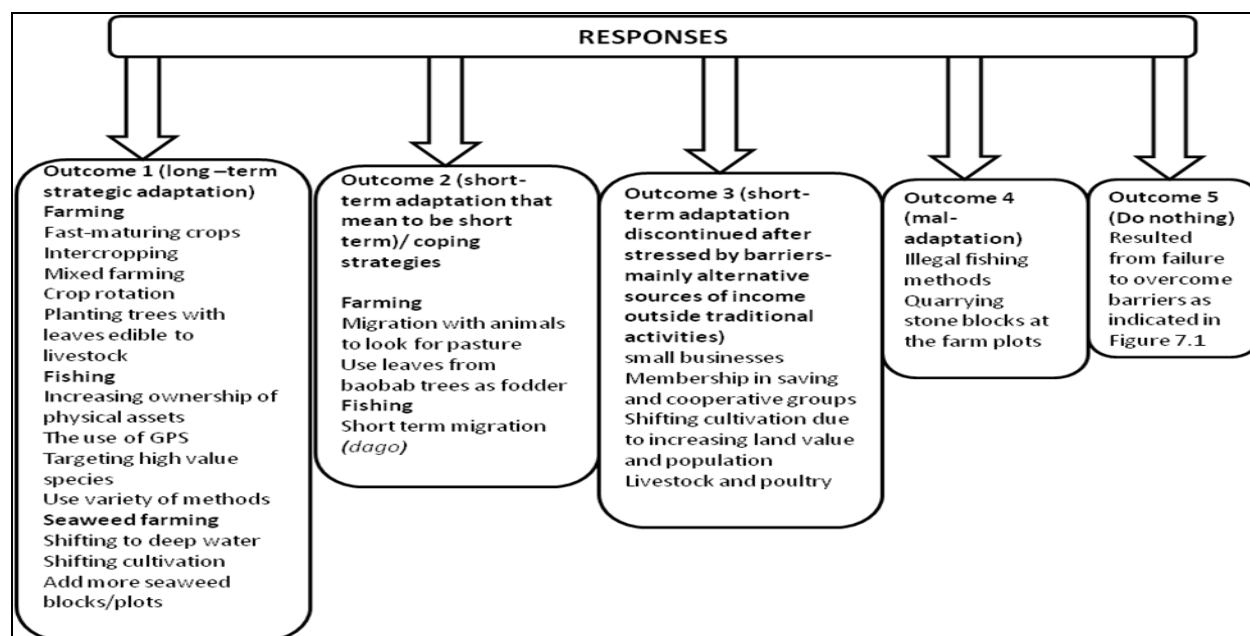


Figure 7.6: Adaptation responses as observed in this study

CHAPTER 8

SYNTHESIS AND CONCLUSIONS

8.1 INTRODUCTION

This thesis aimed to explore the vulnerability and adaptability to climate variability and change and other linked stressors of two east coast communities in Zanzibar. In Chapters 3, 4, 5, 6 and 7, I addressed four main research questions to achieve this aim: 1) what is the current status of capital stocks and access to these stocks in households (i.e. what is the household's adaptive capacity)? 2) What are the current conditions of vulnerability in these communities in relation to food and water security? 3) To what extent are these communities and their livelihoods exposed and sensitive to variability and change in climate and other linked stressors?, and lastly, 4) How do local people in these communities adapt to variability in climate and to other linked stressors, both within important livelihood sectors (fishing, seaweed farming and farming) and through engagement in activities outside these sectors? This chapter endeavours to synthesize the meaning and implications of the findings in response to these questions and to provide greater insight into the vulnerability of Zanzibar east coast communities to present and future changes in climate. This understanding is critical in order to shape future interventions that could help local people to graduate from vulnerability and enhance their ability to respond to future changes in climate and sea level.

8.2 SYNTHESIS OF MAJOR FINDINGS

8.2.1 What makes east coast communities and households in Zanzibar vulnerable?

This study has demonstrated that households and communities along the east coasts of the two major Zanzibar islands are already vulnerable to climate variability and extremes, and will become increasingly vulnerable to the impacts of future climate change as these interact with a suite of other livelihood stressors. The study communities are exposed to a series of risks related to climate and sporadic coastal floods as discussed in Chapter 5, which threaten existing livelihood sources and aggravate food and water insecurity (Chapter 4). Furthermore, the fact that Zanzibar is a small island developing state and the east coasts already have a harsh and stressed environment creates a context of heightened sensitivity to future climate change. This is exacerbated by the high dependence on natural resource-based livelihood activities (Chapter 3), which makes households extremely sensitive to weather-related events. The study also found that households and communities in the study sites had low levels of livelihood assets and poor access to these, affecting their adaptive capacity and thus their ability to respond to multiple shocks and stressors in any long-term and sustained way (Chapter 3). Below, I present some of the key findings that contribute to this picture of highly vulnerable communities.

8.2.1.1 Exposure to climate variability and change

Communities and households on the east coast of Zanzibar are already experiencing climate change and unpredictability. Rainfall received in the short and long rainy seasons, as well as during winter (*mchoo* in Pemba, *pupwe* in Unguja), was perceived to have declined compared with previous years. Additionally, the frequency of dry spells along the east coast was reported to have increased in the last two decades. In terms of temperature, warmer conditions were perceived in both summer and winter, while wind patterns (north- and south-easterly winds) were reported to be variable over time. People's perception of this variability is informed by the relationship between climate and their livelihood activities (Chapter 5), and on the whole is supported by meteorological data. However, despite local people being acquainted with shifts in the climate, farmers were not following seasonal forecasts that could assist them to cope with the abnormal weather. More importantly, local people associated the perceived climate variability with the will of God and other unscientific causes. This, together with low seasonal forecast uptake among farmers, is a potential cause of concern for policy makers and planners, as it may inhibit people's motivation to adapt or to participate in interventions aimed at building local resilience. With regard to sea level rise, the majority of people across the sites perceived a decline in sea level. Their perception was prompted by shallower water in the intertidal zones which exposed their seaweed farms to the sun's rays. This decline has also been articulated in previous studies and associated with upliftment of the land mass. The general trend in the observed sea level measurement revealed no clear indication whether the sea level is falling or rising, however, the analysis showed a significant increase at the end of the last decade and in early 2011 (Chapter 5). This increase is also attested by coastal flooding of arable lands, particularly in Pemba Island during this period. Moreover, the study highlighted that variability in temperature, rainfall and sea level rise in Zanzibar correlates with ENSO events (El Niño and La Niña) which are related to sea surface temperature (SST). It is expected that changing frequencies of these events will further affect the local climate.

The perceived and observed variability in climate and sea level is already affecting coastal livelihood activities such as fishing, farming and seaweed farming. The sensitivity of these activities to both climate and non-climate stressors is partly responsible for the observed food and water insecurity and widespread poverty (see Chapter 6). Climate variability, particularly dry spells, affects crops and livestock in various ways. Even small-scale variability in one of the rainfall seasons is likely to affect both crops and pasture as the farming system is completely rain-fed and practiced over poor soils. Seaweed farmers believe that increasing warming conditions have affected both the growth and yield of seaweed, while changes in wind patterns have destabilized seaweed blocks. Seaweed farming is also affected by non-climate stressors such as seaweed diseases and algae, the increasing number of seaweed farmers on limited land, and the low price for seaweed. Similarly, fishers perceived that variability and change in climate has had an impact on the abundance of fish stock distribution, the quantity of fish caught and on breeding grounds. However, it is very difficult to attribute these changes in fishery resources solely to climate change. Human actions such

as the use of dynamite and spears can affect coral reefs, one of the most important breeding grounds and source of fishery resources, while the high demand for fuel wood can have a significant impact on the mangrove forests.

Since these activities are the main source of income and food their sensitivity to climate and other linked stressors creates conditions of vulnerability in the two communities. In many instances the study found that non-climate stressors exert more pressure on these activities than do climate risks. For instance, increased value of land in Matemwe mainly due to tourism reduced access to and the size of land for farming. Similarly, the low price for seaweed given to seaweed farmers which is controlled by the world market exerts more pressure on livelihoods than weather related events. Perhaps the most interesting revelation of the study which is thinly covered in other vulnerability studies is that the vulnerability of livelihood activities is partly attributed to their particular set of characteristics. For instance small size of vessels used for fishing trips made fishing vulnerable to the normal seasonality of winds and tides.

8.2.1.2 Food and water insecurity

The changing climate and sea level are increasing water and food insecurity along the east coast of Zanzibar, although this is not a new problem in these areas. Availability and accessibility of food (staple food, fish and vegetables) in households was found to be inadequate throughout the year, even for those that are fishing and farming (Chapter 4). Fishing and farming tend to complement each other to ensure food security in the households, with negative feedbacks occurring if one is affected. For instance, it was found that declining farm outputs increased the need for cash to buy food from the stores, which in turn prompted fishers to sell a large part of their fish catch, thus reducing the supply of this protein source to their households. The problem of food insecurity was not uniform throughout the social system. More female-headed households experienced low availability of food (section 4.3.1.2 in Chapter 4) because these households are characterised by limited access to resources and job opportunities. As no household produces all the staple food it needs, food insecurity may also be associated with low purchasing power for food. For example, the average cost of buying staple food per month was between Tsh. 70 000–100 000 (section 4.3.1.4 in Chapter 4). This is higher than the average income generated by fishing (main source of income) per month (Tsh.50 000–70 000) (section 6.3.4.2 in Chapter 6). Furthermore, there are few other opportunities for income generation. Activities outside of farming and fishing were out of reach for the majority or they were carried out on a scale that was too small to ensure a constant flow of food within the household.

Additionally, unstable prices for imported commodities such as rice (main staple food in Zanzibar) create further problems for people with scarce cash resources. Perhaps the major problem with the status of food security in the study sites was the lack of a continuous supply of food (staple food, fish and vegetables) in

households. For instance, because the abundance of fishery, resources and fishing trips are largely influenced or controlled by differential wind patterns (Chapter 6), the south-easterly wind season (*kusi*) is characterised by low consumption of fish and limited income to purchase food. Furthermore, the study also suggests that the supply of staple foods and vegetables is becoming unstable. Both vegetable and local crops such as cassava, yams, millet, maize and sorghum, among others, have been shown to be sensitive to dry conditions (see Chapter 6).

In terms of the accessibility and stability of other sources of food such as seafood (crabs, prawns, shrimps, and lobsters, various types of shellfish, cuttlefish and octopus), meat and chickens, the study showed low consumption of these. Although the study communities, especially in Kiuyu Mbuyuni, Pemba, are known for livestock and poultry keeping, the animals are used mostly as an asset to be sold during a crisis or to acquire other assets. Interestingly, seafood is no longer an important food of the poor, as its value has increased significantly because of high demand from the tourism sector and in urban areas. Seafood that used to be consumed is now sold; this may have negative nutritional consequences.

The water security situation in the study sites is also precarious. Communities still rely on local wells and coral caves for their household needs. These sources are sensitive to dry conditions, contamination and seawater intrusion. Piped water which is supplied from distant sources is also erratic and unreliable, although better in Kiuyu Mbuyuni than in Matemwe. In some villages of Matemwe, people walk up to 2 km to the nearest community stand pipe. Thus, while in Kiuyu Mbuyuni stand pipes and water from wells complement each other, in Matemwe, most of households obtained most of their water from local sources such as caves and wells.

Farming in the areas is water insecure because of the rain-fed nature of farming (Chapter 6) coupled with the unreliability of rainfall, especially during short-rain season (*vuli*) and winter (Chapter 5), and the lack of techniques for harvesting rainwater for farming, for water conservations and lack of piped water for home gardens (Chapter 4). In terms of livestock, the study found a different pattern between sites. Water from caves is the main source of water for livestock in Kiuyu Mbuyuni, while in Matemwe local wells are the main sources. However, in the case of Kiuyu Mbuyuni where livestock keeping is one among the most important livelihood activities, most of these caves cannot be easily accessed (section 4.3.2.3 in Chapter 4). In fact, the availability of quality water for both livestock and households was found to be a major problem across the sites. In Matemwe, where more than 50% of the local wells are located along the shore, they are prone to saline seawater intrusion and contamination due to their shallow depth. Coral caves across the sites contain hard water of varying saline intensity. The study therefore argues that the observed food insecurity and reported recurrence of food shortages along the east coast in both islands is partly linked with water

insecurity. A good supply of water would be likely to increase agricultural production and ultimately enhance the availability and accessibility of food in the households.

8.2.1.3 Assets and adaptive capacity

The ability of communities and households to deal with the above changes and risks, together with food and water security challenges, are limited by their low access to livelihood assets and high levels of poverty. Considering social capital, the study highlighted that participation in cooperatives and saving groups, which are crucial in accessing financial capital, was low across the sites. The study highlighted the idea of ‘layered assets’ in which access to one form of asset depends on other form of assets. For example education (human capital) can influence trust (social capital) and income (financial capital). Trust together with income is a very important ingredient when it comes to the formation of saving groups. The study found that, apart from lack of savings which led to low capacity to contribute in these groups, lack of trust also influenced membership and drop-out rates in savings groups. Furthermore, participation in decision-making and in village politics was also marginal. However, social cohesion, which is seen as a safety net in times of crisis, was high in both the sites with minor variations between them (Chapter 3). The study argued that somewhat lower level of social cohesion in Kiuyu Mbuyuni, Pemba was influenced by co-variate climate risks within these communities and few alternative livelihood options.

Access to financial resources is minimal in both sites (section 3.3.4 in Chapter 3). For example, households do not have saving accounts, very few receive grants and many have no stock of non-productive assets such as jewellery. Additionally, in both study sites many households have outstanding debts (mainly associated with food loans), low access to credit from both informal and formal sources, and the majority had experienced an income shortfall in the last 12 months. Other stressors on financial assets included the weddings of a son or daughter, agriculture failure, vessels or gear lost due to strong wind or theft, and theft or death of livestock. Indeed, access to financial assets is essential for livelihood diversification and to improve the scale of the existing livelihood activities and thus increase resilience.

Human capital is also low in both sites; there is a high level of illiteracy, even among the youth (see section 3.3.5 in Chapter 3). This in turn marginalises them from employment in formal sectors and even in the tourism sector. Skills, particularly related to handcrafts, are high in both the study sites. However, in Kiuyu Mbuyuni, because there is no tourism to provide a reliable market for handcrafted products, these skills are almost untapped. In Matemwe, Unguja the tourism industry offers a market opportunity for these products. As a result, women’s cooperative craft work groups were observed in this area. Health is another important aspect of human capital as it influences production and may affect households’ savings and loss of physical assets. A considerable number of households were found to be affected by a wide range of illnesses and in some cases, these illnesses also affected them economically. With climate change, diseases that are

common in Zanzibar and partly related to climate, such as malaria are expected to rise (Hay *et al.* 2002; McMichael, 1999; Githeko and Ndegwa, 2001) with huge implications for the livelihoods of the poor.

Physical capital is fundamental to the adaptation of coastal communities to climate change. The majority of people across the study sites live in their own houses, mostly made with stones and roofed with iron sheets. However, most households did not have legal documents confirming their ownership, which can act as a barrier to acquiring loans and credit from formal financial institutions. With regard to equipment, although most fishing households owned a bicycle, they lacked important fishing assets such as vessels, outboard engines, gear, refrigerators and motorbikes. Further, households were deprived of services such as electricity and while a considerable number owned radios and mobile phones, very few owned a television set, furniture, solar panel or sewing machine. All these assets are important as they can be used to increase productivity and opportunities, sold during a crisis or sold in order to acquire productive assets such as livestock and fishing equipment. In terms of ownership of livestock, in Kiuyu Mbuyuni, more households kept cattle than in Matemwe; although households in Matemwe had goats but no one did in Kiuyu Mbuyuni. As mentioned earlier, livestock and poultry keeping in these areas is not meant for food, but for selling the products (eggs and milk), and as a safety net to be sold only during a crisis.

Natural capital is the basis of livelihood activities in the sites and the heart of the national economy. Both sites are endowed with fishery resources, but threatened by a wide range of stressors (see Chapter 6). The small geographical area of the islands means land for farming and livestock is very limited. Similar problems were experienced in seaweed farming along the shore. It has been indicated earlier that increasing land value and demand for land, due to population increase coupled with expansion of tourism infrastructure, have continuously reduced the size of the land area for agriculture and seaweed farming. In addition to increased demand for land, poor planning of land-use and management of limited land resources are responsible for reduced land for farming all over the islands. To avoid future conflicts around land resources, strict land-use measures should be introduced.

The findings demonstrate that coastal communities might easily be affected by climate change and they have limited capacity to adapt. Although perceptions of and belief that climate change is happening are considered to be important ingredients that could facilitate adaptation, the absence of means (capital) may play a greater role in blocking adaptation. For example, across the sites the observed low diversification out of traditional activities is largely influenced by low access to these assets (see Chapters 3 and 7).

8.2.2 What hinders communities from responding to change, risk and existing vulnerability challenges?

While communities and households are extremely vulnerable and often do not have the assets to respond to stressors and shocks, they are not totally without agency. Some households and individuals have attempted to adapt to the changes they are experiencing, but often face barriers (Chapter 7). The study found that fishers, farmers and seaweed farmers have employed various types of adaptation strategies to cope with variability in climate (Table 8.1). Outside these sectors, local people have also responded through diversification of their livelihood activities (Chapters 3 and 7); however, there was also a segment of the population who ‘did nothing’. Most of the adaptation strategies employed both within the specific sectors and households studied were spontaneous (people’s own responses). Few planned adaptation strategies were observed and most of the formal institutions’ responses were ex-post reactive, such as provision of seeds after the effects of dry spells and food aid during prolonged dry spells. One of the only pro-active planned adaptation support strategies observed in both the study sites was the provision of a few motorised boats from TASAF.

Some of the autonomous adaptation practices observed in farming included the use of fast-maturing varieties and intercropping (Table 8.1). Similarly, mixed farming (keeping livestock and growing crops), shifting cultivation and crop rotations were also used to cope with the poor soils and variability in climate. In terms of livestock, coping strategies such as migration, fodder collection outside the areas, planting trees with edible leaves and the use of baobab leaves as fodder were used to cope with the poor performance of pastures caused by dry spells and unreliable rainfall (Table 8.1).

With regard to fishing, the use of GPS was employed by few fishers particularly in Matemwe, to locate fishing grounds to cope with the perceived instability in the fish stock distribution (Table 8.1). Other strategies included increasing hooks per line, changing fishing time and using a variety of methods based on season. Additionally, some fishers switched to motorised boats that could take them further off-shore to cope with the decline of fishery resources in-shore, but few managed to build their own vessels or increase access to other important fishing assets (Table 8.1; Chapter 7). Seaweed farmers are continually confronted with abnormalities that need action and these were mainly spontaneous. The most common strategy observed was for farmers to shift their seaweed blocks to deeper water to cope with the perceived decline of sea-water level at the inter-tidal zones, while increasing the number of seaweed blocks per farmer was used to cope with the low price given by buyers. Other strategies include shifting cultivation to cope with block deterioration, and replacing the weed after it has been damaged by temperature or strong waves (Table 8.1).

Table 8.1: Different types of adaptation strategies used within sectors to cope with various stressors

Sector	Strategies	Type
Farming	Fast-maturing crops	Proactive/strategic
	Intercropping	Proactive
	Mixed farming	Proactive
	Home gardening irrigation	Proactive
	Shifting cultivation	Proactive
	Crop rotation	Proactive
	Migration with animals to look for pastures	Tactical reactive
	Use of baobab leaves to feed animals	Tactical reactive
	Collecting pastures outside areas	Tactical reactive
	Planting trees with edible leaves to animals	Proactive/strategic
Fishing	Increase the number of hooks per line	Reactive/proactive
	Use GPS	Proactive/strategic
	Use a variety of methods	Proactive/ strategic
	Change fishing grounds	Proactive/strategic
	Change to motorised boat	Proactive/strategic
	Change to octopus catching	Tactical reactive
	Use refrigeration	Both tactical and proactive
	Build own dhow with fellow fishers	Proactive/strategic
	Increase depth for walking fishers	Tactical
	Change fishing time (from day to night)	Tactical
Seaweed farming	Shift to deep water	Tactical
	Add more blocks	Proactive/strategic
	Shift cultivation	Both tactical and proactive
	Replace after damage	Tactical
	Find new seaweed branches for planting	Both tactical and proactive

The study showed that seaweed farmers, fishers and farmers wish to do more, both within and beyond their sectors, in order to cope with multiple stressors, but they are constrained by a wide range of barriers (Figure 8.1).

Social and cognitive barriers identified relate to culture, age, gender, social status, conservation practices, superstitious beliefs and perceptions (Adger et al. 2009; Jones, 2010; Jones and Boyd, 2011; Blennow and Persson, 2009; Gifford, 2011). This study has clearly articulated the power of superstitious beliefs, social status, gender roles and perceptions in influencing the decision of an individual to adapt. For instance, superstitious beliefs in Kiuyu Mbuyuni, Pemba that goats are not surviving because of an unknown power has prevented the whole village from keeping goats. Goats are known to be drought resistant animals and they are very common along the east coast in both islands where dry spells are common phenomena. In addition, linking climate with the power of God, perceptions and understanding of climate change and poor conception of the dynamism of risks related to climate variability partly influenced “do nothing” responses (see Figure 7.1).

With regard to social status the study found that a considerable number of fishers, particularly in Unguja, decided not to engage in seaweed farming in order to diversify their livelihood portfolio since seaweed farming is associated with women. Despite the fact that seaweed farming is also affected by varying weather, sea level in the intertidal zones and price it, can still offer additional income to the households.

Perhaps the most interesting barrier observed particularly in Matemwe, Unguja is gender relation within the social system. In addition to the perceptions of hoteliers on local communities regarding their ability to work in tourism hotels, the negative perceptions of the local community to tourism have also prevented local women participating in jobs related to tourism. Some local people associate tourism with sin.

Financial barriers included lack of initial capital, low return from primary activities, lack of savings, lack of participation in saving and cooperative groups and low access to access to credit. Lack of financial capacity bars local people from diversifying their livelihood portfolio into activities which are less sensitive to climate change. Access to financial capital could assist people to increase their livestock, to set up small businesses, become middlemen and increase their ownership of fishing vessels and gear (see Chapter 7). Furthermore, the study suggests that people also wish to engage in aquaculture and modern poultry raising, but are constrained by a lack of knowledge, skills, financial capital and support.

Technical, knowledge and infrastructure barriers were also found to limit adaptation amongst seaweed farmers, fishers and farmers (Chapter 7). Despite the fact that the areas experience dry spells and unreliability in rainfall, small scale rainwater harvesting for home gardening is still possible but is constrained by a lack of infrastructure for harvesting and irrigation (Chapter 4). Similarly poor rural electrification was found to limit access to underground water that could be used for both households and in the fields. Lack of electricity has affected adaptation in fishing through preventing refrigeration (Chapter 7). Perhaps the most notable impact of a lack of education was employment amongst the local community in official and tourism related jobs. This has huge implications for food security and access to financial assets (Chapter 3); the study found that the salary of an employed individual can act as a guarantee to obtain a loan from banks. In contrast, fishers or seaweed farmers cannot use their income as assurance to obtain a loan from these institutions as their activities are so unreliable.

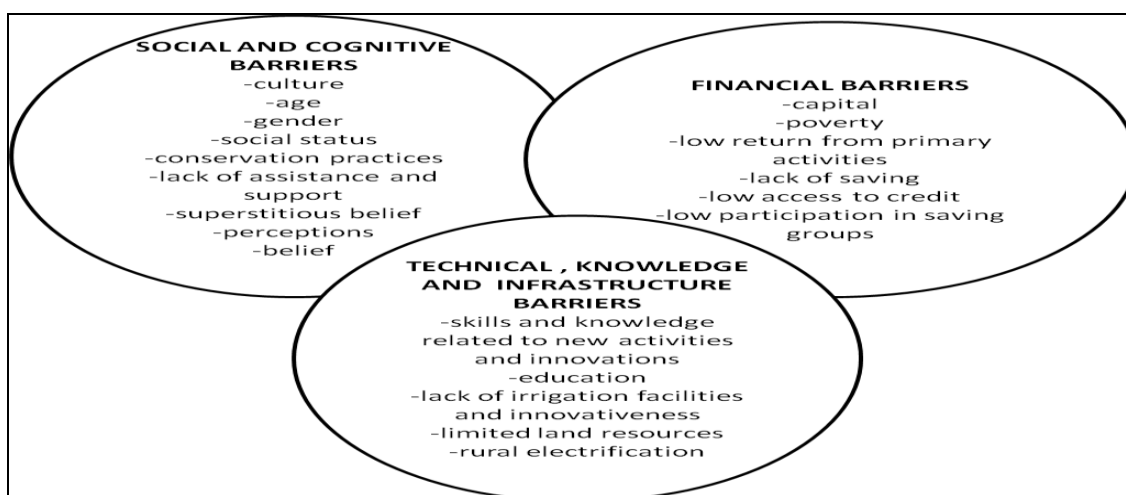


Figure 8.1: Summary of barriers that constrain households from adapting to multiple stressors

Lastly, the study illustrated that since most of the adaptations strategies were spontaneous and autonomous and not supported many households were forced to discontinue these due to barriers (see section 7.3.7 in Chapter 7). For example, activities such as small businesses, modern poultry keeping, vegetable gardens, livestock keeping and dairy-cattle keeping were discontinued because of various barriers. Unreliable rainfall and a lack of an alternative water supply forced some people to discontinue vegetable gardening. Similarly, as dairy cattle are so selective in terms of fodder, variable rainfall which affects pastures and the incidence of diseases, has forced some farmers out. As noted in Chapter 6, peoples' livelihoods along the east coasts are very dynamic, and a household may take up a livelihood activity today and discontinue it after a short period. This again demonstrates the value of this study in the field of adaptation, as it shed light on the limits of autonomous adaptation and livelihood diversification in situations where local people have limited access to capitals and non-climate sensitive livelihood opportunities.

8.3 What is needed to reduce vulnerability and expand the adaptive capacity of east coast communities and households in the future?

It has been indicated earlier that global temperature is expected to increase, and precipitation is expected to behave differently in different regions. While Zanzibar has started to experience coastal floods over arable land partly associated with sea-level rise, the future projection is very alarming. Perhaps the most challenging issue in this regard is the increasing influence of ENSO events on weather patterns and sea-level rise. ENSO events are associated with sea surface temperature (SST) changes which are closely linked with human-induced global warming. While attempts towards reduction of greenhouse gases are constrained by the desire for growth in industrial nations and the fact that the impact of climate change has no boundaries, the need to build resilient coastal communities is evident now more than ever. Since the distribution, patterns, and magnitude of future climate variability and change is uncertain, I suggest the following strategies to building resilient coastal communities:-

- i. Increase access to local sources of water
 - ✓ The study found that accessibility and availability of water for farming is challenged by increasing frequency of dry spells and low capacity to draw water from local sources, mainly caves. This water insecurity is justified by the observed low access to food and vegetables across the sites (Chapter 4). In the present situation of limited livelihood options, reducing hunger and sensitivity to a wide range of risks may be partly achieved by increasing accessibility of fresh water for farming (vegetable gardens) and livestock, and for household uses. Unlike other small island states, Zanzibar especially Unguja Island, has the potential to expand groundwater exploitation for irrigation and increase water supply to coastal villages where their local sources are prone to climate variability and seawater incursion.

- ✓ In terms of increasing water accessibility from local sources (wells and caves), there should be attempts towards making hand-pumps from salinity resistant materials such as plastic. Previous attempts to use iron hand-pumps, particularly in the caves, have failed as these pumps have been corroded by saline water. Hand-pump making may also increase local employment opportunities.
- ✓ Currently, the east coasts of both islands experience unreliable rainfall, especially during the short-rain and winter seasons (Chapter 5). But the annual rainfall received still offers tremendous opportunities for local rainwater harvesting. In Matemwe, Unguja, where some households are located close to farm plots, even small-scale individual water harvesting techniques such as a roof catchment system can improve water availability for both household and farm use. Subsidies to obtain big water tanks and other associated equipment would enhance water security. Furthermore, water-conserving agricultural technologies could also be employed to reduce water insecurity in the farming systems.

ii. Increase climate change awareness

- ✓ Despite perceptions of climate variability and change, the study found that the majority of respondents lack knowledge on the causes of climate change and the dynamics and long term nature of the risks related to this. For example, the majority have associated the change in climate with God. As seen in the previous section attributing variability to God can limit responses to risks. Because knowing the causes of climate variability and change and its dynamism is seen to be the first step forward towards adaptation, interventions aimed at reducing the impact of climate change should mainstream general awareness of climate change amongst local people. Furthermore, local peoples' perceptions and responses to climate variability in local places should be strengthened and integrated within planned interventions to facilitate their participation. For example, although the observed data showed a high fluctuation in sea level from 2007 that caused coastal floods, people across the sites have perceived a decline in sea level. Therefore, any interventions should involve an awareness component in order to alter their perceptions to facilitate their participation.
- ✓ The study found that, despite the perceived unpredictability of rainfall, farmers were still confident in their traditional ways of weather forecasting compared with conventional seasonal weather forecasts. To increase uptake of seasonal weather forecasts, conventional and local traditional systems for weather forecasting should be integrated (Kalanda-Joshua *et al.* 2011). This would increase the legitimacy of the seasonal weather forecast as people would have a stake in the whole process and realise that conventional forecasts are not

meant to overtake their traditional knowledge (Patt and Gwata, 2002). Furthermore, local people's ownership of local weather stations may also improve legitimacy of the forecasts.

iii. Increase access to livelihood capital

- ✓ The study found that the sensitivity of the communities to multiple stressors and their low capacity to adapt could be attributed to low capital stocks and access to these. Policies should enhance and promote access to financial services through saving groups/clubs and official institutions such as banks. For example, legalisation of land and house ownership will make credit and loans from formal institutions more accessible. Increasing awareness of the benefits of saving groups will increase uptake. Increased accessibility of financial services is, indeed, crucial as it increases capital stocks of both non-productive and productive assets (e.g. vessels, gear, land and livestock). All these assets can increase income and act as a safety net during times of crisis and recovery. Further, access to financial services should give some special consideration for the most at-risk groups such as people with disabilities, women-headed households, and women. However, targeting women alone in forming savings and cooperative groups may not always have the desired effect, especially in reducing food insecurity, because married women are not culturally entitled to bear the household expenses, though their income is used during a crisis or when the head of the household (father) is running out of money. Across the study sites, the study found little participation by men in these social groups; men need to be encouraged to join these groups.
- ✓ In terms of social capital, local people's participation in decision-making in all issues should be strengthened through increasing capacity to participate. With regard to participation in cooperative groups and saving groups, barriers that hold people back should be eliminated, especially in Kiuyu Mbuyuni, Pemba. For instance, skills in savings group management should be enhanced among local people to reduce internal conflicts between members. These conflicts cause drop-out and discourage others from joining these groups. Such groups not only increase access to financial assets, but also increase bonding social capital and enhance diffusion of adaptive innovations such as aquaculture within social systems. Although bonding social capital is very high in the study areas, it could be enhanced by reducing political tensions in the country politics.
- ✓ In terms of human capital, both the study sites are located in districts (Micheweni, Pemba and North "A" Unguja) that are characterised by high percentages of illiteracy. This has reduced people's political participation and limited their chances of being employed. Policies should increase access to education by increasing the quality of education, infrastructure, reducing school drop-out and changing parents' perceptions of the

importance of education. Additionally, employment in the tourism sectors should be set aside for local people and they should be given first priority as other job opportunities are currently unreachable. This could include government support on the job training. While conservation policies impose strict measures to ensure benefits are shared with local communities, this can also be applied in the tourism sector in Matemwe, Unguja or any other parts of the islands where tourism is practiced. However, local peoples' perceptions regarding tourism should also be dealt with by increasing awareness and integrating tourism within the culture and religion.

- ✓ Increasing population together with influx of labour migrants to tourism areas particularly in Matemwe, pose a new threat in the spread of HIV/AIDS. This again requires a wide range of interventions that provide local people with knowledge that could increase social resilience to HIV/AIDS. HIV/AIDS and other illnesses adversely interact with climate change and other stressors and weaken the capacity to adapt to anticipated future changes.

iv. Improve the current characteristics of livelihood activities

- ✓ The study found that, fishing, farming and seaweed farming are sensitive because of their particular set of characteristics. These characteristics such as rain-fed nature of farming and over dependence on world market in the case of seaweed are major sources of vulnerability. With regard to seaweed farming, attempts should be made to add value to seaweed by producing products locally and so reduce over-dependency on the world market for raw seaweed. This should again involve promoting access to financial services for local entrepreneurs and subsidies to purchase the needed equipment for producing and packaging those products.
- ✓ Increasing access to modern vessels and gear will significantly improve options for fishers as these vessels will take them off-shore to less exploited fishing grounds. Policies should address the problem of low physical asset ownership and facilitate the best ways in which local people can acquire these assets. In this case, planned interventions with full support from central government may facilitate this aim. With regard to farming, land-use planning should be put in place and enforced to prevent unplanned urban sprawl caused by many factors including population increase. This will increase access to land suitable for agriculture.

v. Diversify the livelihood portfolio outside ecosystem-based activities

- ✓ The study found that ecosystems based activities are the major sources of income and food along the Zanzibar coasts and local people mainly diversify within these activities rather outside of them. Thus, as a way of increasing resilience, policies

should not only solve the problems within primary livelihood activities (fishing, seaweed farming and farming), but also create the opportunity to diversify the livelihood portfolio outside these activities. This can be achieved through increasing access to local job opportunities (e.g. related to tourism and constructions), utilisation of local resources and assets and increasing entrepreneurship skills. As most existing livelihood activities are influenced or controlled by the climate (Chapter 5), rural livelihood diversification may have positive implications for rural well-being and food security. The power of livelihood diversification has also been articulated in other studies in both Africa and in South America particularly in Brazil (see Chapter 3).

- ✓ As the demand for vegetables is quite high in urban areas due to the increasing population among the working class, and to the expansion of tourism, the move from field farming to home gardening may well be a viable way of increasing access to food and cash income. However, this can only be achieved through awareness and increased inputs and access to water.

8.4 CONCLUSION

This study has highlighted the fact that the vulnerability of coastal communities is not solely related to climate variability and change, but rather to a combination of climate, biophysical and social factors. Even without climate variability, these communities are already vulnerable to a wide range of deep-seated challenges that exert enormous pressure on the adaptive capacity of households. Poverty and low access to livelihood capital and livelihood options outside the primary livelihood activities were the major sources of vulnerability and at the same time constrained people from graduating from poverty. In poverty-stricken communities such as those for this study, policies should be directed to help people to adapt strategically. In this regard Owusu *et al.* (2011), Barrett *et al.* (2011a) and Barrett *et al.* (2011b) contend that in order to build resilient rural communities, policies should aim at increasing availability of off-fishing and farming work and access to households' livelihood assets in order to boost adaptability. It is possible to build a resilient east coast community, but it requires political will to achieve sustainable livelihoods and to overcome barriers to adaptation. As WCED (1987) noted "meeting essential needs requires not only a new era of economic growth for nations in which the majority are poor, but an assurance that those poor get their fair share of the resources required to sustain that growth. Such equity would be aided by political systems that secure effective citizen participation in decision making..."

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APPENDICES

APPENDIX I HISTORICAL TIME LINE

A: KIUYU MBUYUNI, PEMBA

TIME	EVENTS
1971-1972	-Drought leads to famine -Fish and seafood used as food during this period -Wild and cultivated plant used as food -Some people died during this period as a result of famine
1972-1973	-Massive forest clearance for new farm plots to cope with food shortage -Some people clear forest on nearby uninhabited islet for new farm fields
1964	-Gravel road built to link district headquarters with the ward
1967	-Primary school in Kiuyu built to reduce illiteracy
1970	-Hospital built
1973	-Village flats built; stimulates local people to build good, modern houses
1972	-Water tap established; does not last; reduced difficulty of fetching water from local sources
1990s	-Seaweed farming started; alternative source of income
1998	-Heavy rainfall
2000-2001	-Droughts associated with localised food shortage and low production; small-scale use of wild and cultivated plants as food
2005	-Piped water supply restored through stand pipe
2002	-Cholera outbreaks cause many deaths
2003	-Widespread malaria; large number of children die
2001	-Political riots after 2000 election cause many deaths
2008-2010	-Droughts create with food shortage



Historical timeline sessions in both Pemba and Unguja

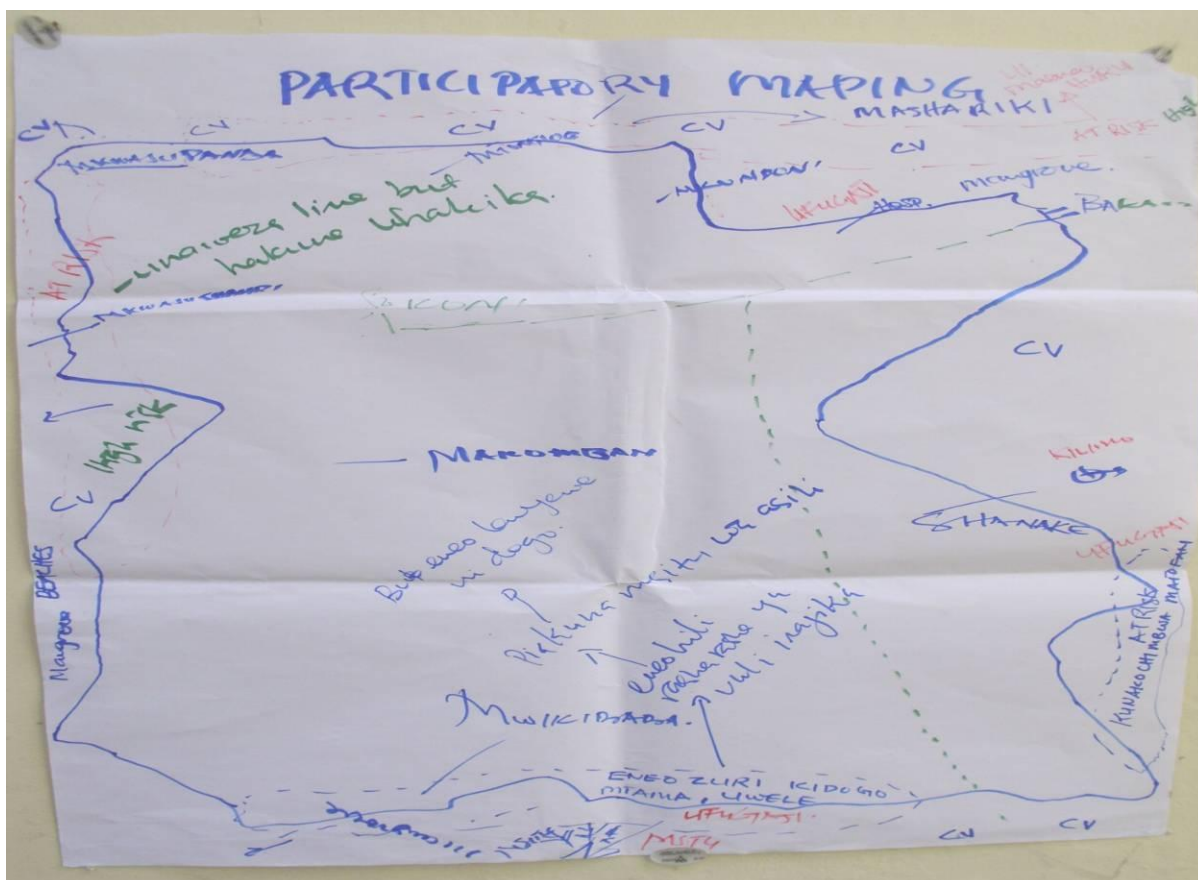
B: MATEMWE, UNGUJA

TIME	EVENTS
Just before the Revolution	-No school, no hospital, no road, no tap water
Before the Revolution (They do not remember the exact year)	-Serious drought; commonly known as “Year of Gwede”. (Gwede: Kind of palm tree, its roots eaten as famine food in those days)
1964	-School starts; reduces levels of illiteracy -Hospital starts: improves access to health services
1964 onwards	-Population starts to increase in the area; has impact on resources
1971-1972	-Drought exacerbated by a ban on food importation in Zanzibar
1990	-Seaweed farming starts; improves economic conditions, especially among women
1990	-Water supply and road construction starts
1995	-Introduction of tourism in Zanzibar, Matemwe in particular -Tourism associated with increasing problems with piped water supply introduced in 1990
1995	-High rate of deforestation begins (Matemwe now has no forest) -Demand for stones for tourism industry; fuel wood and green pegs for seaweed farming contributed to the observed deforestation
1999	-Drought -Livestock die; food security compromised
2000s	-Government divides some farming land for house construction; farming land reduced
2005	-Seaweed production deteriorates; green pegs no longer available; conflict over ocean use with tourism investors
2008	-New local leader appointed
2009/10	-Drought; livestock die and crops die
2010/2011	-Farming land further divided for construction of district school
1995 to present day	-Wells that previously contain fresh water now contain salty water, especially along the shore. - Getting drinking water along the shore becomes difficult; the elderly and women more vulnerable because water is further away
They didn't give exact year	-Fishing deteriorates (high demand, illegal fishing, and external vessels for deep sea); people cannot afford to eat high-value fish; seafood such as octopus remain out of reach

APPENDIX II

PARTICIPATORY RISK MAPPING

1. THE OUTCOME OF THE PARTICIPATORY RISK MAPPING IN KIUYU MBUYUNI, PEMBA



In Kiuyu Mbuyuni is a piece of land that juts out into the ocean (see Appendix V). Geographically a piece of land like this is known as ras. Kiuyu Mbuyuni workshop participants classified the area into three main zones, as follows:

1. East zone

- Shore covered by white sand beaches, followed by natural forest with low concentration of mangrove forest.
- Unlike Matemwe, people do not inhabit the shore.
- This corridor has long been declared by the government of Zanzibar as an economic-free zone.
- Soils perceived to be not as good as those of the west corridor
- The zone mainly used for livestock rather than for crop farming.
- Most of the caves that contain water are located along this corridor, but most of the water is highly saline.
- Water in the caves in Kiuyu Mbuyuni is mainly used for livestock and not for households.

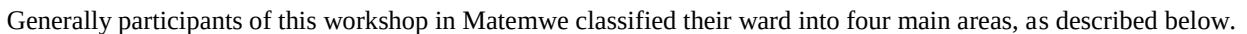
2. Central zone

- Densely inhabited with villages of this ward.
- Soils are good compared with east corridor.
- Most of the wells are in this area. Wells are located away from the shore and thus they are deep.

3. West zones

- This zone is located on west coast of the ward.
- Soils perceived to be good compared with east coast.
- Although rainfall is generally erratic during short rain-season, participants believed that this zone received better rainfall during this period than the eastern corridor.
- West zone consists of both mangrove and natural forest under conservation.

- ## 2. THE OUTCOME OF THE PARTICIPATORY RISK MAPPING IN MATEMWE, UNGUJA



- Covered by sand, not suitable for farming but good for coconut trees. Crops planted here are highly affected by drought.
- Large part of this area closer to the beach is now occupied by hotels and houses for rich people, mainly from town, thus the value of land in this area has increased tremendously. Some local people have sold their homes and coconut plots and moved away from the shore.
- Most local wells in Matemwe are located in this zone but they are prone to contamination (too shallow) and salt water inclusion (too close to the shore).
- The area is prone to cholera and diarrhoeal-related illnesses because pipe water supply is erratic.
- Local wells in this area are not very sensitive to dry conditions because of influence of sea water.
- Only one cave contains water, but the water is not used because of high saline levels (too close to the sea).

- Covered by coral rag soil (rocky kind of soil); most people along the shore use this area for livestock and farming.
- Fertility of the soil is not high, though it is better than Zone 1.
- The crop yield is lower here than in Zone 3 (maize is smaller along this corridor than in Zone 3)

- Small number of local wells; hard rock and distance from shoreline increases depth of water table; wells are sensitive to dry conditions as they were locally-made.
- Most of the caves in Matemwe are located in this corridor; although the cave water is somewhat saline, it is still used for household purposes. Water from one of the caves supplies one of the hotels along the shore.
- The value of land is increasing due to the demand for land for house construction, especially for the households that sold their homes along the shore. District government has also taken part of this zone and divided it into plots for house construction.

3. A suitable area for farming

- Most of the villages in Matemwe occupy this zone.
- Perceived to be covered with good soils compared with other zones.
- Again associated with small number of local wells due depth to water table (More time and energy spent collecting water than in the first zone where wells are shallow but more saline).
- Some local wells prone to dry up during dry season and droughts.
- The value of land here is lower than in the previous zones due to distance from the beach.

4. West corridor

- Unsuitable for farming compared with the third zone.
- Contains springs that supply piped water in the ward and tourism hotels along the shore.
- Availability of pipe water is unreliable.



**APPENDIX III
VULNERABILITY MATRIX**

A: KIUYU MBUYUNI, PEMBA

RESOURCES	RISKS						
	Drought	Variability of wind and storms	Sea level change	Shoreline change	Pest and disease	Human actions	Temperature
Fisheries	0	3	1	0	0	3	2
Coral	0	1	0	0	0	2	0
Mangrove	1	3	0	0	0	3	0
Grazing and pasture land	3	0	0	0	1	3	3
Coral rag forest	1	0	0	0	1	3	3
Farmland	3	1	0	0	3	3	1
Intertidal resources	0	0	0	0	0	3	0
Seaweed	1	3	3	0	3	1	3
Water	3	0	0	0	0	1	3

KEY TO THE INTENSITY OF THE RISKS: 3=SIGNIFICANT IMPACT, 2=MODERATE IMPACT, 1=LOW IMPACT AND 0=NO IMPACT

2. RANKING RISKS

Risks	1	2	3	4	5	6	7
Drought							
Human actions							
Temperature variability							
Diseases and pests							
Intensity of ne and se winds							
Sea level decline							
Shoreline erosion							

B: MATEMWE, UNGUJA

	RISKS					
	Drought	Variability of winds and storms	Sea level change	Diseases/pests for both animal and farming	Temperature of the ocean	Human actions
Fisheries resources	0	2	0	0	2	-
Coral	1	0	0	0	3	2
Mangrove	N/A	N/A	N/A	N/A	N/A	-
Grazing land and Pasture	3	0	0	2	0	1
Farming land	3					1
Intertidal resources	0	1	0	0	3	1
Seaweed	0	2	2	0	3	-
Water	3	0	0	0	0	-
Beaches	0	3	1	0	0	-

KEY TO THE INTENSITY OF THE RISKS: 3=SIGNIFICANT IMPACT, 2=MODERATE IMPACT, 1=LOW IMPACT AND 0=NO IMPACT

RISK RANKING

Risks	1	2	3	4	5	6
Drought						
Storms and wind patterns						
Diseases and pests						
Temperature of the ocean						
Sea level change						
Human actions						



APPENDIX IV

GROUP DISCUSSIONS

1. Livelihood ranking based on importance

KIUYU MBUYUNI, PEMBA	
Rank based on perceived importance	ACTIVITIES
1	Fishing
2	Livestock and crop farming
3	Seaweed farming
4	Small businesses
5	Informal and part-time job outside farming, fishing and seaweed farming
MATEMWE, UNGUJA	
1	Fishing
2	Seaweed farming
3	Crop farming and livestock
4	Tourism
5	Small businesses
6	Informal and part-time job outside farming, fishing and seaweed farming

2. Stressors affecting these livelihoods

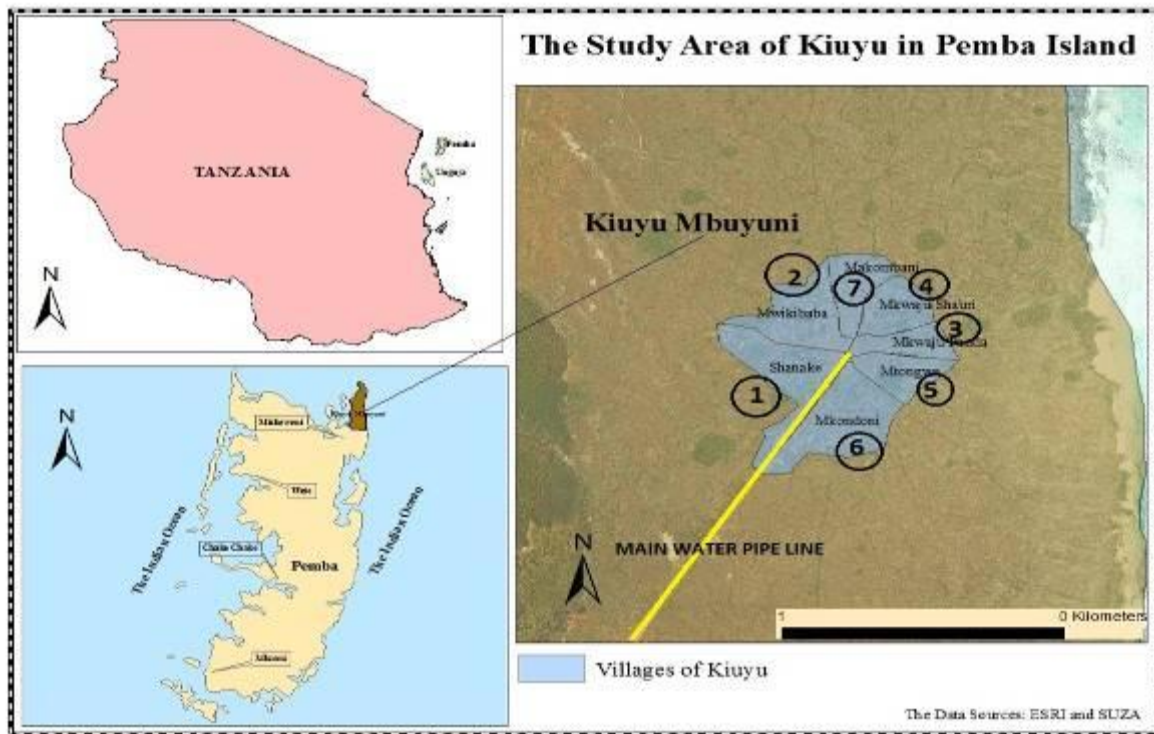
KIUYU MBUYUNI, PEMBA		
	ACTIVITIES	STRESSORS AS PERCEIVED BY LOCAL COMMUNITY
1	Fishing	Fish declined, low technology (small vessels and poor gear), sea has changed, access to credit
2	Livestock	No access to medicine to treat animal diseases, no access to medical facilities, poor performance of pasture due to unreliability of rainfall (caused death and declining milk production), increasing salinity of the water, grazing land too small to compete with crop farming
3	Seaweed farming	Low selling price, market is unreliable, larger number of people farming seaweed created smaller farming areas; sea has changed
4	Small businesses	Initial capital, lack of credit
5	Crop farming	Climate variability, warmer conditions, pests and disease, poor soils
MATEMWE, UNGUJA		
1	Fishing	Low technology, climate variability, illegal methods of fishing, poverty
2	Seaweed farming	Tourism, climate variability (increased temperature), selling price of seaweed, seaweed farming inputs
3	Livestock	Lack of credit, unreliable of rainfall, pests and diseases, livestock theft, poverty, solid waste from tourism hotels
4	Small businesses	Initial capital and customers. Food loans to the neighbours impact small food stores in the area
5	Crop farming	Climate variability, pests and disease, livestock destroy crops, poor soils, not enough land Increased value of land (result of expanding tourism); land used for social services (school) further reduced farming land



APPENDIX V

DISTANCE COVERED BY AN INDIVIDUAL FROM VILLAGES WITHOUT SUPPLY OF PIPE WATER TO VILLAGE WITH GOOD SUPPLY OF WATER IN BOTH SITES. ARC GIS WAS USED TO CALCULATE DISTANCE

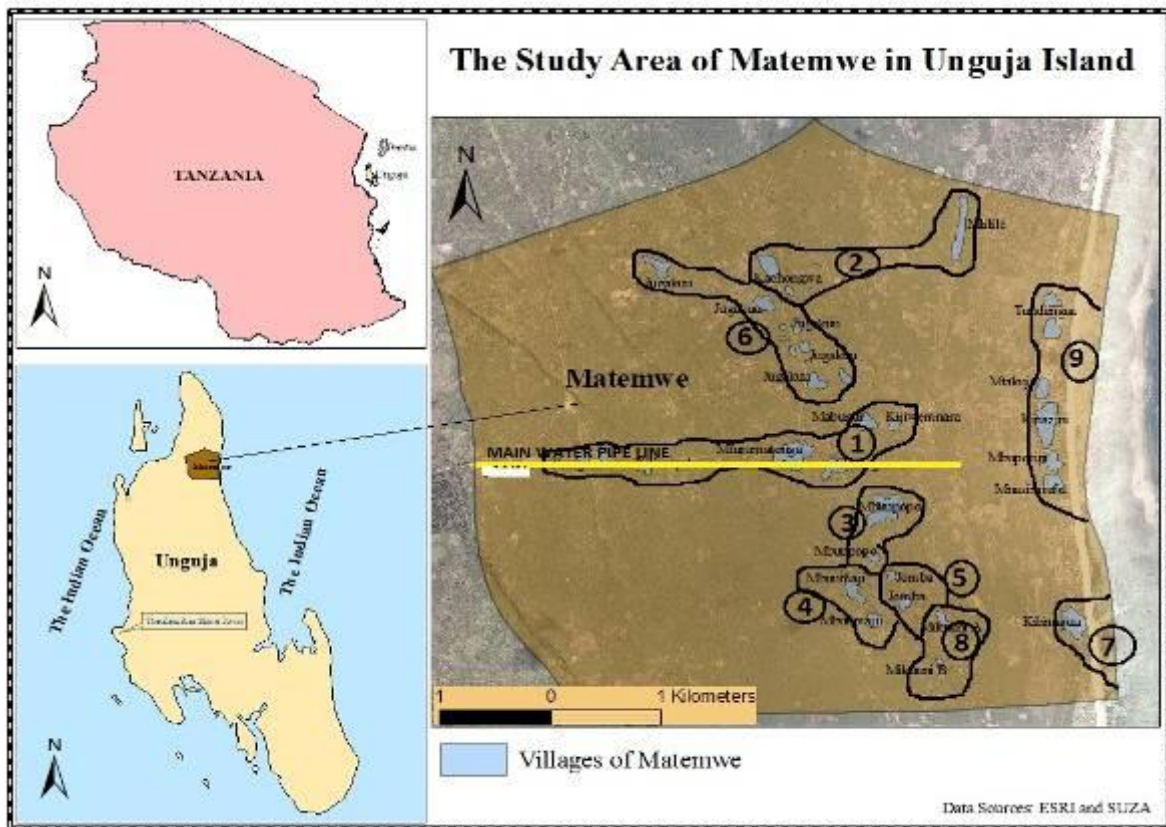
A. VILLAGES IN KIUYU MBUYUNI, PEMBA



The one way distance covered by an individual from the villages that experience difficulties in obtaining piped water to villages with available piped water in Kiuyu Mbuyuni, Pemba

	Villages with unreliable piped water supply	One way distance covered by individual from villages (2, 3, 4, 5 and 7) to village number 1 where water is available regularly	One way distance covered by individual from villages (2, 3, 4, 5 and 7) to village number 6 where water is available regularly water
2	Mwikibaba	256 m	479 m
3	Mkwaju panda	402 m	387 m
4	Mkwaju shauri	450 m	506 m
5	Mtongwe	368 m	270 m
7	Makombani	434 m	583 m

B-VILLAGES IN MATEMWE



The one way distance covered by an individual from the villages that experience difficulties in obtaining pipe water to villages with availability of pipe water in Kiuyu Mbuyuni, Pemba

S/n	Villages with unreliable piped water supply	One way distance covered by individual from villages (2, 3, 4, 5, 6, 7, 8, 9) to village number 1 where water is regularly available
2	Kachongwa	2469 m
3	Mbuyu popo	sporadically receive water supply
4	Mbuyu maji	1705 m
5	Jomba	1930 m
6	Juga kuu	1483 m
7	Kilima juu	3451 m
8	Mikuuni	2474 m
9	Tundangaa	2769 m