UNDERSTANDING THE COMPLEXITY AND DYNAMICS OF MANGROVE SOCIAL-ECOLOGICAL SYSTEMS THROUGH THE USE OF A RESILIENCE APPROACH IN UNGUJA, ZANZIBAR.

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A thesis submitted in partial fulfilment of the requirements of the University of Greenwich for the Degree of Doctor of Philosophy.

May, 2014

DECLARATION

I certify that this work has not been accepted in substance for any degree, and is not currently being submitted for any degree other than that of Doctor of Philosophy (PhD) being studied at the University of Greenwich. I also declare that this work is the result of my own investigations except where otherwise stated.

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ACKNOWLEDGEMENTS

I would like to take this opportunity to express my sincere appreciation to all organizations and people who contributed to the work embodied in this thesis. In particular, I am indebted to my employer, The State University of Zanzibar (SUZA) for offering me study leave and financial support through the World Bank project, to pursue my PhD studies for the entire period between 2010 and 2014. I am very grateful to my supervisors Dr. Tim C.B. Chancellor, Richard I. Lamboll and Professor Alan Cork for their friendly guidance and assistance throughout the study period. Their timely advice and continuous support have immensely contributed toward the completion of this thesis. The constructive and critical comments from my supervisors during presentation of data and revision of various drafts have boosted my knowledge and confidence in issues related to resilience of natural resources.

I am grateful to various SUZA colleagues including Ms. Biubwa F. Aliy and Aziza M. Abubakar for their support at the initial stage of village surveys and interviewing. Mangrove research assistants who were also the third year BSc students at SUZA particularly Mr. Kassim Ame, Fatma M. Ramadhan and Ali M. Kombo are highly acknowledged for their assistance and patience to work in the difficult and impenetrable mangrove habitats in 2013.

I am extending my sincere thanks to the Zanzibar Government officials, particularly the Department of Forestry and Non-Renewable Natural Resources (DFNRNR), for providing research permit, access to information and members of staff which facilitated the process of data collection undertaken for this study. Special thanks should go to the Director of DFNRNR Mr. Sheha Hamdan, Department of Fisheries and Environment, a MACEMP Coordinator, and HIMA representatives for providing background information and sharing their experiences and knowledge relevant to my study. I also very thankful to Mr. Ali Kassim, the head of survey section and other members of the inventory team at the DFNRNR for their tremendous support in mangrove biophysical surveys and Mr. Mwalimu M. Juma from the Department of Statistics for his great assistance on data entry and analysis. Special thanks should go to Fakhar Khalid of the Centre for GIS and Remote Sensing in the School of Science and Roman Zipaj from NRI for assisting with the preparation of maps. My gratitude also goes to the office and management staff of NRI colleagues in Blake 304 for their cooperation and various kinds of assistance which contributed to the accomplishment of this work.

This work would not have been possible without the support of the members of the coastal communities from Pete-Jozani, Michamvi and Charawe Shehia. I am very grateful to village respondents for their time, knowledge and participation in data collection. In particular those who collaborated effectively with me in conducting this study including Village Shehas, their assistants and head of village conservation committees from all my study sites. I would also like to thank local village guides for their assistance in help accessing respondents and organizing mangrove inventory field trips. Among them Mr. Omar Ame (Charawe), Mr. Simai Ame (Pete) and Ali Said (Michamvi) are worthy of special mention.

I would like to express my heartfelt appreciation to my dear ones, particularly my husband, my parents and children for their love, tireless support and encouragement. I am very grateful to you for bearing with dignified patience my long absence from home. To all of you I say thank you very much (*Ahsante sana*).

Last but the first in orientation, I thank the Almighty Allah, who gave me courage and strength to accomplish this important work.

ABSTRACT

There has been growing concern by policy and other decision makers that timber extraction by local communities is the main threat to achieving sustainable management of mangrove systems in Unguja Island, Zanzibar, Tanzania. However, this concern, and responses to the perceived threat to date, do not appear to be informed by a clear understanding of the complexity and capacity of mangrove Social-Ecological Systems (SES) at different scales to adapt to this and other disturbances. The aim of this study was to assess the resilience of mangroves to the increased demand for provisioning ecosystem services and other drivers with a view to identifying options for sustainable mangrove management on Unguja Island.

This study was guided by broad resilience concepts and specific approaches, particularly the components-relationship-innovation-continuity framework developed by Cumming et al. (2005). Data relating to both social and ecological components of the mangrove system was collected. A total of 185 plots were surveyed within mangrove forests from three case study sites of Pete-Jozani, Charawe and Michamvi Shehia (lowest administrative unit) on Unguja Island in which mangrove tree species, diameter and height of trees, the numbers of seedlings and stumps were collected to assess the ecological condition of the forests. Key informant interviews (with government officials and village stakeholders), semi-structured household interviews, village meetings and focus group discussions (with beekeepers, mangrove harvesters, village elders and village conservation organisations) were used to collect social-economic data from the three case study sites.

The results showed that between the 1920s and 1970s at each case study site local communities reported that they were able to obtain diverse ecosystem services while the key variables that defined the identities of the mangrove SES were maintained. The mangrove SES from each case study site was found to have changed over the past three decades in temporal and spatial scales and currently reside at different phases of change. The current mangrove ecological systems of Pete, Charawe and Kinani (part of Michamvi) were found to have been degraded compared to the past. This was evidenced by the quality and quantity of trees present, with a relatively high density of small-sized mature trees with correspondingly small basal areas and volumes, together with significant numbers of tree stumps in the ecosystems. The areas covered by mangrove vegetation in the study sites were also found to have declined. The decline in quality and quantity of trees was found to correspond with a reduction in desirable ecosystem services as reported by communities. The levels of dependence on mangrove wood provisioning ecosystem

services and management approaches have changed across the case study sites. Excessive rates of harvesting of mangrove wood were identified as the key direct driver on mangrove ecological systems, which was fuelled by several underlying drivers including poverty, population change, limited livelihood activities, inappropriate management regimes, and markets for trading mangrove wood ecosystem services. Vijichuni mangrove (another part of Michamvi) was found to be an exceptional case whereby the quality and quantity of mangrove ecological variables had improved. Availability of reliable alternative income sources by the majority of villagers and effective management institutions had contributed to these changes.

The drivers identified were used to develop three alternative future scenarios to explore whether projected changes will result in the mangrove SES maintaining their identities in the future. The findings suggest that the Non-inclusive State Control scenario strictly conserves the mangroves, but does not provide alternative livelihood opportunities to improve the well-being of local communities and so is not desirable. Coastal Boom scenario, characterised by unregulated economic growth, particularly in the tourism sector and community forest management with limited benefits for local communities, results in complete degradation of mangrove and reduced wellbeing of local people. However, the Techno-green scenario which includes green growth, access to low-cost cooking energy and co-managed mangrove forests with benefits for local communities, provides decision makers and other stakeholders with an alternative pathway towards more resilient mangrove SES in Unguja.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF ABREVIATIONS

CBNRM	Community Based Natural Resources Management
COFMA	Community Forestry Management Agreements
DBH	Diameter at Breast Height
DFNRNR	Department of Forestry and Non Renewable Natural Resources
EIA	Environmental Impact Assessment
FGD	Focus Group Discussion
FRMCA	Forest Resources Management and Conservation Act
ICAM	Integrated Coastal Area Management
HIMA	Hifadhi Misitu ya Asili ya Jamii – means Conservation of Community Natural Forests
JCBCA	Jozani Chwaka Bay Conservations Area
JCBNP	Jozani – Chwaka Bay National Park
JECA	Jozani Environmental Conservation Association
JOCDO	Jozani Conservation and Development Organisation
KII	Key Informant Interview
MACEMP	Marine and Coastal Environment Management Project
MEA	Millennium Environmental Assessment
NBS	National Bureau of Statistics
PES	Payment for Ecosystem Services
REDD$^+$	Reducing Emission from Deforestation and Forest Degradation
RGoZ	Revolutionary Government of Zanzibar
SEA	Strategic Environmental Assessment
SES	Social- Ecological System
SONARECOD	Society for Natural Resources Environmental Conservation and Development
TAF	Tanzania Association of Foresters
UWEMAJO	Umoja wa Wenye Mashamba Jozani – means Farmer owners Association in Jozani
VCC	Village Conservation Committee
WEZA	Women Empowerment Zanzibar
ZEMSDA	Zanzibar Environmental Management and Sustainable Development Act

Chapter 1

INTRODUCTION

1.1 Introduction

Human and natural systems interact and are linked at different temporal and spatial scales to form complex social-ecological systems (SES). A SES may be defined as a system that includes societal (human) and ecological (biophysical) subsystems in mutual interaction (Gallopin, 1991). Like any other relatively undisturbed natural system mangrove represents a complex and dynamic social-ecological system that provides ecosystem goods and services to meet the interests of stakeholders (Daily and Matson, 2008). The linkages between social and ecological systems result mainly from the influence of human activities to meet their demand for ecosystem services from mangroves.

Ecosystem services are the benefits that people derive from natural systems (MEA, 2005). These include provisioning services such as crops, water, wood, fish; regulating services (e.g. pollination, erosion regulation, climate regulation, and water and air quality regulation); support services (e.g. supporting other systems like coral reefs) and cultural services, such as aesthetic and spiritual fulfilment (MEA, 2005, Hein *et al.,* 2006). Ecosystem services provided by mangrove ecosystems include: the provision of materials that have direct economic value to communities such as wood, fodder, gums (Warren-Rhode, 2011); support to a wide variety of other coastal ecosystems such as sea grass bed, coral reefs; prevention services such as control of beach erosion, protecting coastal areas from tsunamis or high tide by absorbing wave energy (Alongi, 2008; Walters *et al.,* 2008) and cultural services such as education, recreational and aesthetic values (FAO, 2007). Mangrove plays a significant regulating function such as biodiversity conservation, accumulation of sediment, contaminants, nutrients (Alongi, 2002) and climate regulation through atmospheric carbon sequestration (Ray *et al.,* 2011; Warren-Rhode, 2011).

Zanzibar mangrove ecosystem services have similarities to those of other mangrove systems outside the Islands, although they vary according to the local context. Mangrove system provisioning services, especially those based on wood material for the local communities, meet a variety of purposes, such as house construction, firewood, charcoal, lime making, boat building and traditional medicines (Ngoile and Shunula, 1992; Madeweya *et al.,* 2002). They support traditional fishing practice in that approximately 80% to 90% of local fishing is concentrated in waters close to mangrove vegetated areas, creeks and bays (Shunula, 2001). Many coral reef fish and prawns rely on mangrove areas as nursery grounds for juveniles (Shunula and Semesi, 2001). Mangroves also help prevent coastal erosion and stabilize shorelines providing protection from damaging storm and hurricane winds, waves, and floods (Ngoile and Shunula, 1992).

Despite the benefits offered to the environment and societies, mangrove systems are among the most threatened and vulnerable ecosystems worldwide (Spalding *et al.,* 2010). For example, Alongi (2002) reported that over the last 50 years alone, about one-third of the world's mangrove forests have been lost. The loss of Tanzania mangrove has been relatively low. In Tanzania mainland the total mangrove area of 1,455 hectares (which is 1.26% of the total mangrove area) is reported to have declined between 1990 and 2000 (Wang *et al.,* 2003). However, in Zanzibar, it is widely reported that the total area of mangrove forest has been significantly reduced. Taylor et al. (2003) reported Michamvi area had 800 hectares of mangrove forests in 1949 and just 43 hectares in 1989, while Maruhubi had 1,040 hectares in 1949 and just 76.5 hectares in 1989. The cause for the decline of mangrove area at Maruhubi was the conversion of mangrove forest for the construction of a ferry terminal in Zanzibar city. Recent surveys indicated significant reduction of Zanzibar mangrove forest area from 20,000ha in 1950 to 17,357ha in 2010 (SONARECOD, 2010) to 16,488ha in 2013 (RGoZ, 2013). These reductions make the current area of mangrove of 5,274ha and 11,214ha for Unguja and Pemba Islands, respectively (ibid, 2013). The lost mangrove area excludes the 525 hectares replaced by different mangrove afforestation programmes in Zanzibar (SONARECOD, 2009).

'Sustainability' and 'resilience' are two concepts used to explain the nature of complex SES. Much of the current conservation literature uses the concept of sustainability. This has different meanings to different people, but mostly evokes a positive reaction and is considered a desirable state by most stakeholders (Callicott and Mumford, 1997; López- Hoffman *et al.,* 2006) such as, 'maximum sustainable yield 'or 'Sustainable development'. Sustainability may be defined as the ability to maintain something undiminished over a period of time (Lele and Norgaad, 1996). Through an ecological-economic lens, the concept of sustainability is increasingly being focused on achieving efficiency in economic production to support human life indefinitely, but without destroying the diversity, complexity and function of the ecological life support system (Sneddon, 2000).

Application of the term sustainability to the use of resources may be considered in terms of a 'perception' concept that depends on the values and interests that each stakeholder has attached to the resources. For example, in the western Venezuela mangrove, López-Hoffman et al. (2006) noted that mangrove 'sustainability' was defined differently between the mangrove harvesters and the ecologists, reflecting differences in values between them. While the ecological definition of sustainable mangrove harvesting was considered to be the harvesting level that allows numbers of trees to be maintained or to increase over time, mangrove harvesters defined sustainable harvesting as levels permitting the maintenance of the number of mangrove trees over two human generations, about 50 years (ibid). In this way, sustainability evokes an overarching goal that includes assumptions or preferences about which system states are desirable (Carpenter *et al.,* 2001).

Despite the greater application of sustainability concepts to natural resource management, Cumming et al. (2005) argue that progress toward the goal of long term sustainability depends on understanding the dynamics of linked social and ecological systems. In this context sustainability is not achieved through sustaining production of biological resources alone, but requires management actions and plans that take into account the complex relations, drivers and external shocks that would lead to avoidance of unexpected results (Holling and Meffe, 1996). Sustainability also requires maintaining the functionality of a system when it is perturbed, or maintaining the elements needed to renew or reorganize if a large perturbation radically alters structure and function (Walker *et al.,* 2002); a phenomenon that can be explored well using the concept of resilience. Resilience is the central concept that provides a highly reliable way of analysing social-ecological change and addressing the challenges of sustainability (Carpenter *et al.,* 2001; MEA, 2005). This is because the resilience concept takes into consideration ecological, social or economic dynamics in the system which can be expressed and measured in ways specific to particular situations or systems and develop options to prevent the system from moving toward undesirable regimes (Gunderson and Holling, 2002). However, to determine measurable variables for assessing resilience of complex systems is difficult, due to the abstract and multidimensional nature of the resilience concept. This makes it necessary to develop a simplified framework to operationalise the concept in the field of studies (Cumming *et al.,* 2005). Resilience is the core of the SES approach to manage human–nature relations (Glaser *et al.,* 2000) that may also be evoked in the studies of mangrove SES.

The term resilience has been evolving and is defined differently by various scientists. Resilience has multiple levels of meaning: It can be considered as metaphor related to sustainability focused on stability and efficiency of the system (Holling, 1973). It can be defined as the magnitude of disturbance that can be tolerated by the system before a social-ecological system (SES) moves to a different region, state, or space controlled by a different set of processes (Carpenter *et al.,* 2001). Resilience also reflects a property of dynamic models, and is a measurable quantity that can be assessed in field studies of SES (ibid, 2001, Gunderson and Holling, 2002; Walker *et al.,* 2002; Cumming *et al.,* 2005). Cumming et al. (2005) came up with a simplified definition that has also been adopted in this study. They defined resilience as 'the ability of a system to maintain its identity in the face of internal change and external shocks. System identity is defined as the property of the key components and relationships (networks), their continuity through space and time, innovation and memory of the SES (ibid)'. This definition has been adopted in this study because it helps to more clearly define which variables can be measured in assessing changes and resilience of complex SESs.

The application of resilience concepts needs to be considered in more specific terms, including answering the questions of resilience of 'what' to 'what' (Carpenter *et al.,* 2001, Cumming, *et al.,* 2005). When a resilience concept is applied to mangrove SES it refers to the capacity of mangrove ecosystems to maintain the supply of desirable ecosystem services in the face of human use and a fluctuating environment. To answer the question of resilience 'of what', Cumming et al. (2005) present four attributes or indicators that clearly define the identity of a SES and need to be maintained for a resilient SES. Thus the SES is said to be resilient if it is able to maintain: the components that makes up the system; the relationship between the components; the ability of both components and relationship to maintain themselves continuously through space and time and the innovation and self-organisation of the system. On the other hand, the answer to the question 'to what' represents the specific drivers (internal changes and external shocks) that are likely to change the systems' configuration (ibid). Applying this concept to mangrove, it refers to the capacity of the mangrove SES to retain its identity when exposed to internal and external drivers of change. In this context, resilience application provides a new way of understanding complex mangrove systems and suggests new approaches to managing mangrove resources (Glaser *et al.,* 2000).

Unlike sustainability, resilience can be desirable or undesirable. For example, a system that ensures continuous provision of clean water can be desirable. In other situations, system states that decrease social welfare, such as polluted water supplies or dictatorships, can be highly resilient but undesirable (Carpenter *et al.,* 2001). Some social systems may be resistant, yet not resilient; i.e. they do not allow for self-organisation and learning, but some undesirable ecological configurations may indeed be both resistant and resilient (Carpenter *et al.,* 2001; Walker *et al.,* 2002). Resilience concepts address the role of multiple scales of system dynamics and examine the feedbacks within and between the social and ecosystem domains (Walker *et al.,* 2006). This means that a resilient ecosystem should be able to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks (Walker *et al.,* 2004; Walker *et al.,* 2006).

Management approach is one key issue that can determine the resilience and sustainability of a SES. Management approach can either destroy or enhance the resilience and sustainability of a SES and its ecosystem services, depending on how the SES organizes itself in response to management actions (Folke *et al.,* 2002). There are different natural resource management approaches that influence human and ecosystem behaviours. Like any other complex common pool resource, mangrove SES can be either managed exclusively by local communities guided by their informal institutions (e.g. using social taboos) without any government interventions (Colding and Folke, 2001) or through a completely regulated approach whereby the Government (or other managing authority) is the sole organ responsible for formulation and implementation of laws and regulations related to management (Mangora, 2011). Also, mangrove SES can be managed through different combinations of both formal and informal institutions (e.g. Community Based Natural Resources Management or co-management) where a group of users share authority with the Government to formulate a set of design principles for resource management mainly implemented by local communities (Ostrom, 1990).

Similarly, there is a wide range of management approaches that have been practiced to manage Zanzibar's mangrove SESs. Before the 1940s Zanzibar mangrove was managed by local communities who were using mangroves for subsistence needs, despite the extensive uses of this ecosystem by the colonial government for commercial exploitation of bark and poles for exports. Zanzibar mangrove ecosystems have been managed under formal institutions, whereby the mangrove forests were considered as public land, since 1949 (Griffith, 1950). Mangroves then declared as a forest reserve by the Zanzibar government after independence in 1964. In this management system most of the mangroves were owned and completely managed by central government as an open access resource whereby existing forest policy and laws were implemented by the Department responsible for forests [currently this is the Department of Forestry and Non-Renewable Natural Resources – (DFNRNR)]. This is the dominant approach to ownership and management of most of the mangrove forests throughout Zanzibar (Madeweya *et al.,* 2002). Apart from the main management approach, some mangrove patches, especially Chwaka Bay which is composed of two blocks, Mapopwe and Kinani, were managed through an alternate 10 year 'closing and opening scheme' of mangrove harvesting [though this has been banned since 1990 following the Jozani Chwaka Bay National Park (JCBNP) declaration]. Other forest mangrove areas were managed under community-based management arrangements. In the latter approach most of the communities living close to the forests were persuaded by government to formulate local organisations [Village Conservation Committees (VCC)] and village bylaws called Community Forest Management Agreements (COFMA) for management and conservation of forest, but not necessarily including mangroves, while the resources ownership still remained under government jurisdiction. This approach has had very limited application to mangrove SESs in Zanzibar because of the ecosystem being declared as forest reserves or promoted to the status of National Park.

However, the application of any of these approaches does not necessarily ensure the resilience of the Mangrove SES. The reason behind this is that most of the early and current management approaches were strongly shaped by the conventional top down, efficiency-focused, optimum state approach through application of optimizing models of natural resources management outside of the area of its origin (Walker and Salt, 2006). These models were applied without taking into consideration the contextual understanding of the dynamic changes and interactions of SES between and across spatial and temporal scales. The resilience of management approaches depends on how management actions and actors are capable of coping with ecosystem dynamics and environmental feedbacks (Berkes and Folke 1998). It may be argued that this is achieved through adaptive management that allows the management system to learn from experience and to adopt to change (Folke *et al.,* 2002). The aim of resilience management and governance is to keep the system within a particular configuration of states that will continue to change and deliver desired levels of ecosystem goods and services, and prevent the system from moving into undesirable configurations from which it is either difficult or impossible to recover (Walker *et al.,* 2002).

1.2 Problem statement and justification

Zanzibar mangrove has been managed using different approaches since the 1920s (ranging from those practiced under full community initiatives, full government control to those allowing some level of community participation) without giving any current insight to achieving sustainable ecosystem services and well-being of the system. Many mangrove areas have been destroyed and many others are under threat of destruction (Ngoile and Shunula, 1992; Ely *et al.,* 2000; SONARECOD, 2010). It has now become a dominant view held by scientists, policy and other decision makers that Zanzibar mangrove suffers from severe degradation through cutting of wood material by local communities (ibid, 1992; Ely *et al.,* 2000; Jumah *et al.,* 2001; Madeweya *et al.,* 2002, Mohammed, 2004). This has been caused by excessive cutting of mangrove trees to meet the ever increasing demand for wood resources especially for building poles, charcoal and firewood. The Zanzibar energy balance survey of 2007 indicated that 95% of energy sources came from fuel wood biomass, with petroleum products contributing 3% and electricity 2%, and demand for wood fuel in Zanzibar town is about 1.5 million m^3 per year (Magessa, 2008). Earlier studies suggest that the expanding human population has taken its toll on mangrove forests in Zanzibar, as the trend of mangrove product utilization closely follows demand in response to population growth. For example, Zanzibar's population has almost quadrupled from 354,815 in 1967 to 1,303,569 with a current annual growth rate of 2.8% (NBS, 2012). Total mangrove volume for the whole of Zanzibar in 1990 was estimated to be about 640,000 m^3 while the demand for mangrove wood products in 1996 was equal to 66,702 m^3 (Leskinen *et al,* 1997). More recent work indicated the relative increase of mangrove volume to 792,485 m^3 with a dramatic increase in mangrove demand to 1,111,908 m^3 per year (SONARECOD, 2009). Out of the total mangrove demand, about 65% of Zanzibar mangrove wood product is imported from mainland Tanzania to Unguja (SONARECOD, 2010). Thus, without these imports the situation in terms of potential supply in relation to demand suggests that the Unguja mangrove system is completely unsustainable.

Several efforts have been undertaken in recent years to address this situation. These include emerging new ideas such as strengthening restrictions on use of resources (ban of 'opening and closing' harvesting system), advocating different use of alternative ecosystem services to replace the traditional mangrove resources exploitation activities, accompanied by the formulation of a new Mangrove Management Plan (SONARECOD, 2010). The emerging question is why, despite application of different management approaches and allocation of a substantial amount of resources and efforts for management of SES, most of these management practices result in unsustainable resource use. Similarly, it is not clear to what extent traditional human uses and management practices influence the capacity of Zanzibar mangrove SES to maintain its identity. It is also not clear to what extent the newly introduced ecosystem services-based interventions will yield economic returns to local people that will compensate for the loss of benefits obtained from traditional mangrove ecosystem services to improve the well-being of people (increase social resilience) and the response of the mangrove ecosystem to these changes (ecological resilience). Thus application of resilience thinking on the management of the system is expected to offer likely options that will enhance SES resilience for sustainable management of the supply of goods and services in a world characterised by dynamic change (Gunderson and Holling, 2002).

A review of the Zanzibar mangrove literature reveals several studies have been well documented with species lists, distribution, zonation and planning and uses of mangrove forests and associated fauna (e.g. Griffith, 1949; Ngoile and Shunula, 1992; Machiwa and Hallberg, 1995; Shunula, 1996; Olasfsson and Ndaro, 1997; Shunula and Whittick, 1999; Shunula, 2001; Mohammed and Johnstone, 2002; SONARECOD, 2009; 2010). Most of these studies concentrated on current practices of sustainability-related management approaches and analysed the impact of human activities in ecological systems without taking into account the interdependence, complexity and interaction between the system components and how they respond and adapt to changes.

A number of studies have been done to address changes in ecosystems, including a comprehensive global assessment of the world's major ecosystems and their consequences for human well-being (MEA, 2005). Other studies specifically address changes in mangrove ecosystems in the developed world (Alongi, 2002; Polidoro *et al.,* 2010) and a study on the Tanzania mainland (Wang *et al.,* 2003). Comprehensive studies analysing linkages between the social and ecological components (Crona, 2006) and resilience in SES have been conducted mostly in developed countries (Berkes and Folke, 1998; Carpenter *et al.,* 2001; Folke *at al.,* 2002; Berkes *et al.,* 2003; Anderies *et al.,* 2004; Cumming, *et al.,* 2005,) including those specifically addressing resilience linked to mangrove SES (e.g. Adger, 1997; Krause, 2002; McLeod and Salm, 2006). Apart from the study done by Saunders et al. (2010) which investigated the forces dynamically influencing institutional and mangrove forest cover change at Kisakasaka village between 1984 and 2005, there are no other studies that have investigated the changes in Zanzibar mangrove SESs. The mangrove cover changes in the Saunders et al. (2010) study were not analysed using a social – ecological framework that would indicate the linkages between the mangrove ecosystem and the people who are directly or indirectly depending on and/or influencing these systems and their responses to both internal changes and external drivers. Indeed that study did not analyse the effects of human induced impact on maintaining resilience of mangrove SES.

With the increasing pressure on the mangrove system, mainly caused by anthropogenic activities in Unguja, it is not known how mangrove SES will respond to these on-going disturbances, stresses or shocks. There have been no systematic studies of the extent to which the perceived problem of increased demand for mangrove provisioning services is shared by diverse stakeholders with different and competitive values regarding mangrove resources. In addition, despite the fact that a number of development interventions have aimed to reduce the rate of dependence on mangrove provisioning services and compensate people's conservation efforts, their efficiency is uncertain. Therefore, it is of critical importance to analyse to what extent human uses and conservation practices impact the resilience of mangrove SES in Unguja so as to better understand changes and prevent the system from shifting to alternative and undesirable states. One way of exploring this is through application of resilience concepts to assess the capacity of mangrove ecosystem to supply the desired ecosystem services in the face of increasing internal and external pressures which is the focus of this study.

A conceptual framework that defines the major attributes which describes the current state for resilient mangrove SES has been developed. The study also explores the dynamic of changes of Mangrove SES, external drivers of the changes, responses of the ecosystem and actors to changes and evaluates the existing and potential responses that can improve the Unguja mangrove into more resilient SES. It is hoped that the resilience approach used in this study will provide a contemporary way of analysing complexity and dynamics of mangrove ecosystem and its implication to achieve resilient mangrove SES in Zanzibar using an integrated and holistic framework in the context of a linked social – ecological system.

1.3 Research Objectives

1.3.1 General aim

The aim of this research is to investigate the resilience of mangrove to the increased demand for mangrove provisioning ecosystem services and external drivers and shocks in order to develop options for sustainable management of mangrove in Zanzibar.

1.3.2 Specific objectives

The specific objectives of the study are to:

1. Determine the current state of mangrove SES (Mangrove SES identity) including:
    - The structure and components of the system
    - Linkages and interactions between and within mangrove ecosystems and stakeholders for resilient management of the system
    - System continuity
    - Innovations
2. Investigate changes that have occurred in the mangrove SES over time.
3. Investigate the factors that have driven changes in mangrove SES into the current state.
4. Examine and evaluate the impact of changes on maintaining the identity of mangrove SES with respect to the supply of and access to ecosystem services.
5. Examine the existing and potential responses that can be implemented to improve the resilience of the mangrove SES to meet the need of diverse stakeholders.

This chapter has described the background information and central concerns of the thesis. Since the thesis is focused on the application of resilience theories to assess complexity and dynamics of mangrove ecosystems and the implications for the supply of ecosystem services, it is important that the general information on mangrove SES and the main theories and approaches used in this study are elaborated. Chapter Two does this by introducing resilience and related concepts and how they can be used in this study to address the study objectives.

Chapter 2

LITERATURE REVIEW

This chapter reviews the general condition of mangrove SES, theories and approaches used for management of mangroves and how the resilience concept can be used as a methodological approach to assess the resilience of mangrove social-ecological systems.

2.1 General overview of Mangrove Social-Ecological System

A mangrove social-ecological system is a complex system composed of two components; the ecological and social. An ecosystem or ecological system is a dynamic complex component of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit (MEA, 2005). A mangrove ecosystem or 'mangal' refers to mangrove communities of plants, animals and the interactions within the system (Duke, 1992). Mangroves represent taxonomically diverse groups of salt-tolerant, flowering plants growing in the intertidal zones of marine coastal environments along tropical and subtropical regions (Ellison and Stoddart 1991; Duke *et al.,* 1998; Giri *et al.,* 2011). The social component is composed of the stakeholders and their institutional rules which influence the ecological system to provide ecosystem services for the benefit of humans. There is increasingly recognized evidence that understanding and anticipating the behaviour of the social and ecological components of the SES in many cases requires simultaneously taking into account both components, which raises the need to investigate the whole SES (Berkes and Folke, 1998; Folke, 2006).

In this context, a social-ecological system (SES) is defined as a system that includes societal (human) and ecological (bio-physical) subsystems in mutual interaction (Gallopin, 1991). A social-ecological system needs to be specified at a range of scales; from the individual, community and its surrounding environment to the global system constituted by the whole of humankind. When this concept is applied to mangrove systems, a mangrove SES may be defined as a complex and dynamic system consisting of strong coupled relationships between the ecological component (mangrove ecosystem structure and function) and the social component that through their activities strongly shape the mangrove ecosystem on which they depend.

Ecosystems range from highly productive to non-productive degraded systems. For example, productive mangrove ecosystems are found in north-eastern Queensland which receives high rainfall which supports the growth of tall trees (up to 40 meters), of high species diversity with a closed canopy (Field *et al.,* 1998; Zann, 2000; Alongi, 2002; FAO, 2007). These productive ecosystems, with their array of services, provide people and communities with resources and options they can use as insurance in the face of natural catastrophes or social upheaval. On the other hand, less productive mangrove areas are found in areas that are drier, have increased water and salinity stress and produce shorter mangrove trees (1-5 meters), with open canopy and lower leaf litter and organic matter productivity (FAO, 1994; Field *et al.,* 1998; Zann 2000; Alongi, 2002).While well-managed ecosystems reduce risks and vulnerability, poorly managed systems can exacerbate them by increasing risks of excessive degradation and resulting decline of ecosystem services (MEA, 2005).

2.2. Mangrove distribution, Species diversity and Zonation

Climatic factors such as temperature and moisture affect mangrove distribution (Saenger and Snedaker 1993). Other factors that determine and control mangrove distribution include salinity, sediments and wave energy (Tomlinson, 1986), tidal fluctuation (Ong and Gong, 2013). Mangroves are distributed latitudinally within the tropics and subtropics, reaching their maximum development between 25°N and 25°S (FAO, 1994). The growth of mangrove is bordered between major ocean currents, by water temperature greater than 24ºC in the warmest months (Duke *et al.,* 1998) and where the seawater temperature is not less than 20°C in winter (Field *et al.,* 1998; Alongi, 2002). In Tanzania mainland and Zanzibar Islands, mangroves occur along the continental coastal areas of Tanga, Mtwara, Kilwa, Dar es Salaam, (Semesi, 1992) Pemba, Unguja islands (Shunula, 2001) and in a few small Islands of Zanzibar such as Kwale and Chumbe.

Globally, mangrove, accounting for 0.7% of total tropical forest, covered a total area of 13,776,000 hectares in 2000 in 118 countries and territories. Approximately 75% of these mangroves are concentrated in just 15 countries with the largest extent of mangroves in Asia and Africa followed by North and Central America (Giri *et al.,* 2010). The Sundarbans mangrove is the world's largest forest ecosystem covering a total of 2,040,000 hectares. Tanzania mainland has about 175,200 hectares of mangrove reserves, out of which only 115,901 hectares are occupied by mangrove vegetation (Semesi, 1992). The Rufiji Delta represents the largest mangrove area in East Africa covering an area of 53,255 hectares, which is about 46% of the total mangrove area in Tanzania (ibid, 1992). Zanzibar has a total of 16,488 hectares of mangrove forests which cover only 7.4% of the total land area and 15% of the total forested land

(RGoZ, 2013). Unguja Island has a total mangrove forest area of 5,274 hectares (ibid, 2013) represented by several patches which are scattered throughout the Islands with the largest mangrove areas found in Chwaka Bay followed by Menai Bay mangrove reserves covering an estimated area of about 2,132ha and 988ha respectively (SONARECOD, 2009).

Mangrove ecosystems are relatively low in tree species composition compared to other types of forest systems. Globally, mangrove ecosystems consist of about 70 mangrove species in 20 genera, from 17 families (Tomlinson, 1986) with the highest species diversity found in Asia, followed by Eastern Africa. A total of 10 mangrove tree species (Table1) from 7 families are found in the Western Indian ocean and East African Region including Zanzibar (Shunula and Semesi, 2001; Madeweya *et al.,* 2002). These different species of mangrove exhibit different and variable characters; in particular growth rate, coppicing ability and growth requirements that enable them to grow and adapt in the system (Table 1). For example, *Sonneratia alba*, *Avicennia marina* and *Lumnitreza racemosa* are good colonisers on exploited mangrove stands due to their ability to re-sprout/coppice from surviving stems (Brown, 2007; Walter *et al.,* 2008). In contrast the adult trees of *Rhizophoraceae* family cannot be coppiced because they lack a reserve meristem (Tomlinson, 1986) and therefore their regeneration requires replacement by successful seed dispersal and new seedling establishment (Kairo *et al.,* 2002). Other physiological adaptations include trees with aerial roots for gaseous exchange, anchorage and high nutrient absorption; salt excretion glands to desalinate ocean water and vivipary of seeds for efficient reproduction system (Tomlinson, 1986). Mangrove ecosystems is also characterised by sediments deposition with a degree of soil anoxia, pH (neutral to acidic), predation and competition (Smith, 1992).

Despite relatively low biodiversity, plants in mangrove forests have a broad range of structural and functional attributes which promote their survival and propagation in the relatively harsh conditions of the intertidal zone. In this sense, the diversity of mangrove plants is not measured in terms of number of species, but in terms of the ability of each species to cope with the wide range of environmental conditions by utilizing their individual specialised attributes (Duke *et al.,* 1998).

Table 1 Mangrove species of Zanzibar

Scientific name (Swahili name) and Family name	Description	Growth behaviour and functional role	Regeneration and coppicing ability	Physiological adaptation	References
*Rhizophora mucronata – RM (*Mkoko magondi) *Rhizophoraceae*	Attains a height of 15m and can be easily recognised by its aerial, bowed, stilt roots, many of which arise from quite high on the trunk and branches, and by its viviparous seedlings. Leaves are simples of deep green colour with blunt tips.	Light demander, with stand competition in open area, grows fast	Lacks coppicing ability – need natural seed dispersal by water due to buoyancy of propagules or artificial replacement	Viviparous germination and has stilt roots	Juncosa, 1982 in FAO, 2007 Tomlinson, 1986; Kairo *et al.*, 2002; Duke *et al.*, 1998 Richmond, 2002.
Bruguiera gymnorrhiza – BG (Msisi/Mfinzi/ Mui Mchonga) *Rhizophoraceae*	Grows up to 24m high and can be recognised by its buttressed trunk, close set foliage, dark bark and viviparous seedlings. It has kneed roots that appear sporadically out of the soil.	Light demander, withstands competition in open area, and grows fast.	Lack coppicing ability – needs natural seed dispersal by water due to buoyancy of propagules or artificial replacement.	Viviparous germination, with thick and short propagules, buttressed roots and knee roots pneumatophores .	Juncosa 1982 in FAO, 2007 Tomlinson, 1986; Kairo *et al.*, 2002 Duke *et al.*, 1998 Richmond, 2002.
Ceriops tagal – CT *(*Mkandaa/Mkoko mwekundu) *Rhizophoraceae*	Grows up to 5m high. It can be recognised by its reddish bark and the angular characters of the long viviparous radicle.	Light demander, with stands competition in open area and grow fast.	Lacks coppicing ability – needs natural seed dispersal mostly by water due to buoyancy of propagules or artificial replacement.	Viviparous germination, narrower propagules than BG, buttressed roots and knee roots pneumatophores .	Juncosa 1982 in FAO, 2007 Tomlinson, 1986; Kairo *et al.*, 2002 Duke *et al.*, 1998 Richmond, 2002.
Sonneratia alba – SA *(*Mlilana/Mpia) *Sonneratiaceae*	A small tree which can be recognised by its reddish trunk and branches, its flowers which consist of a bunch of filamentous white stamens which are quickly shed, star and berry like fruit that have spine at the tip and the stout vertical pneumatophores which serve as breathing organs for the underground roots.	Short and contorted growth form, rounded leaves.	Coppices from living stem.	Early coloniser, cryptovivipary germination, pencil-like pneumatophore roots.	Walter *et al.*, 2008 Richmond, 2002.

Avicennia marina – AM (Mchu) *Avicenniaceae*	Spreading trees with willow-like yellowish green foliage. It has long spreading horizontal roots and from these arise small vertical pointed leafless suckers in great abundance. The bark is smooth and greenish yellow when young and variegated green and reddish in the older tree.	Short and contorted growth form.	Coppices from living stem.	Early coloniser, cryptovivipary germination, pencil-like pneumatophore roots, salt excretion gland.	Tomlinson, 1986; Walter *et al.,* 2008.
Xylocarpus granatum – XG (Mkomafi/Mka umwa/ Mkuo) *Meliaceae*	A small tree about 7m high found scattered through the mangrove association usually in the higher parts. Produces large, globate, round fruits of 10-25 cm wide with wedge like seeds. Both *Xylocarpus* spp. have unisexual flowers with stamens united by expanded filaments to form a staminal tube.	It is an evergreen plant.	Has pale, orange, flaky and smooth bark.	Cryptovivipary germination knee roots pneumatophores are absent.	Tomlinson, 1986.
Xylocarpus moluccensis – XM (Mkaumwa wa kijani) *Meliaceae*	A small tree about 5m high found scattered through the mangrove association usually in the landward zones. It can be easily distinguished from other mangrove by its compound pinnate leaves. It is rarely found and not familiar to the general public. Produces large, globate, round fruits of 8-12 cm wide with wedge like seeds.	It is deciduous with leaves turning red and orange before falling in the dry season.	Has dark, vertical fissured rough bark.	Cryptovivipary germination, with knee small pneumatophores conical roots.	Field observation
Pemphis acidula – PA - *(*Kilalamba dume) *Lythraceae*	It is often referred to as a shrub; but the trunk size of a large *Pemphis* can reach around 1.5 meters in girth. Leaves are small, simple, opposite, fleshy and succulent. Together with *Lumnitzera racemosa* it is the only mangrove species that is not viviparous and does not produce large diaspores.	Bushy like trees	Not viviparous and produces dark reddish brown fruits.		Field observation
Heritiera littoralis – HL (Msikundazi) *Sterculiaceae*	A tall tree can reach up to 35m easily distinguished by the silvery scaly under surfaces of its simple, oblong or elliptical leaves. Produces boat-like fruits with wing shaped nuts.		Has buttressed roots and no viviparous seedlings.	Early coloniser	Benfield *et al.,* 2005; Richmond, 2002
Lumnitreza racemosa –LR (Kilalamba/ Mkandaa dume/ kikandaa/ Mkaa pwani) *Combretaceae*	It occurs as a small shrubby tree of not more than 2-3m and has small while flowers that produce clove-like fruits. The plant has flat spoon-shaped (spathulate) leaves with emarginate tips. It grows in isolated clusters in landward areas of high salinity areas together with a *Avicennia.*			Normal simple roots	Richmond, 2002

Similarly, the natural distribution of individual tree species varies dramatically across intertidal zones. Figure 1 indicates common zonation of mangrove species within East Africa.

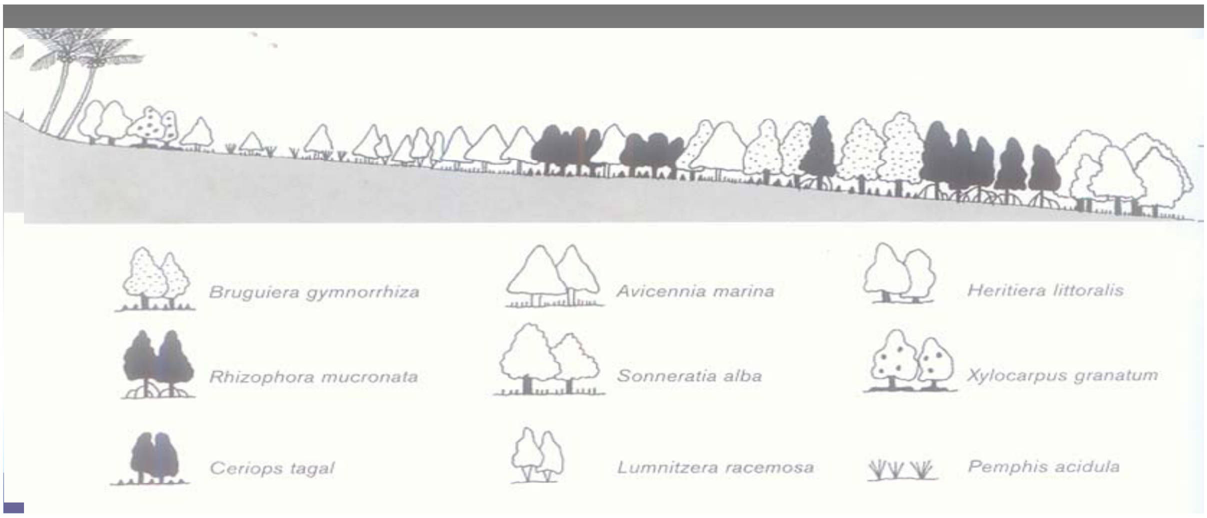


Figure 1 Mangrove Zonation within East Africa. ***Source: Richmond M.D (ed.), 2002***

Diverse mangrove groups have been able to exploit different coastal zones because of their ability to overcome the critical conditions of anoxia, salinity and tidal inundation across intertidal area (Shunula and Semesi, 2001; Ong and Gong, 2013).

2.3 Stakeholder diversity and interests in mangrove ecosystem services

Mangrove SES is characterised by a diversity of stakeholders with multiple and often conflicting interests in their diverse ecosystem services. The term stakeholder refers to all individuals, groups or societies who affect, and/or are affected by the policies, decisions and actions of the system (Grimble (ed), 2002). They can be individuals, communities, social groups or organisations of any size, aggregation or level in society. Thus stakeholders can be physically present at the system or outside the systems representing regional, national, and international level of interests to particular ecosystem services (ibid, 2002). Moreover, an actor, i.e. an individual or a group of people, may have complex and flexible social identities (Cleaver, 2001), which implies that an actor may be part of several stakeholder groups even if these have conflicting interests. They can be "primary" stakeholders, defined as those with a direct interest in the resource; either because they depend on it for their livelihoods or they are directly involved in its use in some way. Secondary stakeholders are those which benefit indirectly from the ecological services supplied by an ecosystem (Landell-Mills *et al.,* 2002) such as those involved in organisations or agencies concerned with managing the resource or those who depend at least partially on wealth or business generated by the resource. Understanding the interests of each stakeholder and their relationship on the use of ecosystem services is crucial as the interests of one stakeholder can affect the capacity of the ecosystem to meet the interests of other stakeholders which can have significant impacts on the management of the ecosystem.

Ecosystem services are the benefits that people derive from natural systems (MEA, 2005; Daily and Matson, 2008). Mangrove forests are among the most productive and biologically important ecosystems of the world because they provide diverse ecosystem goods and services to human societies and coastal and marine systems. As stated previously, the ecosystem services provided by relatively undisturbed mangrove ecological systems include provisioning services such as wood, fish; regulating services (pollination, erosion regulation, climate regulation); supporting services (e.g. providing habitats for other organisms) and cultural services such as aesthetic and spiritual fulfilment (FAO, 2007; Ray *et al.,* 2011).

However, the diverse range of ecosystem services offered by mangrove ecosystems are not of equal importance to different stakeholders, both across different segments of society and between stakeholders at different scales. The importance of particular resources depends on stakeholder's values/interests attached to those particular resources (Grimble (ed.), 2002) and knowledge about mangrove ecosystem services (Crona, 2006). Thus mangrove benefits can be either desirable or undesirable depending on the way society (in general or specific stakeholders) regards the flow of goods and services from one regime of a system in contrast to an alternative regime. Some of the interests of local people may differ from the interests of other stakeholders such as scientists, and or policy and other decision makers, thus resulting in conflicting interests between resource users. Badola et al. (2012) found that local communities in most cases value those functions of mangrove that make a direct contribution to their well-being. These are the 'provisioning services' of mangrove ecosystem which provide materials that have direct economic value to the communities such as wood, fodder, gums, collection of the molluscs, crustaceans and fish (McLeod and Salm, 2006; Warren-Rhode *et al.,* 2011).

To avoid underestimation of the benefits it is important to consider economic valuation of multiple benefits provided by mangrove ecosystems (Costanza *et al.,* 1997; MEA 2005). Total economic value includes direct use values, indirect use values, optional and existence values generated from mangrove ecosystems (Hein *et al.,* 2006). The annual economic value of mangroves, estimated by the cost of the products and services they provide, has been estimated to be \$200,000 - \$900,000 per hectare (Wells *et al.,* 2006). In the Solomon Islands, village-derived economic data indicates a minimum annual subsistence value from mangroves of US$ 345–1501 per household (Warren-Rhodes *et al.,* 2011).

Tanzania mainland and Zanzibar mangrove ecosystems provide a wide range of provisioning ecosystem services that have similarities to other mangrove systems in other part of the words. Mangrove ecosystems provide wood material to the local communities for a variety of uses such as wood for house construction, fuel wood, charcoal, boat building and traditional medicines (Ngoile and Shunula, 1992; Madeweya *et al.,* 2002; Taylor *et al.,* 2003). Mangrove wood is also used for making fish traps, and provides sticks to seaweed farmers, material for furniture, drums, canoes and serving dishes (Taylor *et al.,* 2003).

The perception and interests of different stakeholders are changing and have direct influence on uses, management and conservation actions with regard to the resources. Negative impressions that people have towards particular ecosystem services may change unexpectedly once the community realises the direct benefits from resources. For example it has been recently recognised that payments for ecosystem services (PES) through carbon trading can make a potential contribution toward mangrove conservation while providing carbon sequestration ecosystem services, biodiversity conservation and improving the livelihood of people depending on the resources (Warren-Rhodes, 2011). Clear understanding of the potentiality of mangrove to secure carbon and obtain benefits through PES could switch the communities from traditional ways of using mangrove to less destructive uses, depending amongst other things, on the level of direct benefit received by local communities.

However, people's perceptions do not necessarily enable them to make the decision that would lead to the acquisition, appropriate utilisation or conservation of resources. The relationship between knowledge, practice and management decisions is not straightforward. People could have clear knowledge on a certain matter but application of that knowledge depends on the socio- economic and ecological context. This may be the case in most developing countries where farmers understand that some forest-related activities, such as clear cutting of large patches of forestry, are responsible for on-going forest degradation but they continue to utilise the available resources (Kairo *et al.,* 2001) because of the poverty status of many indigenous coastal communities. Limited awareness amongst decision makers on the true value of mangrove forests can lead to inappropriate decisions on management and utilization of mangrove resources (Semesi, 1992). In this case, evaluation of the importance of mangroves for society requires insight into the value and flow of products and services within the social system of coastal communities, and how they are linked and influenced by domestic and international markets and institutions (Ronnback, 1999).

Environmentalists and forest resource scientists, policy and other decision makers and conservation organization members, put more value on ecosystem services that maintain the ecosystem integrity or support the supply of non-marketed ecosystem goods and services (such as carbon sequestration, other regulating and supporting function). Many of these ecological services constitute an important support to other coastal ecosystems such as sea grass bed and coral reefs. They provide suitable habitats for breeding, spawning and hatching of sedentary and migratory fish species and habitats for a large number of molluscs, crustaceans, birds, insects, monkeys, and reptiles (Taylor *et al.,* 2003; McLeod and Salm, 2006). For example, many coral reef fish and prawns rely on mangrove areas as nursery grounds for juveniles (Shunula and Semesi, 2001). The ecosystem enhances productivity and sustainability of capture fisheries and aquaculture operations (Ronnback, 1999).

Mangroves are efficient carbon dioxide sinks and together with associated soil, globally sequester approximately 22.8 million metric tons of carbon each year. Mangrove forest accounts for 11% of the total input of terrestrial carbon into the ocean (Jennerjahn and Ittekot, 2002) and 10% of the terrestrial dissolved carbon (DOC) exported to the ocean (Dittmar *et al.,* 2006). Despite their high capacity to store carbon, direct burning of wood as firewood or charcoal, and for various purposes such as salt and lime and processing fish, releases greenhouse gas emissions that contribute to global warming and climatic change. This trend might be reversed if the direct ecosystem users receive significant benefits in return of conservation of mangrove for carbon fixation.

2.4 Changes, causes and impacts of dynamics in mangrove social-ecological system

2.4.1 Changes in mangrove social-ecological system

Globally, in recent decades there have been dramatic changes in mangrove SES which may cause degradation and reduce the capacity of these systems to cope and respond to the drivers of change. Despite the benefits offered to the environment and societies, mangrove ecosystems have been seriously degraded in recently years caused by internal and external drivers of changes. As indicated in earlier sections, mangrove has undergone significant loss in mangrove areas whereby over the last 50 years alone, about one-third of the world's mangrove forests have been lost (Alongi, 2002). The rate of mangrove loss indicates an increasing trend (FAO, 2007) which calls for significant attention to reverse the trend to reduce the threats to the ecosystem.

In the Tanzania mainland there has been no dramatic change in the overall coverage of mangroves as the area lost is compensated for by different afforestation programmes in the country. For example, Wang et al. (2003) estimated the mangrove area of Mainland Tanzania to be approximately 109,593 hectares from 1988-1990 and about 108,138 hectares in 2000. However, there is fear that in the future more mangrove areas will be lost through prawn farming (Rufiji Delta inset), construction of solar evaporation pans for salt production (there are 30 salt works in Bagamoyo alone) and clearing mangrove for tourism hotels and complexes, as has occurred along the beaches (Taylor, *et al.,* 2003). In the 1980s Zanzibar mangrove experienced a significant reduction in the total area covered by mangrove forest. Leskinen *et al.* (1997) estimated loss of natural forests, including mangroves, to be about 1,000ha annually; of this amount, about 950 ha were cleared for agriculture and collection of firewood and building poles. A recent estimate published in 2013 indicated that a total of about 3,512ha of mangrove area in Zanzibar has been lost (RGoZ, 2013) over the past six decades with only 525 ha replanted under different afforestation programmes from 1996 in the Islands (SONARECOD, 2009).

Changes in mangrove ecosystems are not limited to the changes in vegetation cover only, but also involve changes in mangrove structure and species composition, which in turn may impact the type and quality of ecosystem services it produced. An assessment of each species' probability of extinction reported that 11 of the 70 globally identified mangrove species (16%) are at elevated threat of extinction especially from Atlantic and Pacific coasts of Central America, where as many as 40% of mangrove species present are threatened with extinction (Polidoro *et al.,* 2010).

Similarly changes in the quality of mangrove ecosystems have been experienced in most restored mangrove stands that are unable to provide the same quality of ecosystem services as the original natural stands. Thus, although restored areas can perform similar functions to those of natural mangrove stands (Bosire *et al.,* 2008), these depend on the responses of the mangrove system to specific management actions (silviculture treatments). For example, Taylor et al. (2003) reported that the common mangrove extraction method practiced in Chwaka Bay on Zanzibar, of selective cutting, was not properly done leaving the mangrove stands with trees of lower quality.

Furthermore, the lower quality mangrove wood, from smaller diameter dominant trees, or species less used in construction, provide ecosystem services which are less desired and provide less income to the stakeholders. It was noted in Chwaka Bay for instance, those poles used in construction are of a relatively poor quality and were sold for TSHS 4000 to 5000 per score (US$ 5.5 to 7.5 in 2003) whereas wood imported from mainland Tanzania can be sold for TSHS 9 000 to 10 000 (US$12.5 to 14.0) as it is of a higher quality (Taylor *et al.,* 2003). The changes in the amount of timber extracted to the level that exceeds its threshold may affect the resilience of not only of the mangrove ecosystems but also to the communities which depend on them.

2.4.2 Human induced threats to mangrove Social – Ecological System

Humans as an integral part of the ecosystem represent a major driving force in global change and shape ecosystem dynamics from local environments to the biosphere through their activities (MEA, 2005). Early studies suggest mangrove ecosystems are highly degraded by anthropogenic activities (Semesi, 1988; Hangqing, 2004) that have reduced the global range of these forests to less than 50% of their original total cover (Saenger and Snedaker, 1993; Spalding *et al.,* 2010). The human cause of resource degradation and loss of ecosystem services can be accelerated by a wide range of drivers of unsustainable development grouped into three categories (Walker and Salt, 2006). One scenario is that resource degradation can be caused in a situation where people have no choice but to use their resource base due to poverty accelerated by excessive demand for ecosystem services stemming from economic growth and demographic changes (MEA, 2005; Walker and Salt, 2006). Walker and Salt (2006) argue that this driver of unsustainable wood harvesting by poor village residents does not apply to most mangroves because rural communities have a general history of excellent stewardship of mangroves, extracting products including timber, but in balance with what the ecosystem can safely provide. This might be true in some developed countries where population and poverty levels are relatively low. In the case of developing countries, there is evidence however that the increased critical mass of poor local communities who have high demand for timber and fuel production and lack of alternatives has caused indiscriminate cutting, overexploitation, and decline of mangrove (Walsh, 1974; Semesi, 1988; Hussein, 1995; Alongi, 2002; Mohammed, 2004; McLeod and Salm, 2006). In Tanzania, the clearing of mangrove areas for timber has been rife around the capital city of Dar es Salaam. Clear cutting of mangrove wood for charcoal, lime and salt production are the main activities which involve heavy exploitation of mangrove in Zanzibar (Ngoile and Shunula, 1992). Forest products (fire wood and/or charcoal) are the major source of domestic fuel for over 90 percent of

Zanzibaris (Magessa, 2008). Some households use as much as 40% of their income just for firewood (Rashid, 1991). The economic shift towards tourism after the fall of world clove prices has made a significant contribution to the national economy of Zanzibar (RGoZ, 2010), but narrowed the economic development opportunities for most coastal communities. Increased urbanisation and in-migration from the mainland creates fierce competition for the tourism related opportunities in the areas (Gossling and Schulz, 2005). As a result, the majority of local communities in the tourist areas have further increased dependency on generating cash income from local resources such as wood and fish (Saunders *et al.,* 2010) because they are not favoured by the tourism sector.

Mangrove is subject to high human threats in a second scenario when resources are depleted wilfully by a relatively small number of individuals or investors who can exploit mangroves to meet the desires of their choices (Walker and Salt, 2006). In this case among the destructive human activities that have caused significant loss of mangrove system is clearing of mangrove areas and conversion into different uses, especially for indiscriminate coastal development and aquaculture (Terchunian *et al.,* 1986; Ngoile and Shunula, 1992; Primavera 1995; Rajkaran *et al.,* 2009). The consequences of aquaculture projects for mangroves are well documented for Ecuador, Thailand, Indonesia, Malaysia, Vietnam, Bangladesh and India (EJF, 2004). For example, in the Philippines, over 70% of the mangroves were lost between 1951 and 1988 due to shrimp or fish aquaculture (Primavera, 1995). In Vietnam too about 2,291ha of mangroves were lost between 1982 and 1987 for shrimp farming in the Minh Hai Province alone (Sam *et al.,* 2005). Shrimp farming in Eastern Africa is still on a small-scale, but as the business is increasing it has potential to increase mangrove degradation in the near future. For example, from 1972 to 1995, 75,000 hectares of mangroves were lost from Mahajamba Bay in Madagascar and development of aquaculture facilities contributed to part of this degradation (Taylor *et al.,* 2003).

Conversion of large scale mangrove ecosystems for indiscriminate coastal development has been experienced throughout the world. Mangroves are being increasingly degraded through clear-felling for house building and hotel complexes, notably in Sri Lanka, Florida USA and Mexico. In Mauritius, threats to mangrove ecosystems were mostly (88%) attributed to construction of hotels. When urban zones are expanding, mangrove areas have been reclaimed for towns, ports, and hotels in Tanzania.

Other activities that have led to clear cutting of mangrove forests include the disruption of mangrove ecosystems by oil reservoir construction resulting in oil spill; salt pan construction, agricultural intensification resulting in pollution and sedimentation; dyking, channelization, agro-chemical mining practices and diversion of freshwater for irrigation (Bakobi, 1997; Alongi, 2002; Ellison, 2009). For example, oil exploration in Nigeria Delta caused a loss of 18,293ha of mangrove between 1985 and 2000 (Twumasi and Merem, 2006). Overheating and filling of sea area (land reclamation) to create farmland and expanding aquatic breeding has resulted in a dramatic reduction in mangrove area by 50% since the 1950s in China (Hangqing, 2004). In the Tanzania mainland, rice cultivation in northern areas of the Rufiji Delta has led to losses of around 1,700ha of mangroves (Taylor *et al.,* 2003). The decline in mangrove ecosystems in Zanzibar were threatened by human development activities such as clearing mangrove patches for ports, salt pan and hotel construction (SONARECOD, 2010).

Agriculture intensification and excessive use of grazing land near mangrove systems has resulted in excessive sedimentation from topsoil erosion into sheltered bays and estuaries which has seriously affected some of the mangrove forest and coral reefs in East Africa. For example, the central Mozambique coast (800km long) is devoid of coral due to discharge from the Limpopo and Zambezi Rivers (Taylor *et al.,* 2003). Mangrove ecosystems in close proximity to urban areas have become vulnerable to pollution from heavy metals, agrochemicals and damming of rivers that alter water salinity levels (Lewis, 1990; Wolanski, 1992). In the Tanzania mainland most of the coastal systems such as Msimbazi mangrove suffered from excessive water pollution from upland sources causing high accumulation of heavy metals in the body of marine animals. Heavy metals have been recorded as accumulating in soft body parts and shells of fish and gastropod species and this extra metabolic pressure may affect growth rates and survival (Mremi and Machiwa, 2002). Oil spills have impacted mangroves dramatically in the Caribbean (Ellison and Farnsworth, 1996). There have been 14 minor and two major crude oil spills in Maputo harbour that have affected mangroves. A heavy fuel oil spill in 1992 affected part of the Macaneta peninsula, including mangrove areas in Mozambique (Taylor *et al.,* 2003).

Markets are very important underlying drivers for changes of mangrove ecosystem services and human welfare. Market availability may have very different and opposing effects on degradation of ecosystem services. Availability of markets for some ecosystem services may provide some level of conservation of the ecosystem and improves human societies. For example, institutions are now only beginning to be developed to enable those benefiting from carbon sequestration to provide local managers with economic incentives to leave the forests uncut (MEA, 2005; Brown *et al.,* 2008). In Zanzibar the United Nation Framework Convention on Climatic Change (UNFCCC) launched the Reducing Emission from Deforestation and Forest Degradation (REDD) program for the purpose of sustainable conservation of forests while generating carbon income which may provide direct and equitable incentives to communities to conserve forests sustainably (Sheikh, 2011). CARE International in Tanzania in collaboration with the Revolutionary Government of Zanzibar (RGoZ) and communities are implementing *Hifadhi Misitu ya Asili ya Jamii* (HIMA) as a pilot project for conservation of community forests including small mangrove areas (HIMA, 2010).

On the other hand, market mechanisms frequently do not ensure the conservation of ecosystem services, but serve as incentives to promote rapid degradation of ecosystem services (MEA, 2005). For example, excessive cutting of mangrove might be attributed to market availability for wood products such as firewood and charcoal in order to meet income demand of local stakeholders. Therefore, even if a market exists for ecosystem services, the results obtained through the market may be socially or ecologically undesirable (MEA, 2005).

Lack of land security and clear tenure and forest rights have accelerated the rate of destruction of mangrove ecosystems in Zanzibar (Mohammed, 2004). Unclear or absence of property rights can be seen as important sources of resource degradation. For example, the Government may claim the ownership of natural resources based on the notion that those are important to the country and their management has important and economic externalities (RGoZ, 1996). However in many cases, especially in developing countries, national governments lack the capacity to enforce State property rights regulation on resource management. This leads to public property being considered open access, eventually leading to overuse and resources depletion (Agrawal and Ostrom, 2001; Mangora, 2011).

Humans can also cause serious threats to mangrove under a third scenario when the decline of mangrove resources is due to inappropriate application of management models on how the world works (Lacerda, 2002; Walker and Salt, 2006). In this situation mangroves are disappearing due to application of faulty ecological principles (e.g. introduction of species without clear knowledge on its function in the ecosystem) even in areas where positive intentions, adequate resources and efforts are all focused on their sustainable proliferation.

2.4.3 'Natural' drivers of change

In addition to these anthropogenic threats, mangroves are also affected by global warming (especially sea-level rise) caused by 'natural' (but largely contributed by human activities) phenomena such as variations in output from the sun and the activities and lifestyles of the earth's human population. Although mangroves are considered as one of the toughest ecosystems that have a remarkable ability to cope with extraordinary levels and types of stress, they are among the ecosystems most vulnerable to projected sea-level rise especially mangrove ecosystems on low relief Islands and those deprived of sediments (McLeod and Salm, 2006; Gilman *et al*., 2008) compared to mangrove ecosystems with ample sediment supplies and/or room to move inland (McLeod and Salm, 2006). Although small Island communities contribute the least (< 1%) to the natural problem of global climate change (mainly emission of greenhouse gases), the projected sea-level rise in 2100 of 0.5 to 1.4 meters above the 1901-2010 level of 0.17m to 0.21m by Intergovernmental Panel on Climate Change fifth Assessment Report (Rhein *et al.,* 2013) is expected to have disproportionately greater effects on the economic and social development of many small Island States. A recent study on the impacts of climate changes on Zanzibar Islands (Sheikh, 2011) revealed that sea level rise has caused extensive damage to shore vegetation other than mangroves through coastal erosion and strong winds with the most affected areas in northern Pemba and almost all the east coast of Unguja. The resilience of mangroves to sea-level rise is conditioned by the composition and status of the stands and other factors such as tidal range and sediment supply (Woodroffe, 1995).

Apart from global climatic effects, mangroves are also greatly affected by biological invasion of pests and diseases (Hangqing, 2004). Biological invasions are probably the most significant environmental threat to the maintenance of natural forest ecosystems in North America and elsewhere, especially when new pests arrive in a new forest ecosystem where there is little natural defence against the pest, or disease pathogen (Liebhold *et al.,* 1995). In China, insects caused serious attack on mangrove forests whereby about 653 ha of mangroves were damaged by a leaf eating caterpillar causing the death of about 70% of the affected mangrove (Hangqing, 2004). Elster et al. (1999) found that insect larvae caused substantial mortality (up to 100% at some sites) of the black mangrove, *Avicennia germinans* (L.), stem propagules and seedlings. Sousa et al. (2003) found that the boring activity of the scolytid beetle, *Coccotrypes rhizophorae* (Hopkins), into red mangrove, *Rhizophora* mangle propagules, killed 72–89% of seedlings planted in closed canopy sites, but only 1–2% of trees in more exposed open-canopy sites.

Mangroves become more susceptible to diseases and pests when stressed by changes in salinity, tidal inundation, sedimentation and soil physiochemistry, the introduction of pollutants such as oils, herbicides, metals, sewage and acids, and damage from storms and cyclones (Alongi, 2002).

2.4.4 The impacts of changes on the availability of mangrove ecosystem services

Changes in the ecosystem have great impacts on availability of ecosystem services on which humans depend. As the demand for ecosystem services grow, human actions are at the same time increasing serious degradation in the capability of ecosystems to provide these services (MEA, 2005). This can be also true to the natural drivers whereas their effects are inflicted by human activities before the disaster. For example, the high impact of the recent tsunami on Sri Lanka was blamed on the destruction of the mangroves which were unable to protect the coastal areas from being damaged by the tsunami impact. The Sri Lanka mangrove has become vulnerable because it consists of discontinuous patches of mangrove and the once extensive forests were converted by private investors, especially into prawn ponds. In contrast, Bangladesh was little affected because of the existence of healthy mangrove stands in the area. Excessive degradation can result in complete ecosystem shifts such as mangrove forest that becomes a 'pock-marked terrain' full of *Acrostichum* fern and abandoned shrimp ponds (Brown, 2007).

The impacts of ecosystem degradation vary between urban and rural poor people. Ecosystem degradation tends to harm rural populations more directly than urban populations and has its most direct and severe impact on poor people because of their low ability to purchase the scarce ecosystem services. Poor people often lack access to alternate services and are highly vulnerable to ecosystem changes that result in famine, drought, or floods and they lack financial and institutional buffers against these dangers (MEA, 2005). Changes in ecosystems affect not just humans but countless other species as well. For example, the loss of mangrove habitats has reduced fishery resources and biodiversity (De Graaf and Xuan, 1998) in different parts of the worlds.

2.5 Resilience and related concepts

2 .5.1 Origin of resilience concepts

Resilience is a term that has multiple meanings. In the ecological literature, the term originated in the 1960s in the studies of population ecology focused on understanding the predation role in population dynamics and their functional responses in relation to ecological stability theory

(Holling, 1961). Since then resilience has evolved and been applied in many fields of study and defined in different ways reflecting different sets of scenarios of dynamic behaviour of ecological systems (Carpenter *et al.,* 2001). Resilience has been defined in two very different ways in the ecological literature reflecting two contrasting aspects of stability. Holling (1973) first emphasised two different aspects of stability to draw attention to the distinctions between efficiency and persistence, between constancy and change and between predictability and unpredictability.

The first, more traditional use of the term resilience is as a measure of efficiency of function. It concentrates on stability, near equilibrium steady state where resistance to disturbance and speed to return of equilibrium are used to measure the property (Tilman and Downing, 1994). Resilience using this definition is measured as the time required for a system to return to an equilibrium or steady state following a perturbation (Ives, 1995) or as return times as a measure of stability (Ludwig *et al.,* 1996). This return time definition of resilience has been termed as 'engineering resilience' (Holling, 1996). Engineering resilience therefore focuses on maintaining efficiency of function, conservation, constancy of the system, and a predictable world near a single steady state, thus resisting disturbances to change (ibid). The implicit assumption of this definition is that a system exists near a single or global equilibrium condition – i.e. there is only one equilibrium or steady state or if other operating states exist they should be avoided by applying safeguards. Engineering resilience reinforced the dangerous view that the variability of natural systems can be effectively controlled, that the consequences are predictable and that sustainable maximum production is an attainable and sustainable goal (Gunderson and Holling, 2002). This view was drawn from a tradition of deductive mathematical theory in which simplified, untouched ecological systems are imagined (Folke, 2006, Gallopin, 2006).

In the second definition of resilience it is defined as a measure that determines the persistence of relationships within systems and is considered as a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist (Holling, 1973). This definition focuses on maintaining the existence of the function and stresses the presence of multiple equilibrium states where instability can flip a system into another regime of behaviour – to another stability domain (ibid, 1973). In this case, resilience is measured by the magnitude of disturbances that can be absorbed before the system changes its structure by changing the variables and processes that control behaviour. This is also called 'ecosystem resilience'. Ecosystem resilience is defined as the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes (Carpenter *et al.,* 2001; Walker *et al.,* 2002). In contrast to engineering resilience, ecological resilience emerged to emphasize the conditions far from any steady, equilibrium state and presumed the existence of multiple stability domains and the tolerance of the system to perturbations. This means that a resilient ecosystem should be able to absorb disturbances and re-organize while undergoing changes so as to still retain essentially the same function, structure, identity and feedbacks (Walker *et al.,* 2004; Walker *et al.,* 2006). A resilient system also has the capacity to absorb shocks while retaining the slowly changing controlling variables needed for renewal and reorganization (Folke et al, 2002). Ecosystem capacity to undergo periodic flips from one stable state to another or find a different functional equilibrium within the same system is mediated by changes in slow variables that suddenly trigger a fast variable response which become available for the next phase of ecosystem establishment (Gunderson and Holling, 2002). Part of this organisation depends on the emergence of innovations or the presence of system legacies (e.g. growth of previously supressed vegetation, germinating seeds stored in seed banks) that control the system and move into a functionally different equilibrium stable state (stability domain), but the state variables remain the same (e.g. lake systems that can also undergo eutrophication). Alternatively, less resilient systems have low capacity to withstand external shocks or disturbances. When subjected to massive shock they may experience complete loss of important system components that perform a critical ecological function resulting in the collapse of the system into a qualitatively different state (Holling, 1986; Gunderson and Holling, 2002; Walker et al, 2004). The new state of the system may be undesirable, less productive or organised characterised by changes in scales, state variables and feedbacks as in the case of algal blooms in fresh water lakes (Grimm and Wissel, 1997) and ecosystem shifts from grass dominated to woody dominated semi-arid rangelands in Zimbabwe (Walker, *et al.,* 2004).

Natural and human systems are not separated but interwoven by human activities which strongly shape the ecosystem services people depend on from the local to global scale. This raises the need to understand the application of resilience concepts to social components drawn from the concepts of ecosystem resilience. Adger (2000) found that there is a clear linkage between social and ecological resilience, particularly for social groups or communities that are dependent on ecological and environmental resources for their livelihoods.

Like general resilience concept, social resilience has multiple definitions but all concern on social entities' ability – of may be individuals, organisations, or communities - to withstand, absorb and cope with and adjust to social infrastructure and social, economic, political and environmental stress and disturbances of various kinds (Adger, 2000; Keck and Sakdapolrak, 2013). Resilience in social systems has the added capacity of humans to anticipate and plan for the future. Because of its institutional context, social resilience is more defined at the community level rather than being a phenomenon pertaining to individuals. Hence it relates to the role of institutions, social capital, leadership and learning of societies and communities (Adger, 2000). Indicators for examining social resilience include institutional change and economic structure, and through demographic change in both temporal and spatial fashions (ibid, 2000). Recent advances acknowledge that social resilience comprises of three dimensions including coping, adaptive and transformative capacities (Keck and Sakdapolrak, 2013). It also include understanding of social processes like social learning and social networks, institution and organisation inertia and change, adaptive capacity, transformability and systems of adaptive governance that allow for management of essential ecosystem services (Folke, 2006). Resilience, in both its social and ecological manifestations, is an important aspect of the sustainability of development and resource utilization.

For some commentators, the opposite of resilience is vulnerability which cuts across both social and ecological configurations. Vulnerability is the state of susceptibility of people, places, ecosystems and species to harm from exposure to contingencies and stresses associated with environmental and social change and from the absence of capacity to adapt. Vulnerability is the sensitivity to, and their incapability to cope with any adverse effects (Folke *et al.,* 2002; MEA, 2005; Adger, 2006).

For natural ecosystems, vulnerability can occur when individuals or communities of species are stressed, and where thresholds of potentially irreversible change are experienced through environmental changes (Adger, 2000). Vulnerability has technical, social, economic and political dimensions, and vulnerability to environmental change is a characteristic of a SES linked to resilience (Adger, 2006). When a system becomes less resilient it increases the vulnerability of a system to smaller disturbances that it could previously cope with. Thus in a vulnerable system even small disturbances may cause dramatic social consequences which reduce social resilience (ibid, 2006). When resilience is lost or significantly decreased, a system is at high risk of shifting into a qualitatively different state. Thus, issues of resilience and vulnerability are important in the framing of resource management approach. They provide a bridge between the analysis of institutions and economies and the natural resources on which the societies ultimately depend (Adger, 2000).

In this context, application of resilience concepts to both social and ecological systems becomes a necessary prerequisite and has been increasingly applied to analysis of SESs (Berkes and Folke 1998, Gunderson and Holling, 2002; Cumming *et al.,* 2005). Studies on resilience that stressed the linked social-ecological system are considered more relevant in understanding system dynamics than studying the components of the system separately (Gallopin, 1991; Ludwig *et al.,* 2001; Folke, 2006). This is because a resilient social system does not always ensure a resilient ecological system on which people depend (Adger, 2000). For example, a human society may show great ability to cope with change and adapt if analysed only through the social dimension lens (Smit and Wandel, 2006). But such an adaptation may be at the expense of changes in the capacity of ecosystems to sustain the adaptation, and may generate traps and breakpoints in the resilience of a social–ecological system (Gunderson and Holling, 2002). Similarly, focusing on the ecological side only as a basis for decision making for sustainability may lead to too narrow and inappropriate conclusions.

Resilience is a property of these linked SESs and is increasingly used as an approach for understanding the dynamics of SESs (Folke, 2006) and has been well applied to integrated systems of people and the natural environment (SES).

Thus taking into consideration the resilience of SES has, the concept has been further interpreted by using three defining characteristics (Carpenter *et al.,* 2001, Walker *et al.,* 2002, Folke, 2006).

1. The amount of disturbance/change a system can absorb/undergo and still remain within a given state or domain of attraction (i.e. still retain the same controls on function and structure)

2. The degree to which the system is capable of self-organization (versus lack of organization, or organization forced by external factors), and

3. The degree to which the system can build and increase its capacity for learning and adaptation

For ease of understanding and applicability, resilience has been defined as the capacity of the system to maintain its identity following the internal changes and external shocks (Cumming *et* *al.,* 2005). One advantage of using the notion of identity is that it provides a clear separation of drivers from system attributes (Cumming *et al.,* 2005). The use of an identity definition also forces researchers to be explicit about the system attributes that they are most interested in, creating a focal point for the analyses that follow and facilitating the operational step of selecting scales of analysis. In applying this concept to mangroves, it refers to the capacity of mangrove SES to retain their identity when exposed to internal and external drives of change.

2.5.2 Critique on the uses of resilience theory

The concept of resilience has become increasingly prominent and is used widely within several academic disciplines and research fields, from biology and engineering to sustainability studies and research into natural hazards and development issues (Keck and Sakdapolrak, 2013). Resilience theory has been used to guide a systematic approach and develop analytical tools in several studies combining elements of theory from economics, ecology, and dynamical systems for particular case studies (e.g. Janssen *et al.,* 2004; Anderies *et al.,* 2006) and in more general contexts (e.g. Brock *et al.,* 2002; Anderies, 2003). Resilience has also been used as a guiding principle within disciplines such as political science (Ostrom 1999), political ecology and resource management (Berkes and Folke 1995, 1998), and archaeology (Redman and Kinzig 2003). The resilience approach addresses issues about the dynamics of systems at multiple interacting scales (Gunderson and Holling 2002) and provides a base for integrating other theories and ideas to develop a better understanding of the system than might be possible with these other theories in isolation (Anderies *et al.,* 2006). Resilience is a useful concept in the study of ecosystem dynamics and management by focusing attention on particular system attributes that play important roles in the dynamics of SESs and attempting to develop principles to guide interventions in SESs to improve their long-term performance (Cummings *et al.,* 2005; Anderies *et al.,* 2006).

However, with its roots in either mathematical engineering or ecology (Holling, 1986, Holling and Meffe, 1996), resilience theory has been criticized for becoming too multidisciplinary and increasingly applied beyond its original engineering or ecological roots (Berkes, 2006; Bahadur *et al*, 2010; Keck and Sakdapolrak, 2013). Other resilience commentators suggested that application of resilience theory outside its original academic disciplines, particularly from a social sciences perspective, is inadequate and even false when it is being uncritically transferred to understanding social phenomena since its original focus was on nature and natural systems (Cannon and Muller-Mahn, 2010). Resilience theory has been considered to have limited usefulness in consideration of issues of agency (the freedom people have to negotiate their own lives in the face of adverse circumstances) (Leach, 2008; Bene *et al,* 2012). This is because resilience is seen to have limited focus on the choices exercised by individuals within the system, who may, or may not, exert control over the processes by which resilience is shaped (Coulthard, 2012). Furthermore, by advocating a positivistic, rationalistic and mechanistic way of thinking, application of resilience theory has been considered to fail to provide appropriate analytical tools to deal with power relations in the social dimension within resilience research (Leach *et al.,* 2008). Duit et al (2010) argue that resilience is still a cumbersome concept for social science because it is difficult to avoid clashes with cornerstone concepts in social science such as power, democracy, and the right to self-determination when attempting to apply the concept of resilience to questions of politics and governance. The reason for this is that even though some similarities can be identified, societies and ecosystems are also fundamentally different in many ways (Duit *et al*, 2010).

However, recent studies opposed most of these arguments acknowledging that resilience theory is able to address the questions of human agency, social practices, power relations, institutions and discourses from a social sciences perspective (Keck and Sakdapolrak, 2013). It has also been argued that social resilience has the potential to be crafted into a coherent analytic framework that can build on scientific knowledge from the established concept of social vulnerability, and offer a fresh perspective on today's challenges of global change (ibid, 2013).

2.5.3 Resilience and adaptive capacity

Recent concepts of resilience are very much influenced by theory on complex adaptive systems. That is why resilience and adaptive capacity concepts are sometimes used interchangeably. Adaptive capacity is the ability of SESs to cope with novel situations without losing options for the future (Folke *et al.,* 2002). Adaptive capacity is an aspect of resilience that reflects learning, flexibility to experiment and adopt novel solutions and assets and development of generalised responses to broad classes of challenges (Walker *et al.,* 2002). Resilience is the key to enhancing adaptive capacity (Folke, 2006; Smit and Wandel, 2006) that allow for continuous development, like a dynamic adaptive interplay between sustaining and developing with change. Like resilience, adaptive capacity in ecological systems is related to genetic diversity, biological diversity, and the heterogeneity of landscape mosaics (Peterson *et al.,* 1998; Carpenter *et al.,* 2001). In social systems, the existence of institutions and networks that learn and store knowledge and experience, create flexibility in problem solving and balance power among interest groups play an important role in adaptive capacity (Scheffer *et al.,* 2000, Berkes *et al.,* 2003).

2.5.3.1 Enhancement of resilience and adaptive capacity of SESs

Although relatively undisturbed systems are inherently considered to be resilient, their capacity to cope with disturbance can either be degraded, or enhanced. Resilience is a key to enhancing adaptive capacity of SESs by maintaining elements that sustain adaptive capacity of SESs in a world that is constantly changing (Folke *et al.,* 2002). Diversity is considered a key factor/element influencing resilience and adaptive capacity of SESs. Diversity is a recognizable source of creativity and innovation that can provide a basis for competitive advantage (Basset-Jones, 2005) in social and ecological system.

Thus, diversity in SES is of two kinds: firstly; 'functional diversity' which is the number of functions of different groups which influence system performance, and secondly 'response diversity' or 'functional redundancy' which is the diversity of types of responses to the same disturbance of different species within a functional group which influences resilience (Elmqvist *et al.,* 2003; Walker *at al.*, 2006). Components or species in a functional group can be considered as redundant if they perform similar functions but loss of one species allow another species to replace the function of the lost species and maintain the system productivity. In ecological systems, biodiversity plays a crucial role in resilience building by providing not only species diversity but functional redundancy or response diversity and spatial heterogeneity (Elmqvist *et al.,* 2003). Functional diversity of mangrove ecological system determines productivity of the system which is enhanced by diversity of functional groups of species. Thus resilience of an ecosystem is not about the number of species *per se* that help sustain an ecosystem in a certain state or domain of attraction, but rather the existence of species groupings, or functional groups (e.g. predators, herbivores, pollinators, decomposers, water flow modifiers, nutrient transporters) with different and often overlapping characteristics in relation to physical processes (Walker *et al.,* 1999; Hooper *et al.,* 2005). A resilient mangrove forest would have enough different types of mangrove plant species from different functional groups, including colonizers, to vegetate different habitats and maintain the basic functions of a mangrove forest (Brown, 2007).

Biodiversity enhances resilience if species or functional groups respond differently to environmental fluctuations, so that declines in one group are compensated for by increases in another (Elmqvist *et al.,* 2003; Hughes *et al.,* 2005). Response diversity in the mangrove ecological system may be reflected by diversity of responses to disturbances among mangrove species contributing to the same function in the ecosystem.

Biological diversity is essential in the self-organizing ability of complex adaptive systems both in terms of absorbing disturbance and in regenerating and re-organizing the system following disturbance (Folke *et al.,* 2004). Species that may seem redundant and unnecessary for ecosystem functioning during certain stages of ecosystem development may become of critical importance for regenerating and re-organizing the system after disturbance and disruption (Folke *et al.,* 1996; Bellwood *et al*., 2004). For example, in a grassland ecosystem, several different species will commonly perform nitrogen fixation, but each species may respond differently to climatic events, thus ensuring that even though some species may be lost, the process of nitrogen fixation within the grassland ecosystem will continue (Folke, 2006).

Spatial heterogeneity can also confer resilience as when refuge areas provide sources of colonists to repopulate disturbed regions (Nystrom, and Folke, 2001). In addition part of this capacity lies in the regenerative ability of ecosystems and their capability in the face of change to continue to deliver resources and ecosystem services that are essential for human livelihoods and societal development (Adger, *et al.,* 2005).

Systems with high adaptive capacity, and therefore resilience, are able to re-configure themselves without significant declines in crucial functions in relation to primary productivity, hydrological cycles, social relations and economic prosperity. Thus in a resilient SES, disturbance has the potential to create opportunity for doing new things, for innovation and for development (Folke, 2006).

Diversity can also enhance resilience and adaptive capacity in social systems. Diversity and redundancy of institutions (overlapping functions) play a central role in absorbing disturbances, spreading risks, creating novelty and re-organizing following disturbance (Low *et al.,* 2003). Addressing how people respond to periods of change, how society reorganizes following change, is the most neglected and the least understood aspect in conventional resource management and science (Gunderson and Holling 2002). Folke et al. (2002) identify and expand on four critical factors that interact across temporal and spatial scales and that seem to be required for dealing with natural resource dynamics during periods of change and reorganization:

- learning to live with change and uncertainty – taking advantage of changes and turning them into opportunities
- nurturing diversity for resilience;
- combining different types of knowledge for learning; and
- creating opportunity for self-organization towards social-ecological sustainability.

Diversity increases social resilience and adaptive capacity when a social system's governance and management frameworks spread risk by diversifying patterns of resource use and by encouraging alternate activities and lifestyles (Adger, *et al.,* 2005). Another example is when the management of a resource is shared by a diverse group of stakeholders (e.g. local resource users, research scientists, community members with traditional knowledge, government representatives, etc.), decision-making is better informed and more options exist for testing policies. Active adaptive management whereby the management actions are designed as experiments encourages learning and novelty that increases resilience in SESs.

2.5.3.2 Degradation of resilience and adaptive capacity of SES

Alternatively resilience and adaptive capacity of the ecological system can be degraded through loss of diversity (Holling and Sanderson, 1996) and toxic pollution. A consequence of a loss of resilience, and therefore of adaptive capacity, is loss of opportunity, constrained options during periods of re-organization and renewal, an inability of the system to do different things. And the effect of this is for the SES to emerge from such a period along an undesirable trajectory.

Resilience of social systems can be degraded through reduction of diversity which is related to the reduction of human opportunities and economic options (Adger, *et al*., 2005). For example, when there is an inflexible, closed institution, perverse subsidies encourage unsustainable use of resources, a focus on production and increased efficiencies that lead to a loss of redundancy.

2.6 Resilience, sustainability and natural resource management approaches

'Sustainability' and 'resilience' are two concepts used to explain the behaviour of complex SES at different and opposing scenarios. As presented in section 1.1, the sustainability concept can be applied in diverse fields of study but always evokes a positive reaction of desirable SES state by the stakeholders. Sustainability has its root from World Commission on Environment and

Development Summit (1987) which defined sustainability as "development that meets the needs of the present without compromising the ability of future generation to meet their needs" (United Nations, 1987).

Sustainability is related to resilience in a sense that it reflects the first meaning of resilience which focused on maintaining efficiency of function to achieve maximum productivity of the system (Berkes and Folke, 1998; Gunderson and Holling, 2002). It represents the desired outcome of resilience analysis as a set of targets for management options to achieve sustainability – i.e. continued well-being of economy, society and the natural resource base (Walker *et al.,* 2002). Thus sustainability is an overarching goal that includes assumptions or preferences about which system states are desirable (Carpenter *et al.,* 2001).

In contrast resilience focuses on maintaining the existence of a system's function in response to internal changes and external shocks (Holling, 1973). Unlike sustainability which only reflects desirable state, resilience can be desirable or undesirable (Carpenter *et al.,* 2001) as explained in section 1.1.

Both sustainability and resilience concepts have been widely applied to natural resources management depending on management objectives. Throughout history natural resource management has been guided by a wide range of theories and practices. These approaches range from full State control, common property rights to community based natural resources programmes of different forms and combinations.

The application of an approach of natural resources management is determined by resource management objectives which can destroy or build resilience and sustainability depending on how the SES organizes itself in response to management actions (Folke *et al.,* 2002). In traditional societies, natural resources are or were managed through a local management approach. This was based on observation, experience and local knowledge of the resource users themselves (without government scientists and managers) [Gadgil and Berkes, 1991; Colding and Folke, 2001]. This management approach is more consistent with an ecosystem view and current ecological theory (Gadgil and Berkes, 1991; Berkes and Folke, 1998), although it relies on the Government for legal recognition of their rights to own the resources. Traditional management approaches are perceived to result in sustainable and resilient systems through application of management practices based on observations, experiences, cultural diversity and local knowledge of resources (Gadgil and Berkes, 1991; Berkes and Folke, 1998)

With an increase of population relying on natural resources, there is increasing pressure towards the application of a top–down command and control approach to management of natural resources (Holling and Meffe, 1996). This is the approach which is known as 'Fortress conservation' or 'western resources management science' (conventional resources management) [Pimbert and Pretty, 1995; Berkes and Folke, 1998]. This method recognises the use of western science and scientific methods to represent a particular brand of science which is used as a basis for resource management by centralized government throughout the world (Berkes and Folke, 1998). Development of this approach was based on the assumption that the manager is outside the system being managed and is often based on a presumed ability to predict probabilistic responses to management and external drivers such as climate (Walker *et al.,* 2002). The guiding principle of this approach was 'a sustainability-oriented view' emphasizing equilibrium, the maintenance of a predictable world, achieving a stable maximum sustained yield of a renewable resource with as little fluctuation as possible (Folke, 2006). This system often assumes a very limited set of property rights: State property (regime based on Government regulations), private property (market oriented regime), or common property – a tragedy of the commons (Hardin, 1968; Berkes and Folke, 1998). Although this management system can lead to high production of a system at the beginning, it usually ended with unforeseen consequences for both natural and human welfare in the form of collapsing resources, social and economic strife, loss of biodiversity and loss of resilience, a phenomenon called "Pathology of natural resources" (Holling and Meffe, 1996; Gunderson and Holling, 2002). A definitive pathology emerges when resource management agencies, through initial success with command and control lose sight of their original purposes, eliminate research and monitoring and focus on efficiency of control.

Mangrove is one among common property resources - a kind of resource which needs to be managed under a common property regime. Its management differs from privately owned and managed as well as State controlled resources in the sense that exclusion is difficult and the joint use involves subtractability (Ostrom, 1990). Subtractability in the use of resources implies that when one individual uses some of the ecosystem services reduces the level of the resources available for other users. The management of common pool resources require that the resources are governed based on common property rights whereby a group of resource users develop a set of institutional design principles for managing resources (ibid). However, this has not been the case for management of forest resources including mangrove in most East African countries including Tanzania (Semesi, 1992; Kairo and Dahdouh-Guebas, 2004). Poor governance and economic situations in most developing countries made them unable to make plans for their resources. Governments in these poor nations have often adopted the western style of management plans which fall short in rural poor societies (Mangora, 2011). For example, in Tanzania, including Zanzibar, mangrove forests have been declared as forest reserves in 1960s and centrally administered by the State (Semesi, 1992; Holmes, 1995; Saunders *et al.,* 2010) with no formal recognition of local communities around the mangrove on decision making and uses. The Government incentive for this exclusionist approach, coercive conservation (Dressler *et al.,* 2010) was driven by the belief that this was the most efficient and effective means for the State to assert management control over the resources and ultimately for the people who rely on these resources for cultural and material nourishment (Neumann, 1997). However, in Tanzania, this nationalization of mangrove forests has not been successful in reversing mangrove degradation and the mangrove is increasingly exploited as cheap sources of wood and forest land is converted for other uses (Mangora, 2011). Thus this conventional prescription of resource management is in many cases not resulting in sustainability and ecosystem resilience (Holling *et al.,* 1995, Berkes and Folke, 1998). In this context, sustainability is not achieved through sustaining production of biological resources alone, but also needs to understand the dynamics of linked SESs and measure the capacity of the system to cope and adopt with the change.

Over the past two decades there has been a considerable shift in natural resources management from centralised natural resources management policy approaches to Community-centred institutional arrangements with an associated range of different property rights arrangements under variations of communal management arrangement (Saunders *et al.,* 2010). Many of the current systems of natural resource management show a mixture of jurisdictions through sharing of resource management responsibility and authority between users and Government - (Co-management or collaborative management, Community Based Natural Resources Management) – [Berkes, 1995]. With its base on common property management strategy, Community Based Natural Resources Management (CBNRM) was introduced in most African countries and other developing worlds as an alternative approach to achieve local sustainability to preserve both the ecological characteristics of mangrove and encouraging equitable and sustainable environmental resource use (Pinkerton, 1989). While CBNRM has attracted widespread international attention, its practical implementation frequently falls short of expectations. The main reasons for poor performance have been identified including a tendency for intended beneficiaries to be treated as passive recipients of project activities (Pimbert and Pretty, 1995) and a tendency of the project to be short term in nature and over reliant on expertise. Another reason is the lack of equal consideration and involvement of diverse institutions that are found at different scales resulting in conflicts between different resource users (Leach *et al.,* 1999). In mainland Tanzania, diverse forms of community-based restoration and conservation programmes have been introduced mainly with donor support. Many of these projects resulted in poor performance which negatively affected the livelihoods of rural poor who were consequently identified by the Government to be culprits and responsible for the ecological degradation (Mangora, 2007; Mangora, 2011).

The Zanzibar Government began to support local participatory approaches to conservation in the 1990s in an effort to attract international expertise and financing to create more efficient management of natural resources and development opportunities. Donor interests in collaboration with government initiatives resulted in a policy shift which gives legal recognition for CBNRM programmes through passing of the Zanzibar Environmental Management for Sustainable Development Act (ZEMSDA) and the Forest Resources Management and Conservation Act (FRMCA) in 1996. In these arrangements, local communities are persuaded by the Government to formulate mangrove resources institutions (COFMA) to control mangrove cutting and through the assistance of international conservation organisations the communities are provided with alternative income livelihoods that result in little environmental degradation. However, these initiatives have met with mixed success in practice. For example, in Kisakasaka village in Zanzibar, a CBNRM programme was introduced as a pilot project in 1996 to reduce the rate of mangrove cutting by the local communities while developing alternative income means for the village residents. The result indicated that the rate of mangrove clearance had dramatically increased and about 69% of the mangrove had been clear cut at some point between 1984 and 2005 (Saunders *et al.,* 2010).

Despite the greater application of diverse management approaches Cumming et al. (2005) argued that efforts toward achieving sustainability of SESs need to be governed by management actions and plans that take into account the complex relations, drivers and external shock that would lead to avoid unexpected results. A resilience approach emerged to challenge the dominant traditional view of natural systems focused on equilibrium centred, command-and-control strategies that aim at controlling the variability of a target resource (example of fish populations, insect outbreaks) to control resource flows in an optimal fashion (Folke, 2006). Resilience and adaptive capacity are sometimes used interchangeably in resource management because both emphasise the importance of feedback from the environment to shape policy and learning by doing (Walker *et al.,* 2002). A resilience approach is opposed to the conventional resource management approach in the sense that it encourages adaptive management approaches that allow comparative analysis of ecosystem behaviour (Berkes and Folke, 1998). A management approach based on resilience therefore emphasize the need to keep options open, the need to view events in a regional as well as local context, and the need to emphasize heterogeneity. In this case resilience provides a shift in perspective to contemporary natural resource and environmental management that emphasizes the necessity to learn to manage by change, thus taking consideration of uncertainty and surprise as part of the game (Carpenter *et al.,* 2001; Berkes *et al.,* (ed.) 2003)

2.7 Resilience assessment approaches and indicators for resilient SESs

2.7.1 Resilience assessment

Depending on which definition is been adopted resilience can be measured using widely different approaches, but focused on the similar concepts of measuring capacity of the system to persist and reorganise following changes. For example, in a definition that considers resilience as a time required for a system to return to equilibrium or steady state following a perturbation, resilience measurement is based on how far the system has moved from the equilibrium (Ives, 1995) and how quickly it returns (Ludwig, *et al.,* 1996). Resilience can also be measured using an attractor based definition which considers that an ecosystem has lost its resilience when entering into a new domain or alternative regime (Gunderson and Holling, 2002). Walker et al. (2002) proposed a framework with four steps for resilience analysis of SESs which requires close involvement of SES stakeholders:

Step 1: Begins with a stakeholder led development of a conceptual model of the system, including its historical profile (how it got to be what it is) and preliminary assessments of the drivers of the supply of key ecosystem goods and services.

Step 2: Deals with identifying the range of unpredictable and uncontrollable drivers, stakeholder visions for the future, and contrasting possible future policies, weaving these three factors into a limited set of future scenarios.

Step 3: Uses the outputs from steps 1 and 2 to explore the SES for resilience in an iterative way. It generally includes the development of simple models of the system's dynamics for exploring attributes that affect resilience.

Step 4: Stakeholder evaluation of the process and outcomes in terms of policy and management implications.

In addition, resilience can be measured using an identity-based definition which considers that resilient ecosystem should maintain its system identity (Cumming *et al.,* 2005). In the context of Zanzibar mangroves, SES resilience may be measured using an identity based definition as the capacity of the mangrove ecosystem to supply ecosystem services to different stakeholders in response to changes caused by internal and external drivers/stress. Using this approach resilience is measured according to whether the system is maintaining or changing its identity. Thus if system identity is maintained over the time horizon of interest under specified conditions and perturbations, we can conclude that the system is resilient. If the identity of the system is lost or modified, the aspects of the system in which we are interested may lack resilience to different degrees.

The framework for resilience measurement using this approach involves five central elements:

- Define the current state of the system. Describes the essential attributes that define the system's identity and need to be maintained for resilience analysis.
- Define possible future systems – using scenarios building approach.
- Clarify change trajectories – it involves defining the main causes of change of the system, with particular relevance to their impacts on properties of interests.
- Assess likelihoods of alternative futures
- Identify mechanisms and levers for change.

The resilience assessment using an identity-focused definition provides an operational way of assessing resilience because it provides a clear separation between drivers from system attributes, necessitating researchers to be explicit about the system attributes they are most interested in. It also allows clear definition of a focal point and scale for analysis and enables resilience to be assessed in relation to potential and specific change in the system (Cumming *et al.,* 2005).

2.7.2 Indicators for resilient social-ecological system

Threshold values are fixed points used to define and indicate when the system identity/resilience is changing (Cumming *et al.,* 2005) or levels that represent a breakpoint between two alternative system states and help reveal what is contributing to or eroding system resilience. Being aware of critical thresholds between system states can potentially provide advance warning of impending change as well as opportunities for preventing undesirable shifts in system states (Cumming *et al.,* 2005; Resilience Alliance, 2010). Sustainability is concerned about knowing if and where a threshold of slowly changing variables exists and having the capacity to manage the system in relation to these thresholds (Walker and Salt, 2006). The defined threshold levels serve as useful indicators for assessing resilience of mangrove SES. Among the established thresholds/indicators the chosen thresholds had to meet the following criteria as suggested by Tagtow et al. (2011). The selected indicators should be valid and measurable, reliable and originate from a credible source, collected in a timely manner and reported consistently to establish trends, publicly available, transparent and understandable and related to the mangrove SES goals. It also stressed that the establishment of these levels require that they should be based as far as possible on reliable science and the view of stakeholders that best supported the goal of obtaining sustainable conservation that enhance the supply of desirable mangrove ecosystem services and improve human well-being. However, due to paucity of basic information on the dynamics of SESs and the relationships of ecosystem services to human well-being it is difficult to come up with precisely established indicators. However, even if the exact location of a threshold is unknown, simply being aware of a threshold can help reduce the likelihood of crossing into a new state.

Cumming et al. (2005) mentioned four systems characteristics/attributes that define the system identity. For the SES to be considered as resilient it should be able to maintain the following attributes that describe the system identity. Thus system identity is largely dependent on (1) the components that make up the system; (2) the relationships between components; and (3) the ability of both components and relationships to maintain themselves continuously through space and time (Cumming *et al.,* 2005) and (4) innovation and self-organization.

2.8 Dynamics of Mangrove SES, Adaptive Cycle and Resilience

One of the important and common aspects in all resilience assessment approaches is the understanding of changes and repeated behaviour that the system has undergone over its historical time. The Adaptive Cycle concept as used in other systems (Holling, 1986; Gunderson and Holling, 2002) can be applied in mangrove SES to facilitate clear understanding of system dynamics which identify various phases of change the mangrove SES may have moved into, together with the phases of change in which the mangrove SES currently exists. Even the resource management systems tend to move through cycles of crisis and recovery and of institutional renewal (Berkes, 2006). The Adaptive Cycle as postulated by Gunderson and Holling (2002) [Figure 2] is a metaphor which can be used to think about SES dynamics because it emphasises the importance of changes in resilience and focuses on the timing of management interventions (ibid, 2002; Walker *et al.,* 2002) which are appropriate in different phases. It can be used for resilience assessment by identifying which phase a SES falls into by defining the current phase of the focal system (Gunderson and Holling, 2002). It puts emphasis on the second side of resilience which focuses on the capacity of the system to recover and re-organise after deep transformations, the capacity to adapt to changes and generate novelty. This part of resilience is less in focus but is essential for sustainability of the system (Gunderson and Holling, 2002).

The Adaptive Cycle involves the movement of a system through four phases: (Fig 2). Rapid growth and exploitation (r) phase; leading to a long phase of capital accumulation, monopolisation and conservation of structure, during which resilience tends to decline (K); followed by a very rapid breakdown or release [creative destruction phase (Ω)] and finally a relatively short phase of renewal and re-organisation (α-phase). If in this phase the system still retains sufficient of its previous components it can reorganise and remain within the same configuration as before. But it is also a time when novelty can enter – new species, new institutions, ideas, policies and industries – and the “new”, emerging system, whether it is in the same or a different configuration, gains resilience. The system can also flip into alternative non-resilient regime as shown on an exit arrow in Figure 2.

The four stages of the Adaptive Cycle have three properties that determine the dynamic characteristics of each cycle. These characteristics include ‘potential’ which indicates the limits in the number and kinds of future options available, ‘connectedness’ which determines the degree to which a system can control its own destiny through internal controls, as distinct from being influenced by external variables, and 'ecosystem resilience', which determines how vulnerable a system is to disturbance (Gunderson and Holling, 2002). That potential includes accumulated ecological, economic, social (skills, networks of human relationships, and mutual trust), and cultural capital as well as unexpressed chance mutations and inventions. The system connectedness provides a measure that reflects the degree of flexibility or rigidity of a system to external variability (Holling, 2001). When a system is moving from re-organisation (α) to growth (r) phase, potential and resilience is high while connectedness is low, which permits novelty and experiment to foster ecosystems' re-organisation. During the slow sequence from r to K, connectedness and stability increases, while the potential is very high but not available, due to high connectedness which reduces ecosystem resilience. In the presence of external disturbances (e.g. fire, climate shock, grazing pressure) the stored capital is suddenly released (at Ω) and its potential for other uses and resilience drops until the released resources that remain are re-organised so that the potential for other uses re-emerge in the α phase (Holling, 2001; Gunderson and Holling, 2002).

Description of system dynamics through the Adaptive Cycle concept relates strongly to Boom and bust cycles that also provide potential for explaining cycles of growth and collapse of social, ecological or biological resources systems (Gunderson and Holling, 2002). However, a boom and bust cycle has more focus on social systems, explaining a process of economic expansion and contraction that occurs repeatedly. A boom and bust cycle of industrial forest management that occurred in the Tongass National Forest in Alaska (USA) demonstrates a remarkable fit with the Adaptive Cycle (Beier et al, 2009). This industrial forestry system passed through phases similar to those indicated by the Adaptive Cycle. It started from the organization phase [α], when the demand for lumber supplies created the opportunity to initiate the Tongass forestry system. In the presence of political authority and economic subsidies to harvest large tracts of primary old-growth forest of the Tongass system that provided guaranteed low-cost timber and other subsidies in exchange for the construction and operation of timber mills in the region, the Tongass system changed rapidly and initiated a period of vigorous growth (r). Reforms in environmental policy began to erode the authority of the Tongass to harvest timber during the latter years of this growth phase [r], leading to a period when the system sought stability in the face of change – the conservation phase [K]. Changes occurred during this time, including globalization of timber markets, stronger environmental protection policies, and institutional reforms at the US Forest Service. When the US Congress reformed the establishing policies and removed timber subsidies, during a market downturn for Alaskan forest products, the long-term leases were terminated and the Tongass system entered the collapse phase [Ω]. Collapse of the Tongass system led to dramatic declines in employment and major changes in local and regional economic conditions and degraded forest conditions.

The point of departure between the Adaptive Cycle and boom and bust cycle is that the Adaptive Cycle does not apply in all details to human organisations. That is in human dominated systems, the ability for developing forward expectations, together with an effective market mechanism could potentially stabilize the boom and bust cycles of the Adaptive Cycle (Gunderson and Holling, 2002).

The Adaptive Cycle exhibits two major transitions distinguishing the period before and after destruction and can be used to correspond with the management objectives of an intervention (Walker *et al.*, 2002). The first slow moving "forward loop" (r to k) corresponds to managing for production aimed at maximizing income. In this phase the system is characterised by high capital accumulation, connectedness, stability, strong controls, monopolisation and conservation of structure during which resilience tends to decline through gradual changes in slowly underlying variables controlling the system. This is the phase where most of the research, development and management efforts are focused.

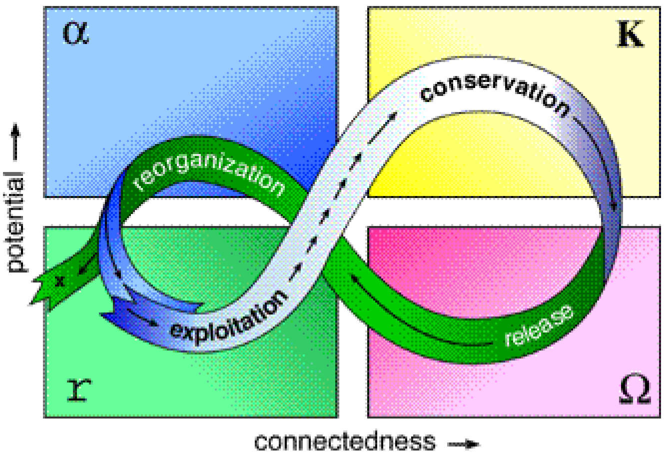


Figure 2 Potential phases in the Adaptive Cycle. *Source: Gunderson and Holling, 2002*

On the other hand the "back loop" (Ω to α) corresponds to managing for sustainability aimed at maximising flexibility to cope with and adapt to, unexpected change in the system. In this transition the system is characterised by rapid changes, loss of resources and emergence of new ideas which might lead to subsequent evolution of the system (Walker *et al.,* 2002). In this phase resilience can be determined if the system is still able to retain sufficient of its previous components to reorganise to remain within the same configuration as before (Holling, 2001). In addition resilience can be evaluated through assessing the capacity of a system to cope with new emerging ideas to renew and reorganise without the ecosystem flipping into undesirable trajectories. This is the most neglected phase and receives very little attention to understanding and managing systems going through periods of turbulences, transformation and changes (Gunderson and Holling, 2002; Walker *et al.,* 2002).

One important aspect of understanding realistic behaviour and resilience of complex SESs is to consider the role of cross scale interactions of subsystems, a phenomenon called "Panarchy". Gunderson and Holling (2002) developed an empirical model of nested adaptive renewal cycles emphasising cross scale interplay. The model emphasised that regional SESs do not consist of just one kind of cycle at one scale but function as a nested, hierarchical structure, with processes clustered within subsystems at different scales. Thus different subsystems, at different scales, may be in different phases and may change at different rates.

This chapter described general characteristics, and distribution of mangrove ecosystems. The chapter has also extensively described the common concepts used in this study especially linked mangrove SES, mangrove dynamics, threats, and its impacts, sustainability and resilience concepts and how it can be used to assess resilience of mangrove SES. The next chapter describes research design and methods for data collection and analysis of the thesis based on the resilience theories.

Chapter 3

STUDY APPROACHES AND METHODS

In this chapter the approaches and methods used in the study are presented. This includes the research design and conceptual framework, data collection and analysis approaches and methods. It also presents the limitations encountered during data collection.

3.1 The study process

The study process was implemented in three main phases between 2011 and 2013. The first phase (between May and July 2011) started with a review of a large body of literature relating to the general state of Zanzibar mangroves, development of the research design and conceptual framework, and selection of data collection tools. Thus the methods and procedures for data collection and analysis were guided by resilience theory and a conceptual framework adapted to this study. This was followed by preliminary field visits to verify the suitability of the study sites and appropriateness of methods in relation to the research questions. The field visits were combined with reconnaissance surveys that provided opportunities for identifying potential respondents and pre-testing data collection methods and analysis before wide scale data collection was undertaken in the second phase.

The second phase (from August 2011 to June 2012) involved detailed data collection of both mangrove biophysical and socio-economic data through primary and secondary sources. This was followed by preliminary data analysis and report writing to assess the state of the collected data and define the information gaps that needed to be collected for the accomplishment of the research.

The third phase of data collection (January to July 2013) focused on collection of additional data to fill information gaps on specific areas defined following the initial data analysis and report writing. With the exception of the scenario building approach, most of the data collection methods used during this phase were similar to those used in the second phase.

3.2 Research design and conceptual framework for mangrove SES

This study examines the resilience of mangrove SES to drivers of change influencing supply of mangrove ecosystem services. A conceptual framework was developed to characterise the mangrove SES and provide guidance for this study. Through this framework the information collected from localised case studies from Pete-Jozani, Michamvi and Charawe Shehias was used to assess resilience of their mangrove SESs (Figure 3). Resilience in this study is defined as the capacity of the system to maintain its identity in the face of internal change and external shocks and disturbances (Cumming *et al.,* 2005). When resilience concepts are applied to mangrove SES it refers to the capacity of the mangrove ecosystem to maintain the supply of desirable ecosystem services in the face of human use and fluctuating drivers for change (Carpenter *et al.,* 2001).

This conceptual framework includes the essential attributes that define the desired identity of mangrove SES of Zanzibar and, when these are maintained, ensure the resilience of the system. The identity of mangrove SES of Zanzibar is defined by four attributes which are as follows: the components that define the system, relationships between the components, the continuity of the system and sources of innovation.

The two main components are ecological and social. The ecological component is described by the state of the mangrove tree component as this is the principal source of productivity in the system (FAO, 1994; Duke *et al*, 1998; Bosire *et al*, 2003). This includes total mangrove vegetation cover, mangrove tree species diversity, standing density, diameter distribution, rate of cutting, basal area, regeneration, and volume. The social component covers the diversity of stakeholders, their knowledge, interests and ecosystem services obtained from the ecological component.

Ecological relationships include the mangrove-animal interactions, while social relationships are described by the mixture of management arrangements with respect to formal and informal rules governing the management and uses of ecosystem services by the stakeholders.

Mangrove SES continuity is described by slowly changing variables that maintain cohesive identity after disturbance. The ecological continuity may be explained by mangrove seedling recruitment or coppicing ability for example. Social continuity is explained by the presence of social memory, such as presence of institutional support, participation of elderly people and recognition of diverse institutions in the management of the system.

Innovation refers to the development of novel solutions and response to changes. Mangrove tree diversity relates to ecological innovation while diversity of management institutions and livelihood activities correlates with social innovation.

A mangrove ecological system is comprised of a wide range of spatially defined ecological scales varying from the level of an individual tree to ecosystem at village, national and international scales. However, this study focused on mangroves at ecosystem scales from the three villages of Pete, Michamvi and Charawe mangrove ecosystems. Mangrove ecosystem services generated from these areas provide linkages and interaction to social components of the system across spatial scales.

The social component of the system comprises the stakeholders operating at different scales and their institutional rules which strongly shape or manipulate the ecological system to provide ecosystem services for the benefits of humans. The focal social component of the system comprises local communities from Pete, Michamvi and Charawe Shehias, whose residents use mangrove products, participate in mangrove conservation work or have any other interests in mangrove. It covers all stakeholders with an interest in mangroves (e.g. wood cutters, mangrove traders, beekeepers and local conservation organisations). Other stakeholders at district, national and international scales (for example decision makers, DFNRNR staff, and donors, International conservation organisations) were also considered because they reflect different levels at which decisions on the utilization and management of the resources are taken.

Actions and interventions carried out by different stakeholders at different scales are guided by their rules and values attached to different mangrove ecosystem services. Such interventions include cutting of trees, planting of seedlings, patrolling, beekeeping, ecotourism etc. These stakeholders' interventions and associated drivers provide complex interactions between the components at different scales that directly and indirectly modify ecosystem structure and function.

The main issue of concern is to explore the perceived problem of increased demand for mangrove ecosystem services by diverse stakeholders. Specifically the increase in demand and exploitation of wood provisioning ecosystem services by the local communities within and outside these villages is the main problem of concern that the resilience assessment seeks to address. Therefore, the general goal is to assess the resilience of mangrove SES to perceived problems of increased levels of exploitation of mangrove ecosystem services and under increasingly unpredictable circumstances. This research also analyses the possible options for building more resilient mangrove SES in Unguja, Zanzibar.

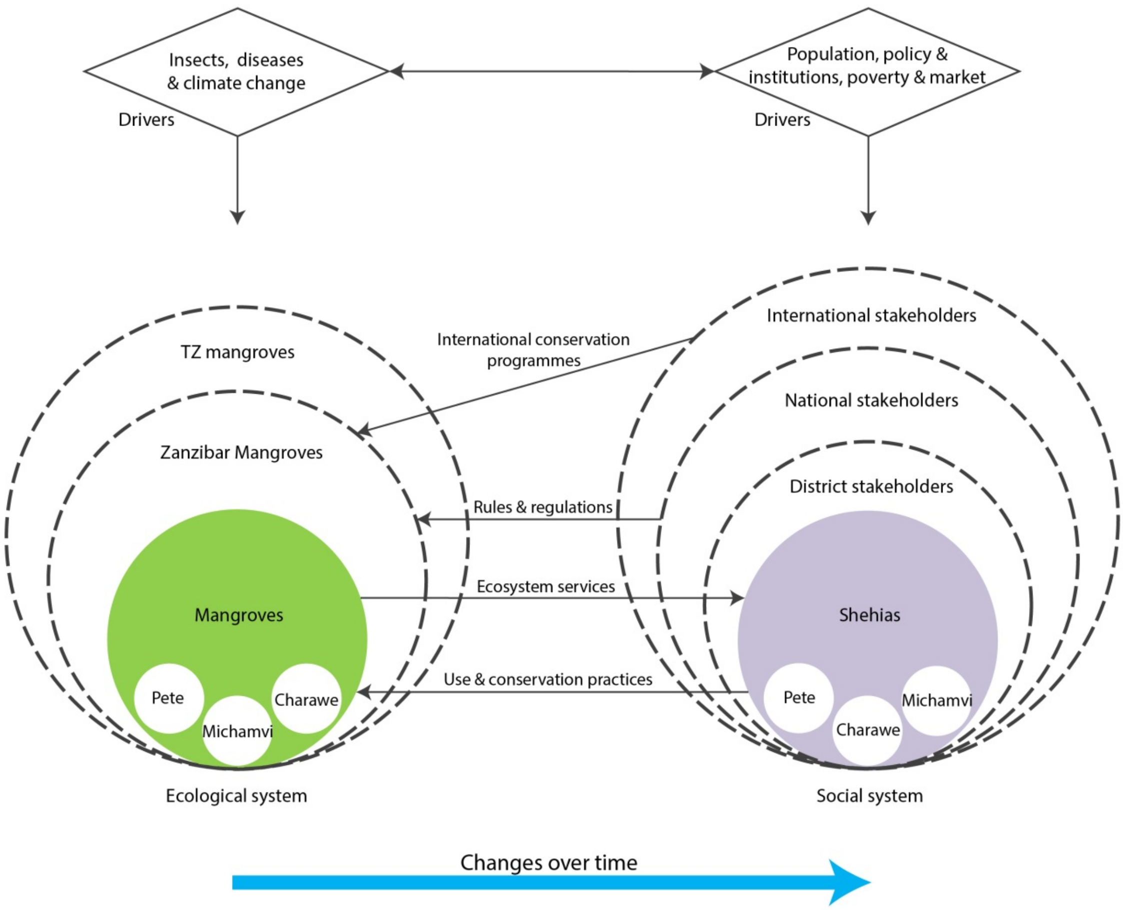


Figure 3 Conceptual framework of Unguja mangrove SES for resilience assessment.

It defines the components of Zanzibar mangrove SES and recognizes interwoven relationship between the social and ecological elements of the system which is essential for building residence of Mangrove SES.

3.3 Preliminary field visits and reconnaissance survey

Before the detailed data collection started, preliminary field visits were conducted in several mangrove SESs of both Unguja and Pemba in May 2011. Initial contacts with potential informants were made through interviews with key informants and group discussions with government officials from DFNRNR and local communities. These methods were combined with the development of a timeline of key events and a mangrove transect walk. The visits were conducted to develop a clearer understanding of the mangrove SESs of Zanzibar in order to better identify potential study areas and the practicability of various approaches to be used in the study. During these visits good rapport with Shehia leaders (Shehas) was established and potential key informants to work with in the future were identified. Shehia is the lowest administrative unit in Zanzibar and its leader is called a Sheha (section 4.2 provides more details). The information collected during these field visits and the literature review gave an initial insight and allowed further definition of some of the relevant issues/variables related to the adopted resilience framework and concepts (see above). Such variables include level of poverty and dependence on mangrove ecosystem services and management regimes. Because of the relationship of these variables to the selected framework, they were used and considered as among the criteria for the selection of the study sites.

3.4 Selection of Study sites

This study was carried out on Unguja Island in three Shehias of Pete-Jozani, Michamvi and Charawe mangrove SES (Figure 4). A general description of Zanzibar including Unguja related to location, administrative structure, vegetation, climate, population and related aspects is presented in Chapter 4 and descriptions of each case study site are provided in the respective case study chapters (Chapter 5, 6 and 7). The case study sites were selected because they are located in Chwaka and Menai Bays; the two largest contiguous mangrove forest systems in Unguja Island (section 4.3) representing the ecosystem of high national conservation importance (RGoZ, 1996). The cases also represent diverse mangrove SES conditions which makes them of significant importance and provide specific opportunity to examine the complexity of the systems. The accessibility of the village was also taken into account (Table 2) as it affects the possibility of getting quality information based on the time and other resources available for the research. The sites were also chosen because of the researcher's knowledge of some of these Shehias through previous research and employed work in these areas. Some of the variables that were found to relate to the selected resilience framework/concepts were considered as other criteria for site selection to represent the major variations of mangrove SES in Unguja. These criteria included wealth of village, level of dependence on mangrove ecosystem services, and diversity of management interventions (Table 2).

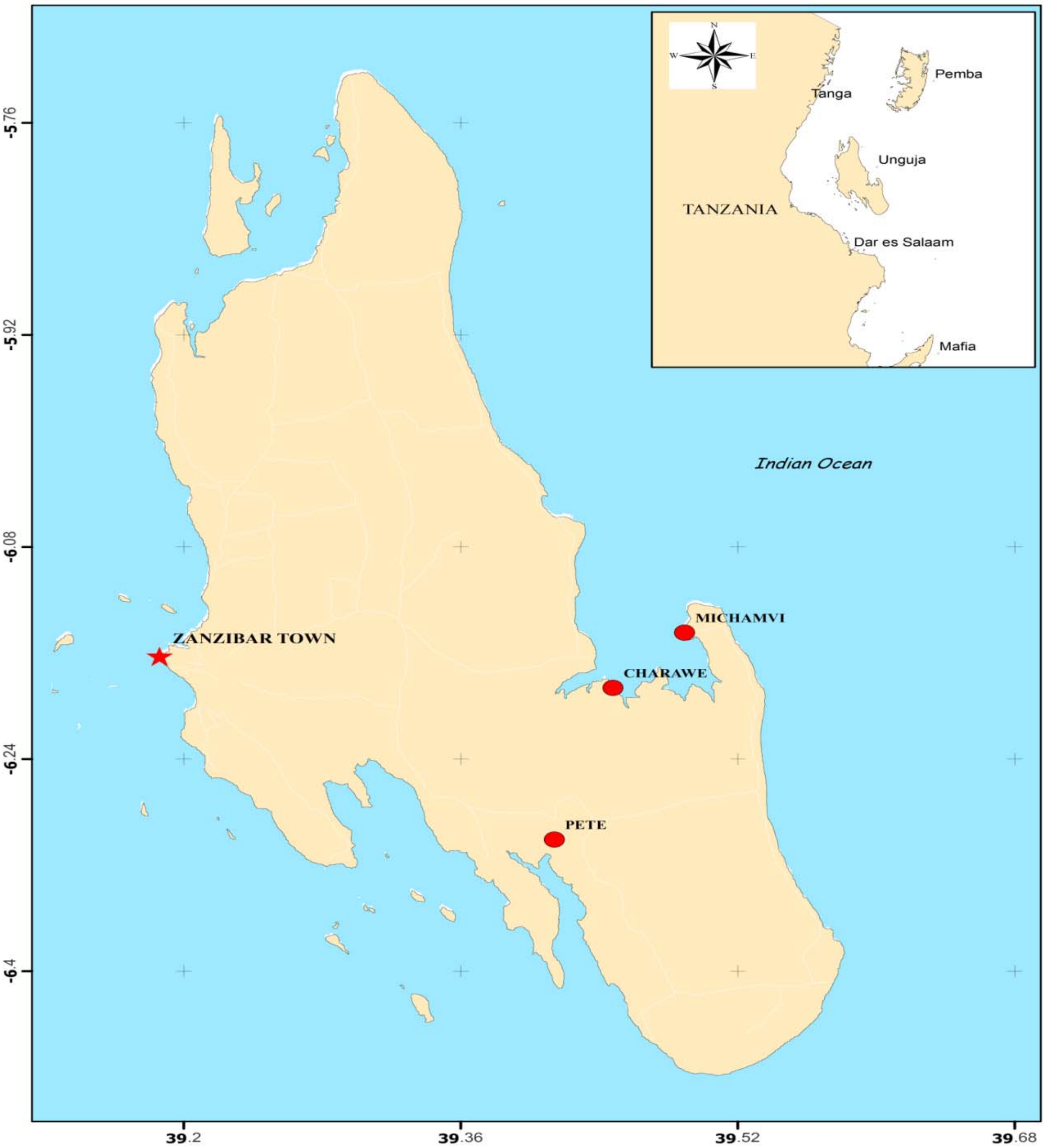


Figure 4 Maps of Zanzibar and location of three study sites in Unguja Island

According to the most recent Zanzibar Household Budget Survey (RGoZ, 2010a), the level of poverty (measured using income and food poverty line) in Unguja Island is generally higher in North A and South District (where Pete-Jozani Shehia is located) and slightly lower in Central District (Charawe and Michamvi Shehia). Poverty is lowest in Zanzibar Urban District in Unguja Island. Despite high levels of poverty, no villages were selected from North 'A' District because of poor road infrastructure and the condition of the mangroves was judged to be similar to the situation in the selected study villages.

Table 2 Study sites and Criteria for Selection

Selection criteria	Study sites (District)		
	Michamvi (Central)	**Pete-Jozani (South)**	**Charawe (Central)**
Poverty level	Relatively high	Moderate	Low
Dependence on mangrove wood provisioning services	Relatively low	Moderate	High
Management arrangement	Community and State	CBNRM and State	State and National Park
Village accessibility	Relatively high	Relatively high	Relatively low

Source: From this study, 2011

Pete-Jozani Shehia was selected primarily because it is within the poor district of Unguja (ibid, 2010a) and is highly accessible with a moderate level of mangrove dependence (based on level of mangrove wood harvested by village residents). Although Charawe Shehia is located in a district where the poverty level is relatively low (ibid, 2010a), preliminary field visits indicated that the poverty level (measured using the established wealth ranking criteria by communities) of Charawe was relatively high compared to other study sites. This was then confirmed during wealth ranking as described in section 3.5.3.1. In addition, Charawe village was selected because of a high level of dependence on mangrove products by the communities. Michamvi Shehia is within Central District, accessible and village residents have a relatively low level of dependence on mangrove wood products. All of the selected sites represent diversity and complexity of mangrove management regimes involving different combinations of state and CBNRM. State-CBNRM is practiced in Pete-Jozani Shehia, State- National Park practiced in Charawe while Michamvi mangroves combine both state and community management arrangements in the Shehia. These case study villages were considered to broadly represent the range of conditions of other mangrove SES in Unguja.

3.5 Data collection methods

3.5.1 Case studies approach

A case study approach was used in order to explore and present the specific and contextual nature of social and ecological issues for each study site (Bryman 2012). The case study approach considers each Shehia as an independent mangrove social-ecological system. Differences and similarities in the mangrove SESs emerging from each case has been used for detailed discussions. The use of the multiple case studies approach is suggested by resilience scholars (Anderies *et al.,* 2006, Walker *et al.,* 2006) who emphasize the need to bring together diverse cases and make comparisons using similar principles of data analysis to cast light on management practices and social mechanisms for building resilience. The approach also provides useful evidence of the complexity and dynamics of mangrove SES and drivers influencing the resilience which is a key aspect of this research.

3.5.2 Selection of data collection methods

The study of resilience requires the use of pragmatic, mixed research methods and designs to facilitate understanding of the general complex behaviour of systems involving people and nature (Walker *et al.,* 2002). Thus this study integrated both quantitative and qualitative research methods to examine different variables that have been incorporated in the developed framework to determine resilience. The collection of data was based on the active involvement of relevant stakeholders in all of these methods. Some of the methods were used in group activities and meetings including wealth ranking, timeline approach and scenario development in order to clearly understand the stakeholders' knowledge that provided key information required for assessing and improving resilience of mangrove SES. Household interviews were used for the purpose of learning about the mangrove ecosystem services and their relationship with the local livelihood activities.

Both socio-economic and bio-physical data relating to mangroves SES were collected using diverse data collection tools and approaches (Table 3) from each study site. The use of a wide range of data sources enable a rich understanding of mangrove SES, whilst also increasing reliability by providing more opportunities for triangulation (Bryman, 2012). Wealth ranking, focus group discussions (FGDs), Village meetings, key informant and household interviews were used to gather information on the social system while mangrove field surveys and field observations were used to obtain information on the bio-physical condition of the mangrove system. A combination of these methodologies was used to collect detailed information to describe the current and past trends, together with projected future scenarios of mangrove SES which is critical for resilience analysis.

3.5.3 Data collection methods for social sub-system

Social surveys were conducted to provide detailed data on the mangrove social system with FGDs, including use of a time line approach, key informant interviews, wealth ranking, household interviews and village meetings. Most of these surveys involved semi-structured interviews or discussions which provide qualitative data on the views and experiences of the stakeholders. This offered the best approach to capture the opinion, and understanding of stakeholders in relation to mangrove SES temporal and spatial dynamics, drivers, impacts and other variables related to resilience analysis. Sampling of respondents was done purposefully, having identified key stakeholders who were engaged in different livelihood and management interventions in the areas. Interviews and discussions were conducted in Kiswahili because the researcher, assistants and respondents were conversant in this language.

3.5.3.1 Wealth Ranking

A wealth ranking was the first data collection approach employed in each village before detailed data collection. The aim of this approach was to explore the diversity of livelihood opportunities and other socioeconomic activities and interests in order to stratify the communities into different wealth/poverty groups for subsequent data collection (Kebede, 2009). In this approach, a list of households and their members was prepared from each Shehia under the assistance of the Sheha with other persons allocated by the Sheha to give assistance on his behalf. This was followed by the categorization of households into wealth groups based on common livelihood activities engaged in by household members and how their wealth status was perceived by other people involved in the discussion. In this context the households from each Shehia were divided into four major wealth groups; namely, the richest, rich, poor and poorest (Table 4) based on the specific wealth ranking criteria established by the key informants and other villagers from each Shehia (See Appendix 1, 2 and 3 for Pete-Jozani, Michamvi and Charawe respectively). The defined wealth ranking groups were later used for systematic selection of respondents of household interviews (section 3.5.3.4 below) while some of the envisaged livelihood groups were used as respondents for FGDs in the village. In addition, the wealth ranking technique was used to define the potential respondents for key informant interviews at the village level.

3.5.3.2 Focus Group discussion and Time line approach

These were two data collection methods which were in some situations simultaneously conducted to determine current states, changes and drivers of change to mangrove SESs over time. FGDs were guided by a checklist of questions while the developed timeline (Appendix 4) was used to facilitate discussions during these participatory group discussions with community members working with mangroves. A total of 22 FGDs were carried out in all study sites in the two phases involving members of VCCs and Sheha, tree planting associations, farmers, fishers, mangrove wood cutters, tree planters, beekeepers, seaweed farmers and others (see Table 3). Each FGD was attended by 4-8 participants most of them with mixed gender participants. The discussions were started by asking community members to explain the present states and describe changes over time by linking them to specific historical events in the past that correspond to specific changes/characteristics of the mangrove SES in the village. To help the villagers, especially the elderly people in the community, to remember about the past they were facilitated to draw participatory maps of the mangrove SESs and indicate the mangrove location and other features today and compare how the situation was in earlier times. The maps form a framework during transects in the mangrove to verify information from FGD. Information collected during FGD and time line approach provide temporal variations on mangrove characteristics and trends (area, species composition, size class of trees mangroves), stakeholder's interests in mangroves, types of mangrove products and services from mangrove ecosystems, institutional arrangements, conflicts and level of interventions in mangrove systems.

The villagers' views on plausible future scenarios were discussed during FGDs with members of VCCs, village elders, Islamic leaders, mangrove harvesters and tree planters. The scenarios were developed through a participatory process that effectively involved substantial interactions between the researcher and diverse stakeholder groups and/or expert judgments using the methods suggested by others (Peterson *et al.,* 2003; McKenzie *et al.*, 2012; Mahmoud *et al.*, 2009; McKenzie *et al.*, 2012). Using these methods scenario development was achieved through four steps involving decisions around the focal problem(s) to be addressed by the scenario, identification of the main drivers of change, scenario development and analysis across scenarios (Ranganathan *et al*. 2008; McKenzie *et al.*, 2012). During this participatory process the researcher facilitated discussion that allowed the participants to understand and agree on the key common problems of increased harvesting of mangrove wood provisional ecosystem services in Unguja especially in villages where most residents were extracting wood products such as Charawe, together with the appropriate timeframe where the future can focus. The participants then identified the most uncertain and uncontrollable crucial factors (drivers) that could have more impacts on the dynamics of the system and affect their future. Through iterative discussions and creative thinking the participants described varieties of possible futures based on the assumptions about expected responses/outcomes on the combination of future drivers as detailed inputs were incorporated into scenarios. All of these diverse stakeholders inputs on the storylines seek to clarify expectations about the drivers of change that will shape the future as extended from the past and present situations. The fourth stage of scenario development which involved discussion and description of scenarios analysis results (stakeholders inputs) from various stakeholder groups was partly done during a one day stakeholder meeting (see section 3.5.3.5 below) while further integrating data from various sources, interpretation and write-up of three sets of alternative future exploratory scenarios were done by the researcher as a scientific investigator and field expert (Alcamo *et al.,* 2005; Mahmoud *et al.,* 2009)

3.5.3.3 Key informant interviews

Key informant interviews (KII) were carried out with government officials (Government/projects representatives from different departments such as forestry, Fisheries, Environment, and others) older community members, members of micro-credit groups, NGOs and village Sheha and his assistant, teachers who were not available through FGDs. Other people included beekeepers, seaweed farmers, and crab harvesters. Standard KII checklists were used to guide the interview for Government officials (Appendix 5) and local community respondents. A total of 19 KIIs were conducted with village stakeholders in all study sites while 12 interviews were accomplished with government officials in both phases (Table 3).

Information collected during these interviews include stakeholders interests, knowledge and perceptions on mangrove management in general, challenges and measures to improve existing trends towards overuse perceived to threaten the sustainability/resilience of Unguja mangroves. The information from key informant interviews and focus group discussions were recorded using flip video camera and transcribed for analysis.

Table 3 Summary of data collection methods and collected information

Data collection methods	Collected information	Number and Type of respondents			
		Pete – Jozani	Michamvi	Charawe	Government officials
Wealth ranking	Categorization of household into wealth groups based on wealth ranking criteria. Forms basis for selection of respondents for FGD and household interviews. List of livelihood activities and level of dependence on mangrove	This was done 3 times with 3 different respondents involving Secretary of village conservation committee from Pete Village, other VCC members from Jozani Village and Beekeepers	This was done 3 times, twice with the same respondent (VCC member from Kae Village) and the last time with Deputy Michamvi Shehia leader and VCC	Two times, one with Assistant village Sheha and the other time with Member of VCC in the village	Not applicable
FGDs together and time line technique	Current state and changes in mangrove SESs variables, drivers and impacts. Evaluation of mangrove intervention e.g. Beekeeping, seaweed and others Villagers views on future scenarios and resilience indicators	6 FGDs were done. 1 with VCC members including Sheha 1 with saving and credit groups 1 with farmers and tree planters 1 with tree cutters 1 with village and religious leaders 1 with beekeepers' association	6 FGDs were done. 2 with mangrove users VCC and Sheha 1 with Fishers and farmers 1 with VCC members in Pingwe 1 with seaweed farmers 1 with village elders	9 FGDs were done 2 with young mangrove harvesters 2 with elders mangrove harvesters 1 with mangrove traders 1 with saving and credit groups 1 with beekeepers 1 with seaweed farmers 1 with crabs collectors	1 with DFNRNR staff
Key informant interviews (KII)	Stakeholders interests in mangrove, knowledge, mangrove products, Benefits, challenge, and measures taken to resolve. Villagers perception on the current management system Challenges and measures toward resilience mangrove SESs	8 KII was done: 2 with JOCDO and JECA secretary 1 with VCC secretary and boardwalk project supervisor 1 with Sheha 1 with UWEMAJO secretary 1 with teacher 1 with VCC member & JCBCP employer I with Saving and credit secretary	6 KII were done: 1 with VCC member in Kae 1 with chairperson for saving and credit groups 1 with Sheha 1 with deputy village Sheha 1 Village elder (82 years) 1 with teacher	5 KII were done: 1 with Sheha 1 with Deputy Sheha 1 with teacher 1 with chairperson of saving and credit group 1 with employed tourist guide in JCBNP	12 KII were done: 1 with DFNRNR director 1 with Director of Fisheries 1 with director of Environment 1 with MACEMP manager 1 with DFNRNR administrative officer 2 with District Forest Officers. 1 with Protected area Management Project coordinator. 1bwith HIMA project representatives 1 with Chief Park warden – JCBNP 1 with Menai Bay Coordinator

					in Zanzibar 1 with mangrove in charge in Zanzibar
Household interviews	Household information, kind and amount of mangrove products and services Livelihood activities. Changes, drivers and impacts of changes. Challenges and measures to improve resilience of the system	40 household heads	40 household heads	40 household heads	Not applicable
Village Meeting	Pete development activities, relationship of Pete VCC and other society members, and use of benefits from boardwalk	1 Shehia development meeting – only done in this site			
A stakeholders' meeting	Collect stakeholders views as inputs for development of alternative future scenarios	1 scenario development meeting attended by 29 participants from diverse stakeholder groups at different scales including			
		7 village representatives: 1 Village Sheha 1 Islamic leader 3 VCC members 2 users of mangrove ecosystem	7 village representatives: 1 Village Sheha 1 Islamic leader 3 VCC members 2 users of mangrove ecosystem	7 village representatives: 1 Village Sheha 1 Islamic leader 3 VCC members 2 users of mangrove ecosystem	6 National scale stakeholders: Director from DFNRNR, Department of Fisheries, Chief Officer from Department of Environment. A representative from Institute of Marine Sciences, CARE project and one research assistant from SUZA. At district scale: 2 District (central and southern) forest officers
Mangrove surveys	Mangrove structural variables	60 circular plots	60 circular plots	65 circular plots	Not Applicable

3.5.3.4 Household interviews

Household surveys were conducted using a structured questionnaire (Appendix 6) with individual household heads or their representatives in the selected households. A total of 40 households from each Shehia were selected for interview from different wealth ranking categories. Sampled households in each wealth ranking category were randomly selected with the assistance of the Sheha or his representatives who approached and asked the villagers to participate in the interviews. The number of selected respondents from each wealth ranking category was based on the relative proportion of people in each wealth group in the study site (Table 4). To clarify the types of household livelihood activities, the respondents were asked to list the key household livelihood activities with their corresponding estimated average income earned by any of the household members irrespective of gender.

Other information collected during household interviews included types of mangrove ecosystem services accessed, level of dependence and income from mangrove resources, knowledge of the ecosystem, changes, drivers, and impacts. It also explored measures to improve the resilience of mangrove SES in Unguja in the future.

Table 4 Selected respondents for household interviews

Wealth categories	Total households			Percentage household			Sampled households		
	Pete	Michamvi	Charawe	Pete	Michamvi	Charawe	Pete	Michamvi	Charawe
Richest	35	52	9	12.2	15.9	3.7	5	6	1
Rich	84	59	13	28.8	17.6	5.0	12	7	2
Poor	147	191	184	50.7	57.9	74.0	20	23	30
Poorest	24	28	43	8.2	8.4	17.1	3	4	7
Total	290	330	249	100	100	100	40	40	40

Source: wealth ranking from this study

3.5.3.5 Village meetings and scenario building approach

A one day participatory stakeholders' meeting was held to accomplish a fourth stage of scenario development (see section 3.5.3.2) involving description of scenarios analysis results to provide common stakeholders inputs. This was achieved by facilitating a collective discussion and exploring broadly a possible consensus around the issues discussed in the first three stages for scenario development during FGDs in each of the study village (as outlined in section 3.5.3.2). Emerging new opinions from different stakeholder groups were also considered. This Stakeholders' meeting was done in an open but shaded building at JCBNP reception centre. This meeting point was selected because it serves as a central point and is an easily accessible area for all participants. It also provided a calm and conducive meeting environment accessed with minimum costs. A total of 29 participants from a wide spectrum of stakeholders groups at various scales were involved in this meeting including: 6 government officials at National scales, 2 representative officers at district level, and 21 representatives of villagers from diverse community groups (see Table 3). The stakeholders at national and district scales were involved at this stage in order to provide an opportunity for diverse stakeholder groups to share their views about the most important drivers of change, the impact of their activities and what could be the likely possible outcome in the future.

The meeting discussion was facilitated by both the researcher and a research assistant, who also took notes on the resulting outcomes. The main facilitator began the meeting by stating the meaning and idea of scenarios and describing the scenario development steps to participants (see section 3.5.3.2). Summarized scenario related information collected during FGDs in each village was presented by the facilitator as a basis for meeting discussion. Active listening by participants was encouraged as the facilitator traversed the meeting area. Participants were then divided into two groups (each involved representatives from all stakeholders groups) for in-depth thinking and discussion of the presented matters. To increase the level of participation and ensure the ideas of all or most participants were captured, the facilitator promoted participation of each group members by giving time for every member to speak, expressing their own ideas and feelings freely during discussion. The meeting ended by asking one group member from each group to present and put forward the group views which were collectively discussed and consensus was reached by most of the participants. The information generated and agreed by most of participants at this stage were the common problems of increased harvesting of mangrove wood provisioning ecosystem services, the period required to generate optimum production from mangrove trees, the most crucial drivers that could have more impact on the dynamics of the system and affect their future, the common scenarios' assumptions based on expected responses/outcomes on the combination of future drivers and contribution on the expected outcomes on mangrove ecosystem services across the scenarios in the next 25 years. This information was used as stakeholders' input for the development of alternative plausible conditions of the future mangrove SES pathways which were further developed as scenarios by the researcher based on the key mangrove SESs information on the past trends, current situation and future projections from primary and secondary sources.

In addition to this scenario development meeting, one village development meeting was conducted in Pete-Jozani Shehia (see Table 3). The meeting was held outdoors under a mango tree close to the main road to allow participation of all interested village members from different political parties in the Shehia. This meeting was conducted in Pete/Jozani Shehia only to clarify the existing controversy on the misuse of boardwalk funds (as one important benefit from the mangrove ecosystem) and unequal distribution and benefits of community development project (supported by boardwalk) funds between Pete and Jozani village. Pete-Jozani Shehia leader headed the meeting. He specifically invited VCC leaders and community development committee members to present the progress report on implementation of community development projects and use of boardwalk funds to Shehia members, a situation which existed in Pete –Jozani Shehia only. The information was recorded on video tape and transcribed for analysis.

3.5.4 Data collection methods for ecological sub-system

3.5.4.1 Mangrove surveys

Ground based mangrove ecological surveys were conducted to assess the current condition of the mangrove system in all study sites at two different periods between 2011 and 2013 as explained above. The second survey was performed to increase the area sampled to give better representation of the condition of the mangrove forests. The surveys were done with the assistance of two survey team members from DFNRNR, two undergraduate biology students from the State University of Zanzibar (SUZA) and elderly local guides.

Because of the difference in management priority between the mangrove stands within each case study (section 5.1. 6.1 and 7.1), the mangrove system from each study site was divided into two different mangrove management categories, which were studied separately and their data were compared (see Figure 5) to evaluate the impact of management approach on resilience of the system.

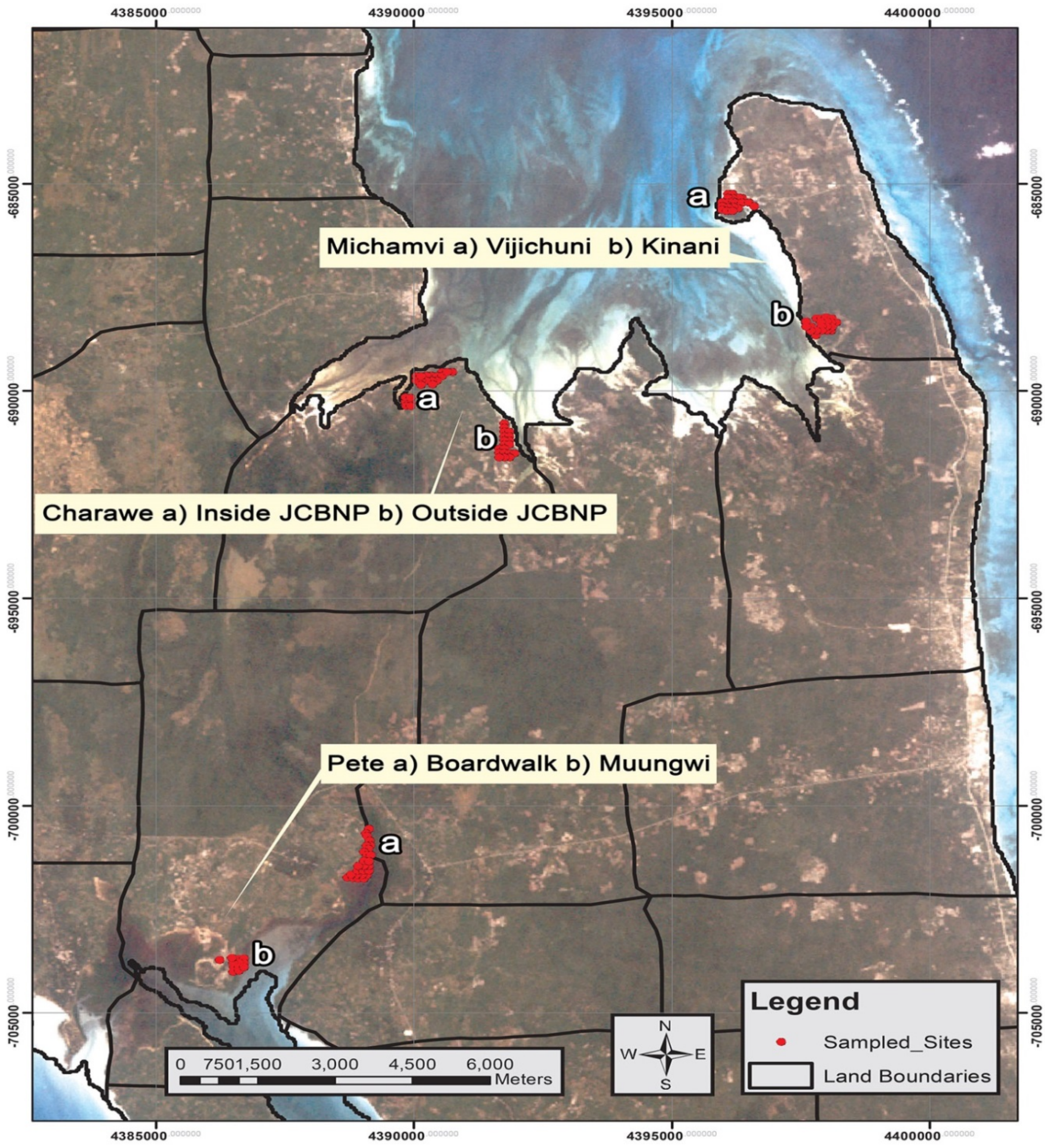


Figure 5 Six surveyed mangrove sites.

The mangrove area studied in Pete included one which is located south of the National Park, close to the village mangrove boardwalk (62ha) and the mangrove area which is located on the western side of Pete village close to Muungwi village (262ha). In Michamvi Shehia the area studied was the mangrove forest from Kinani (86ha) which is considered as a government forest and has received little conservation effort by the communities. Also the Vijichuni mangrove, which is close to the village and is mainly conserved using village by-laws (39ha), was studied. In Charawe Shehia, the study was conducted in the mangrove forest in Kinani which is outside the JCBNP (111.5ha) and in part of Mapopwe mangrove which forms a part of the National Park (755.3ha).

The sampling intensity was fairly low due to time and budget constraints and the inaccessibility of much of the mangrove area. The total mangrove area from each case study sites is indicated in Table 5. The sampled mangrove forests covered an area of 120ha, 70ha and 152ha in Pete, Michamvi and Charawe mangrove forests respectively. Thus a total of 185 circular plots each of 0.04ha were surveyed within the sampled mangrove forests from all study sites in both phases. The number of plots in each mangrove forests is indicated in Table 5.

Table 5 Total Sampled area in mangrove biophysical system

Study Shehia	Total Shehia area (ha)	Total mangrove Area (ha)	Protected/high priority mangrove forest		Low priority or degraded mangrove forest		Total sampled area
			Sampled area (ha)	Number of plots	Sampled area (ha)	Number of plots	(ha)
Pete	3,822	322	44.0	31	76.0	29	120
Michamvi	1,604	125	30.0	30	40.0	30	70
Charawe	3,100	866.7	100	35	50.0	30	152
Total	8,526	1,313.7	174.0	96	166.0	89	342

Source: from this study

These plots were distributed systematically at intervals of 100m along transects which ran perpendicular to the shore. However, due to poor accessibility in the mangrove system and an attempt to capture some of the variations due to site-specific differences in ecological conditions and human influences it was necessary for some of the plots to diverge from the main transects. At the centre of each plot GPS coordinates were taken using a handset GPS and recorded in the local zone coordinate system of Arc – 1960- UTM – Zone 377S format at an accuracy of between 0-5m. Mangrove vegetation variables were measured and recorded on a mangrove survey field form.

Information collected from each plot represents the common variables for studying the mangrove structure as reported by others (Bosire *et al.*, 2003, Dahdouh-Guebas *et al.*, 2004). These variables were mangrove tree species and diameter of all mature trees equal to and above 2cm measured at 1.3m above the ground or immediately above the buttress roots. The height of four mature trees in each species (one largest, one smallest and two average sized diameter trees) were measured to get average species height from each plot. Other variables collected were number of stumps cut for each species and their estimated age as described by local guides. From each main circular plot of 0.04 hectares, a sub-circular plot of 2m radius was established whereby all mangrove plants with a diameter of less than 2cm were counted and recorded as seedlings. Studied variables from the mangrove ecological system included mangrove tree species diversity, dominance, standing density, tree size distribution, basal area, seedlings regeneration rate, rate of cutting/degradation and standing volume. Apart from direct measurement of mangrove tree parameters, field observation and discussion with local guides were made to explore several aspects of mangrove management and interventions, quality of the mangrove trees together with changes that have taken place.

Land use mapping was also done using GPS from each study site in order to determine the area accessible by local communities for various uses in the village as this has direct connection with the uses and dependency on the mangrove system.

Secondary data from online journal articles, government and project reports were collected from various sources available from the University of Greenwich, DFNRNR, SUZA, Institute of Marine Sciences, Zanzibar National Archive and other institutions interested in mangrove of Zanzibar.

3.6 Materials for data collection

A tree calliper was used to determine the diameter at DBH for all trees taller than 2 m. A measuring tape was used to measure the distance between circular plots and transects as well as for establishing radii. A compass was used to direct and guide the proper laying out of the plots within transects. A calibrated stick and clinometers were used interchangeably (depending on the tree height) to measure tree height of the selected trees in the study plots. A handheld-GPS was used for taking coordinates and mapping of the areas. Questionnaires, checklists and flip-charts and flip camera were used for recording information during interviews and focus group discussions while field forms were used for ecological data assessments.

3.7 Researcher's position in the context of undertaking data collection

Resilience is a relatively new field, which is associated with the use of terms, concepts and variables that were not familiar to most respondents. For example the word resilience is a technical term that has no modern Swahili name which necessitated using the term sustainability, with added explanations to elaborate the concepts (see section 3.9). This might have contributed to increased difficulties and the long time spent on data collection, including the development of scenarios with diverse stakeholders in the field. Thus, in this context, the researchers and/or research assistants had to play facilitation roles (as an expert in the field) during most of the participatory methods especially FGD, KII and village meetings for knowledge raising before data were collected (see section 3.5.3.2). Engaging with a University employed female researcher (the author) as a key research facilitator and field expert during data collection is not a very common experience for village communities especially in mangrove ecosystem related research. However, as the researcher was working in an academic institution, the respondents did not directly associate her with the forest sector during the research period. This made the participants to be free of fear which encourged them to provide detailed information, including those related to illegal cutting activities. Such information would not be given to a researcher who is directly working with government institutions responsible for management of mangrove ecosytems. In addition, being a female researcher to some extent mobilised and encouraged participation of women respondents in most of the data collection methods used in the communities. At the same time, participation of research assistants of both genders in most of the data collection provided equal opportunities between women and men respondents to express their views. This helped to avoid gender bias and has hopefully improved gender balance of diverse community members.

This pre-data collection awareness raising practice was necessary and relevant to all approaches of qualitative methodology (Dwyer and Buckle, 2009) in order to introduce the concepts which would give the respondents a clear understanding of the general research themes and provide a framework for discussion. Once clear elaboration of particular research concepts or themes were completed before participatory data collection methods or during quantitative surveys, the position of the researcher and assistant changed and they became more distant from participants acting as learners and outsiders; receiving responses to the questions asked to respondents, which led to more reliable data collection. To make interviewing and field discussion an interactive experience, researcher/assistants were in some cases invited to bring their personal role into the research relationship by answering participants' questions, sharing knowledge and experience, and giving support when asked (Cotterill, 1992).

3.8 Data analysis

Social data were analysed using various methods. Information from FGD and key informant interviews were recorded using a flip video recorder and transcribed and coded using Microsoft Excel 5.0. The data from FGD and KII were qualitatively analysed using analytical induction approach (Bryman 2012). In this approach the key points extracted from the transcribed texts from different respondents were defined and marked with a series of codes. The coded points in each category of respondents were grouped into similar concepts indicating both the consistency and variations of the respondents' answers which form the findings describing key variables of resilience as guided by the framework used in this study. This type of analysis provides clear insight and detailed meaning on mangrove SES variables which is the key for this study. The collected data from household interviews were entered in a Microsoft excel template and then transferred to SPSS 19.0 programme for analysis using basic descriptive statistics.

A three-way ANOVA (between years, sites and conservation status) was carried out to evaluate the influence of seasonal/year variation on a range of mangrove ecological data (e.g. tree density, basal area, volumes etc.) collected in the two different phases. The results indicated that year/season made no difference for all of the variables collected and therefore the two data sets were combined and analysed together.

Mangrove inventory data were processed using Microsoft Excel 5.0. Mangrove bio-physical variables such as trees, seedlings and stump density and their relative values were calculated based on standard relationships for estimation of ecological parameters as described by Smith and Smith (2001). For example, the importance value and dominance of each species was calculated by summing its relative density, relative frequency and relative dominance (ibid, 2001). The Shannon Weaver index of diversity was used to determine the diversity index of mangrove tree species in the ecosystem while Effective Number of Species (Exponential of Shannon index values) was used to indicate the number of abundant species. The total standing volume per hectare for each plot and per species was estimated using mangrove volume equation of V = G.F.H. where G = basal area (m^2), H = mean plot height (m) F = mangrove stand form factor (0.65).

Statistical analysis for mangrove structural variables between case studies was done using two-way ANOVA. Multiple comparison analysis using Tukey's Honestly Significant Difference (HSD) test (statistical test performed after ANOVA test to define to define which groups of variables differ from the other) [Sokal and Rohlf, 1995] was done to assess the difference for most of mangrove structural variables between mangrove sites and conservation status.

Data from both mangrove bio-physical and social variables were pooled together and used for resilience analysis using framework proposed by Cumming et al. (2005). Using this approach, the resilience of Unguja mangrove SES was analysed through 5 central elements.

1. Definition of the current state of the system. In this section four essential attributes that need to be maintained for resilience analysis were described. A clear definition of the current state of the system's structural components, functional relationship, continuity and sources of innovation was provided. This stage was completed by the development of indicators based on villagers' views about when mangrove SES will lose identity. These indicators were established using the methods suggested by others (De Bruin and Barron, 2012) whereby the commonly cited resilience variables across the social and ecological identity were presented to the community members to guide them on the development of locally relevant sets of mangrove resilience indicators to evaluate the changes of mangrove SES identity. In the absence of precise, quantitative data and given the importance of involving stakeholders, villagers (village elders, some Islamic leaders, beekeepers, tree planters) were asked to provides practical mangrove ecological and social indicators for stated resilience variables that maintain the identity of the system. Thus the development of these indicators was based on a consensus of the majority emerging from discussions with the contacted village elders, some Islamic leaders, beekeepers, tree planters and VCC members on the defined and presented mangrove social ecological variables. Differences in views were also recorded and defined.

2. Clarify change trajectories – this involved defining the phases of change a system has undergone together with the current phase of mangrove SES dynamic using the Adaptive Cycle (Figure 2) as developed by Gunderson and Holling (2002). It also indicated the main causes of change of the system, with particular relevance to their impacts on properties of interest. In addition it involved the identification of the kind of perturbations and disturbances against which resilience was assessed.

3. Define possible future systems – potential mangrove SES futures – three plausible mangrove SES futures scenarios using a scenario building approach were defined in all case studies. The developed scenarios were not entirely new systems but include the prevailing and past system experienced some changes and reorganisation. The identified alternative future and resilient

indicators were later used as the base against which to assess the current resilience of Mangrove SES to withstand future drivers of changes.

4. Assess likelihoods of alternative Futures – the resilience of mangrove SES was assessed by evaluation of which alternative future is likely to lead to more resilient mangrove SES by maintaining its identity.

5. Identify mechanisms and levers for change – an alternative future scenario that provides the best options among others to improve residence of mangrove SES in Unguja has been suggested.

3.9 Methodological limitations

Some of the respondents were not willing to cooperate or gave incorrect/misleading information which delayed the process of data collection. For example, some of Pete beekeepers reported that 80% of the beekeeping activities which represented about 400 beehives are located in mangrove system. However, only a few beehives were observed during transect mangrove survey in Pete mangrove system.

Because the supply of ecosystem services were not confined to the study sites only, it was very difficult to contact the stakeholders who would give reliable information on the type and level of ecosystem services they are extracting especially when the majority of the users were living outside the study area. For example, in Kinani mangrove (Michamvi), most of the users were reported to come from villages close to Michamvi such as Bwejuu and Ukongoroni. Relatively few village outsiders were reported to engage in the extraction of mangrove wood ecosystem services from Charawe and Pete-Jozani mangrove forests. Important village outsiders in Charawe were villagers from Ukongoroni and Chwaka villages while people from Unguja Ukuu, Kitogani and Uzi were reported to engage in illegal harvesting of Pete mangroves.

There is no peer review published literature reporting changes of mangrove areas in Zanzibar. Much of the available information is based on consultancy reports. It is difficult to judge the quality of these data because in many cases the methods used to obtain them were insufficiently described and the associated uncertainty was not indicated.

There is generally limited scientific research information relating to mangroves in Zanzibar. Even in the areas where the studies have been conducted little of the documented information has been published through peer-reviewed research publications. This necessitated the use of some of the secondary data sources from the grey literature, government consultancy and project reports.

Resilience is a relatively new concept to most of the contacted respondents. There is no modern Swahili name to refer the term resilience which necessitated using the term sustainability with added explanations to elaborate the concepts.

This chapter described the process of data collection giving insight on the study design, the rationale for selecting the study sites and how different methods were used for data collection and analysis. The next chapter describes generic information of Zanzibar drawn from combination of literature and research findings related to physical, administrative, and economic structure, together with the climate and demographic features of the Islands. The chapter also presents overall information on policies and institutions for natural resources management and conservation in Zanzibar.

Chapter 4

ZANZIBAR GENERAL CONTEXT

This chapter gives a description of the generic issues related to natural resource management in Zanzibar. It provides a physical description and administrative structure of Zanzibar, its vegetation and land use categories. It also presents climatic, demographic, social economic issues together with the general policies, legal and institutional framework for management of coastal resources in Zanzibar.

4.1 Physical description of Zanzibar

Zanzibar is a semi-autonomous entity in the United Republic of Tanzania in East Africa. It is an archipelago consisting of 16 islands in total with two major islands; Unguja and Pemba, with a land area of 166,600ha and 98,800ha respectively. These other small islets include Tumbatu, Changuu, Kibandiko, Chapwani, Bawe, Chumbe, Mnemba, Kwale, Latham, Uzi in Unguja and Fundo, Kojani, Kisiwa Panza, Shamiani and Misali in Pemba. The Islands are found about 40 km off the coast of East Africa in the Indian Ocean and lie between 4 and 6.5 degrees south of the equator (see Figure 4).

4.2 Administrative structure

Zanzibar comprises five administrative regions, two in Pemba and three in Unguja. The regions are North-Pemba, South-Pemba, North-Unguja, South-Unguja and Urban-West. The South-Unguja region is composed of two districts namely South and Central. The two districts have a total of 59 Shehias including the three Shehias of Pete-Jozani, Michamvi and Charawe which form the study areas. A Shehia which is normally composed of two to three villages is the lowest administrative unit in Zanzibar. Every district has a planning officer and a community development officer, as well as officers from sectoral ministries assigned to the district. For example, the district forest officers are working under the district authority to take care of all issues related to forests within their respective districts. The head of a Shehia is called a Sheha and is appointed by the Regional Commissioner upon consultation with the District Commissioner.

According to the standard local administrative procedure in Zanzibar, once a Sheha has been appointed a “Shehia Advisory Council” has to be constituted to act as an advisory team to the Sheha (Othman *et al.,* 2003). The local administrative structure also provides a mandate to the

Sheha to establish different local committees to take part in governing specific Shehia socio-developmental activities. The type and nature of committees in most cases are characterised by the types of natural resources existing within Shehias or problems affecting the Shehia. For instance, typically committees in the Shehias around the JCBNP include a Sheha committee, a Village development committee, a Village health committee, an HIV committee, a Fisheries committee, a Malaria committee, an Environment committee, a Mosque committee and a Village Conservation Committee (VCC). The main task of these committees is to support and advise the Sheha to implement his day to day activities within the Shehia. Almost all committee members are appointed by the Sheha with the exception of some sector specific committees which are selected by villagers in the Shehia after consultation with relevant sectors. For instance, members of VCCs are selected by villagers in the Shehia in consultation with DFNRNR.

The formation and working principles of these VCCs were guided by the international non-governmental organisation CARE in collaboration with DFNRNR during the early 1996 in accordance with the standard requirements of the CBNRM formal institution in Zanzibar (RGoZ, 1996a). This act requires that VCCs members should be active in conservation of both terrestrial and mangrove forests and work to address villagers' interests in development activities in the Shehia. The VCC should serve as a central link between local stakeholders engaged in forest conservation and higher level government authorities.

4.3 Zanzibar vegetation and other land use system

Zanzibar lies within the Tanzania Coastal Forest-Eastern Arc Centre of endemism which forms one of the 25 Primary biodiversity hotspots in the world. Its vegetation belongs to the Zanzibar-Inhambane coastal mosaic (White 1985) comprised of different ecosystems including coastal mangrove areas and sea grass beds, coral rag forests and plantations along the East coast, and coastal forest and ground water forest in the deeper soils of the West (Table 6). Zanzibar has about 147,567 ha of forested area including both marine and terrestrial ecosystems (Leskinen *et al.,*1997). Jozani-Chwaka Bay National Park is the only National Park on the island and includes all of the above ecosystems (Ely *et al.*, 2000).

These forested areas have been reported to be highly degraded which leads to significant reduction in vegetation cover, while other areas such as settlement, agriculture and cleared vegetated areas have expanded (Table 6). Mangrove forest area is the second largest natural forest vegetation, after the coral rag thicket. As reported in section 1.1 of chapter 1, total area of mangrove forests of Zanzibar has significantly declined in the last sixteen years from 7.4% of the total land area in 1997 to the current vegetation cover of 6.2% of the land area. Zanzibar mangroves account for 14.5% of the total forested land and are represented by several patches which are scattered throughout the islands.

Table 6 Area of land use classes in Zanzibar

No	Land Use Classes	1997		2013			
		Area (ha)	Percentage	Unguja (ha)	Pemba (ha)	Total area (ha)	Percentage
1	Coral Rag Forest (Coral and grassland)	98,329	37.1	71,068	15,114	86,182	32.6
2	Mangroves	20,000	7.4	5,274	11,214	16,488	6.2
3	Forest Plantation and main high forests	9,505	3.6	2,688	1,100	3,788	1.4
4	Mixed wood vegetation	19,733	7.4	0	7,149	7,149	2.7
	Subtotal for forested area	**147,567**				**113,607**	
5	Agroforestry system	85,084	32.1	2.0	44,951	44,953	17.0
6	Agriculture land	25,034	9.4	61,343	13,877	75,220	28.4
7	Settlement area	7,715	3.0	16,460	11,300	27,760	10.5
9	Bare land areas	Unidentified		1,230	871	2,101	0.8
10	Wetlands	Unidentified		273	612	886	0.3
	Total	**265,400**	**100**	**158,337**	**106,189**	264,526	100

Sources: Leskinen et al., 1997; RGoZ, 2013

Chwaka bay mangrove where Charawe and Michamvi mangrove SESs are located, represent the largest contiguous mangrove forest system in Zanzibar, with an estimated area of about 2,800ha (Madeweya *et al.*, 2002). The Chwaka Bay mangrove consists of two mangrove management units/blocks of Kinani located in the east and Mapopwe located in the west of the bay. Other mangrove forest systems of relatively large size include Menai Bay where Pete Jozani mangrove SES is located, Makoba Bay in Unguja Island and Pemba Channel Conservation Area (PECCA) in Pemba.

According to the Land Act in Zanzibar, all land is government property. Village land is controlled by the central government although villagers are allowed to use the land in their village but cannot sell it (RGoZ, 1992a). The Government has the power to take the land back whenever the need arises. People can officially inherit the land if their parents had formal land ownership rights from the Government.

4.4 Climate

The climate of Zanzibar is tropical and maritime, mainly influenced by northeast and southeast monsoon winds which result in the Islands' climate having wet and dry seasons. The dry-hot period is from December to March when the northeast monsoon winds blow. With a mean annual temperature of 26.3^{o}C, Zanzibar attains a maximum mean monthly temperature of 33^{o}C during the hottest, driest period and experiences the minimum mean monthly temperature of 23.3^{o}C during the coolest period within a year (SONARECOD, 2010). The wet season of the Islands is influenced by the south-east monsoon (April to November) marked by a bi-modal rain pattern with an average rainfall of 1,628mm per annum. The main rainy season (*masika*) occurs between March and June while short rains (*vuli*), usually start in October and end in December.

There are minor variations in levels of rainfall received between villages within the Zanzibar Islands. For instance, the study area of Jozani-Pete mangrove creek receives an annual precipitation well below average (800mm), in the two rainy seasons (*Masika* and *Vuli*) (Akil and Jiddawi, 2001). Zanzibar is relatively humid throughout the year with an average relative humidity of 76% ranging between 87% in April (*Masika*) rain season and falling to 60% during the dry season.

The coast is washed by a northward flowing current known as the East African coastal current. The surface water is warm, 25^{o}C to 27^{o}C, with only a small annual variation. The water is poor in nutrients, especially nitrates and phosphates, and has a salinity of 34.5 parts per thousands (ppt). The tides rise to about 5m in spring and fall to 3m at the neaps, giving a tidal range of 3–5m (SONARECOD, 2010).

4.5 Demographic information

Zanzibar's population has almost quadrupled from 354,815 in 1967 to 1,303,569 inhabitants in 2012 (Table 7). The average population density is 530 individuals per square km with a current annual growth rate of 2.8% (NBS, 2012). The annual population growth rate had almost doubled from 1.8% in 1967 to 3.1% in 2002. The highest population is found in the Urban Western region and accounts for 46% of the total, while the Southern region where this study was located has the lowest population and accounts for 8.8% of the total population with an average annual growth rate of 2.0% (ibid, 2012). If the population continues to grow at the present rate of 2.8% it is expected that the Zanzibar population will nearly double in the next 25 years. The population of Zanzibar is predominantly rural (68%) and youthful in character (44.3 percent of the population are under 15 years of age). There is a high level of dependency which sets a limit on domestic savings and reduces the ability of women to participate in the labour force (RGoZ, 2010a).

Table 7 Zanzibar and case study area population data from 1967 to 2012

	1967	1978	1988	2002	2012 (households)
Zanzibar	354,815	476,111	640,685	984,625	1,303,569 (253,608)
Pete-Jozani	246	328	543	1,161	1,540 (290)
Michamvi	223	295	501	1,120	1,650 (330)
Charawe	295	393	531	728	1,050 (249)

Sources: NBS, 2012 and Study sites Shehia registers, 2012

At the current Southern region annual population growth rate of 2.0%, the projected population size for the next 25 years from 2012 for Pete, Michamvi and Charawe is given in Table 8.

Table 8 Population projection from 2013 to 2037 for Pete, Michamvi and Charawe Shehias

Shehia	2012	2017	2022	2027	2032	2037
Pete-Jozani	1540	1701	1880	2078	2297	2539
Michamvi	1650	1823	2015	2227	2461	2720
Charawe	1050	1160	1282	1417	1566	1731

Source: This study projection, determined by researcher.

4.6 Zanzibar economy

With its low per capita income of USD 557 in 2009 it is clear that Zanzibar is poor and has a small economy (RGoZ, 2010) according to international indicators for measuring poverty. The Zanzibar Household Budget Survey data of 2009/2010 showed that 44.4% of the Zanzibar population had incomes that were below the basic needs poverty line, while 13% lived below the food poverty line (RGoZ, 2010a). A large percentage of the poor people are in rural areas where this thesis focuses its attention.

Following the fall in the world market price for cloves in the mid-1980s, tourism was identified as an opportunity to lessen the impact of the decline of the clove industry on foreign exchange and economic growth in the islands and was seen as a high priority area in the Zanzibar Poverty Reduction Plan (RGoZ, 2007). The Zanzibar service sector (which among others includes tourism) is the main driver of growth in Zanzibar that contributes 47% of the Gross Domestic Products (GDP) and 80% of the foreign exchange (RGoZ, 2010). However, the tourism sector has not generated as many employment opportunities for the poor coastal communities (Gosling, 2003) as would be expected by most of Zanzibaris (RGoZ, 2009). People from outside Zanzibar are benefiting more from employment opportunities generated in the tourism industry than the local communities who are bearing the full brunt of the environmental and cultural costs of tourism (RGoZ, 2005). In response, Government has recognized that there is a need to train more Zanzibaris in the fields that are useful in tourism, such as hospitality, so as to expand the employability of local people in the tourist industry (RGoZ, 2009). In addition, tourism has a very weak linkage with the rest of sectors of the economy, thus limiting potential multiplier effects in terms of employment and income. For example, tourism takes a very small share of local horticulture products such as vegetables; which limit potential benefits that locals could benefits from the sector (ibid, 2009). Despite its contribution to the national economic growth in Zanzibar, tourism represents one of the most worrying issues with respect to coastal zone management as it has resulted in a rapid transformation of the coast through widespread development seen on Unguja's East Coast, in areas such as Kiwengwa, Bwejuu and Michamvi (RGoZ, 2005; RGoZ, 2010).

The service sector is the largest employer and accounts for the highest employment share of 39.1% of the total employment in the islands **(**RGoZ, 2010**).** Agriculture is the second largest employer, creating 37.7% of the total employment (RGoZ, 2009). Agriculture remains crucial for broad-based and pro-poor growth, contributing about 22.2% of the GDP (RGoZ, 2010). However, Zanzibar farmers have inadequate information on domestic and global market opportunities available to them. Farmers, fishers and livestock keepers are largely disconnected from the local tourism industry for instance, and are not aware of the changing nature of the food industry opportunities and market segmentation (ibid, 2010).

4.7 Religion

Islam is the dominant religion and is practised by most Zanzibaris in the Islands. All towns and villages have mosques which unites the majority of residents through the attendance of prayers five times every day. The domination of Islamic religion in the island creates cultural homogeneity that provides a strong social network and social services governed by Islamic laws. The application of these Islamic laws also promotes linkages through social support systems in the form of 'Saddakar and Zakar'[1]. Regarding management of forest resources there are specific Islamic laws that in principle prevent destruction of forest resources in accordance to the Islamic faith which considers that forests are precious resources that Allah created to support the lives of humans when they are used sustainably. There has been an established trend in most of the villages in Zanzibar for the Islamic religious leaders to give public speeches that emphasise the wise use of forest resources as this is explained by Islamic laws. The application of these laws has become effective in some villages, especially in contributing to people's understanding of the importance of forest resources and conservation because they have to be accepted and obeyed by all believers.

In Zanzibar town there are also a limited number of churches and temples for the small populations of Christians and Hindus. Swahili is the dominant language spoken in the Islands with no other language except English which is mainly practised in formal working and academic institutions.

4.8 Institutional framework for management of coastal resources in Zanzibar

The importance of coastal natural resources in supporting social and economic development of people and nations has been globally recognized. These resources play a vital role in providing surrounding communities with diverse livelihood opportunities. However, some of the activities associated with these opportunities engaged in by surrounding communities can have serious and sometimes adverse impacts on those resources. In many cases the exploitation rate of the resources is very high compared to their regeneration. This then presents a considerable challenge on how to manage these valuable resources in a manner that will achieve sustainable use. In an attempt to address these challenges sets of institutional frameworks including policies

[1] Both are Islamic terms mean the act of giving help in voluntary (Saddakar) and compulsory (Zakar) ways to those in need according to Islamic laws.

and acts have been introduced world-wide. The term 'institution' is used here to refer to the set of rules, laws and regulations that humans use when interacting within a wide variety of repetitive and structured situations at multiple levels of analysis (Ostrom, 2005). It has been realised that it is not only the presence of sets of policies, rules and regulations which decide the effective sustainable utilization of those resources but how these legislative frameworks are coordinated and implemented to deliver crucial and meaningful interventions (Williams, 1998).

Zanzibar, like many other islands in the world, has diverse coastal natural resources which provide essential benefits to meet the demands of their populations and so contribute significantly to the well-being of the nation (RGoZ, 1992b). Some of the important natural resources along the coastal areas include diverse marine and terrestrial animals (fish and bird species, turtles, tortoise, crocodiles) and forests, thickets, shore and other vegetation cover such as mangroves that support this diversity of marine organisms.

According to the Zanzibar Land Act, amended in 2003, all village land and anything connected therein are considered government property, but communities can access and utilise these resources with minimum restriction. Thus most of these resources are directly exploited by surrounding communities through diverse human activities to meet their livelihood needs. The Zanzibar Government has realised the need for improving the quality of the environment and is committed to advocating change to achieve sustainable development through sustainable use of natural resources. It is for this reason that the protection of the Islands' natural resources has become one of the cornerstones of Government policy (RGoZ, 2010). To achieve this vision the Zanzibar Government has formulated a number of policies and legislation in different sectors that are considered to be relevant to support coastal and marine resources protection and to some extent cover some aspects of mangrove management and conservation. The key sectoral policies that provide a framework for management, utilization and conservation of natural resources include National Environmental Policy of 1992, Zanzibar Fishery Policy (1992), Zanzibar Forest Policy (RGoZ, 1996), Zanzibar Tourism Policy (2006), Agriculture Policy (1992) and Energy Policy (2008). Policy formulation has been followed up by the introduction of legislation (some of which already existed) to provide the basis for legal institutions to support the implementation of these policies. Some of the legal institutions that take into account the policy objectives are Zanzibar Fishery Act (1988), ZEMSDA of 1996 (RG0Z, 1996b) and The Zanzibar FRMCA, No 10 of 1996 (RGoZ, 1996a).

A review of most of these policies and institutions [for example, National Environmental Policy of 1992, Zanzibar Fishery Policy (RGoZ, 1992), Zanzibar Forest Policy (1996), Zanzibar Tourism Policy (2006), Zanzibar FRMCA (1996), Zanzibar Fishery Act (1988), ZEMSDA (1996)] indicated that they stressed the need for achieving sustainable use and conservation of natural resources for the needs of present and future generations mainly through putting restrictions on the uses of such resources, or allowing uses that were perceived to have limited impact on the resources/environment. These legal institutions are also focused in promoting local capacity and development of alternative methods of using environmental services without causing serious degradation to natural resources.

For the purpose of providing optimum environmental protection, the Zanzibar Forest Policy (RGoZ, 1996) and Zanzibar FRMCA, No 10, 1996 (RGoZ, 1996a), which are the main decrees governing forest resources in Zanzibar, have set aside areas of high biological importance under forest reserves (including mangroves). Utilization of the forest reserve is only allowed under special permits and for uses that are considered to have limited impact and therefore the decrees now deny communities free access to reserved forests. The Act also declared Natural Forest Reserves of higher conservation value such as Jozani National Park, for permanent preservation of their environment for biodiversity and scenic beauty. These permanent reserved areas are only used for scientific, education and recreational/eco-tourism purposes while putting a complete ban on direct resource extraction by surrounding communities. For example, in the case of the Jozani Chwaka Bay National Park, surrounding communities are prevented from harvesting such forest products as fuel wood and wild game. Moreover, the Reserve protects animals that damage farmers' crops (JCBCP, 1996), thereby affecting the livelihoods of farmers.

One of the major reforms in these legislative tools is the declaration of a community forest policy which allows local communities to participate in sustainable planning, management and conservation of forest resources. This idea emerged following realisation that the existing reserve status of mangrove forests before the introduction of Nature Conservation Areas did not provide the opportunity for community participation and the villagers had no incentives to participate in conservation (Ely and Makame, 1997). In these community forest programmes local communities have legal power to either engage in co-management arrangements to assist Government in conservation of the forest reserves and nature conservation areas or establish and manage their own village forest areas. The forest areas managed by communities (such as coral rags, woodlot establishment) were aimed at ensuring sustainable provision of fuel wood and other essential goods, environmental stability, income and employment in rural areas.

The Zanzibar Tourism Policy (2006) has also provided guidelines on how to achieve sustainable economic development for the benefit of future generations. The policy objective relevant to natural resources emphasises sustainable tourism through rational and sustainable use of coastal resources. This is designed to be achieved by conducting Environmental Impact Assessments (EIA), Strategic Environmental Assessments (SEA) where development is taking place and the development of recreational facilities in protected and adjacent areas and areas along the coasts.

In the case of fishery resource, the Zanzibar Fishery Policy (1992) and the Zanzibar Fishery Act (RGoZ, 1988) recognize the importance of mangrove as fish breeding grounds, and that fishing is an important economic activity for the coastal people. The fishery policy goal places emphasis on increasing awareness of the need for sustainable management of marine resources through the establishment of Marine Protected areas, control of illegal fishing methods, and the re-introduction of the traditional opening and closing harvesting system. The policy also calls for community participation in coastal resources management.

One of the crucial natural resources aspects emphasised by most of these legal instruments is the importance of bio-fuel energy to meet the ever-increasing demand for domestic energy in Zanzibar. Like many other less developed countries, the majority of people in Zanzibar use bio-fuel as the main source of domestic energy. Most of these policies highlighted that the high bio-fuel domestic energy demand is met through both importation of forest products from mainland Tanzania and unsustainable harvesting of forest products within Zanzibar (RGoZ, 1996, Zanzibar Energy Policy, National Environmental Policy of 1992, Agriculture Policy, 1992). The only existing environmentally friendly source of energy in Zanzibar is the hydro-electric energy from Tanzania mainland national grid through Tanga and Dar es Salaam via underwater cables. However, both initial installation and monthly payments are very high for local community members to afford. The unsustainable supply of forest resources is not related to energy issue alone but also is evident in the limited availability of building poles whereby a significant amount of mangrove poles are imported from mainland Tanzania to help meet domestic demand. For example an annual average of 10,03korja/scores of mangrove poles was imported from Tanzania mainland between 2007 and 2011 (Figure 6).

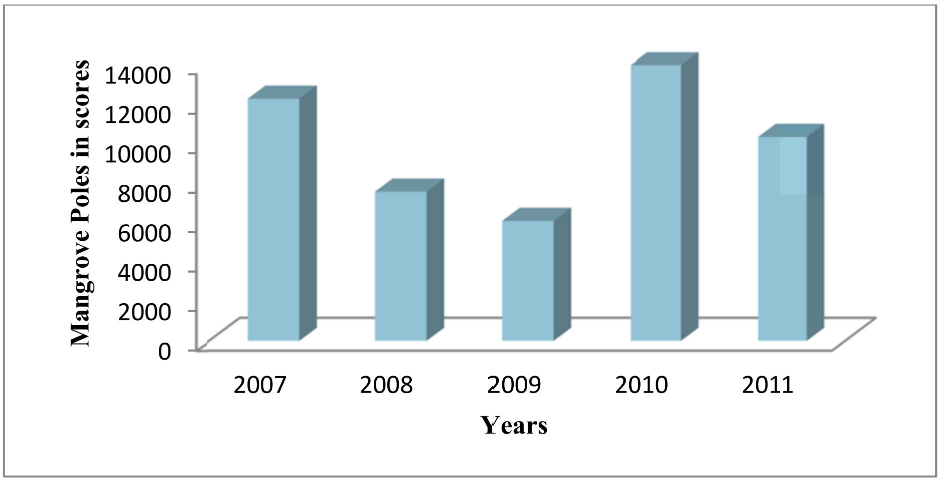


Figure 6 Imported mangrove poles from Tanzania mainland between 2007 and 2011

Source: DFNRNR files.

In addressing domestic energy demand the Government set a vision to make Zanzibar an energy secure economy by 2015 (RGoZ, 2010). Thus most of these sectoral policies and regulations aim to promote the development of reliable, affordable and environmentally feasible renewable alternative energy sources. The potential alternative energy resources under consideration are renewable sources such as solar, wind and tidal waves. Efforts are currently under way to investigate the potential of these new energy sources by making initial contacts with the contractors, building institutional capacity through training and identification of the pilot areas for windmill installation and oil exploration (RGoZ, 2013a). It is the expectation of all sectors that the successful introduction of affordable and environmentally-friendly energy sources will reduce excessive cutting of mangroves and coastal forest for fuel wood.

4.8.1 Inter-sectoral linkage and co-ordination

Analysis of existing legal institutional frameworks related to natural resources indicates that they were formulated with slightly related objectives with respect to achieve sustainable conservation of natural resources in Zanzibar. These sectoral policies and acts present defined concepts that are supported by regulations related to sustainable use of existing natural resources. At the same time most of the policies are promoting community participation in conservation and management of natural resources. However, the question of sector coordination and linkage in planning and implementation has received very little attention which resulted in each sector working independently and inefficiently. Consequently, one sector may address a community by emphasizing issues related to its sector while putting less emphasis on issues related to other sectors in managing the same natural resources. Despite the introduction of the concept of an Integrated Coastal Zone Management (ACAM) framework (National Environmental Policy, 1992; ICAM, 1996) that seeks to coordinate different actors in planning, decision making and sustainable management of coastal resources, it remains far from implementation.

4.8.2 Evolution of governance systems for managing mangroves and other forestry resources in Zanzibar

The forest management policies and other relevant institutions of Zanzibar have evolved through the years starting from the colonial era to the present. The reported management institutions are starting from the 1920s reflecting the oldest known governing systems; either from other studies or furthest memorised information that villagers have been narrated by their parents. Two known systems of forest management were practiced prior to the current governance approach.

1920s to mid-1960s - The colonial era

From 1920s to the mid-1940s, Zanzibar was a British protectorate administered through an Arab Sultan. During the 1920s the governance of mangroves and all forests in Zanzibar including Jozani was managed under the ownership and custodianship of local communities who had access to and use of the resources (Masoud, 2000). Village elders' consensus from this study indicated that there were no formal institutions related to governing forest resources (Section 5.8, 6.8 and 7.8). The forests were managed through informal institutions associated with people's traditions, cultural behaviour and Islamic religious beliefs. Under colonial control between the 1930s and early 1940s Zanzibar terrestrial and mangrove forests were commercially exploited for the production of timber and poles (ibid, 2000). For example, Pete-Jozani villagers confirmed the results reported by other studies (Swai, 1983) that a private Indian merchant purchased a portion of Jozani forest from Jozani village elders to undertake commercial logging in the forest. Small-sized sawn timber from Jozani was exported to mainland Tanzania for the construction of soap and beer boxes (Griffith, 1950). At the same time some of the mangrove forests of Zanzibar were used by the colonial companies as a trade commodity for commercial bark stripping and the production of poles exported from both Pemba and Unguja Islands since 1930s (Griffith, 1949). Commercial bark harvesting was carried out in the mangrove areas that had a good proportion of *Rhizophora mucronata* and *Bruguiera gymnorrhiza* trees, with diameters of 20cm and above. These two species were considered by the colonial companies as commercially important trees for bark stripping while other mangrove species were extracted for commercial pole production in special areas. The bark was exported to Europe and United States for tannin extraction, a project which was managed by the Colonial Development Corporation. Between 1938 and 1942 an annual average of 889.8 tonnes of bark were exported. Export reached a peak between 1943 and 1947 with an average amount of 4867.4 tonnes of dry bark and 66,220 scores of poles harvested and exported from Zanzibar annually (ibid). Bark stripping was a wasteful harvesting method which eventually killed the girdled trees but left them standing, wasting valuable wood and preventing regeneration.

By 1949, all commercially designated mangrove areas for bark extraction were fully exploited and the forests had a limited amount of 20cm diameter trees suitable for bark production. A five year working scheme was developed and implemented as a policy strategy to allow reduced diameter limit of 15 cm for bark stripping and regulate domestic harvesting for cutting poles and firewood (Griffith, 1950).

In spite of the presence of the colonial administration local people had access to and use of mangrove resources. For example, Chwaka Bay mangroves were under traditional management and villagers around the bay exercised some control over their exploitation in areas traditionally identified as being under the jurisdiction of the villages concerned (Mohammed, 2004). Villagers reported that the management and use of mangrove wood products was achieved through opening and closing harvesting seasons between Mapopwe and Kinani mangrove blocks. This management system was introduced by local people in this period, but effectively enforced and slightly formalized after the forest governing system officialised in 1945 (see below). During this period a joint mangrove management council was created by representative village leaders from each village around the bay. This council met regularly at Chwaka village to discuss and make decisions on issues pertaining to the management of mangrove (this study section 6.8 and 7.8). However, others have suggested that this management system was established after Zanzibar's independence (Mohammed, 2004).

Subsequently, in order to meet their commercial needs for timber and poles colonial interests ignored this traditional forest management approach and from 1945 slowly replaced it with formal management arrangements. In this period, the colonial government formulated the Wood Cutting decrees (CAP 120 No 8 of 1945) with a view to conserving and developing forest areas on Unguja Island (Griffith, 19950). The Decree declared all mangroves to be government land/public land whereby neighbouring communities were given access and allowed by law and without permit, only to cut wood for building poles for subsistence uses (ibid, 1950). Apart from these allowable uses, local communities were using mangroves for diverse domestic uses through the opening and closing harvesting system. The local council in Chwaka Bay received royalties for the exported bark and poles from the Government which were used to run their activities (Madeweya *et al.,* 2002, this study section 6.8). However, this community use right of unrecorded harvesting was perceived as a major threat by the colonial governments and led to the introduction of a permit system in 1949 (Griffith, 1950).

The colonial government purchased 194 ha of Jozani terrestrial forest in 1948 and made this area into a forest reserve in 1960 (constitution order of 1960; Masoud, 2000). The Government managed the forest by stopping commercial exploitation and initiated a programme of reforestation in areas harvested before the purchase (Abdalla and Kitwana, 1997).

1965 - After independence

Following Independence in 1964, the Revolutionary Government of Zanzibar (RGoZ) declared all mangrove forests as forest reserves to be managed by the central government as State property in 1965 (Mohammed, 2004; SONNARECOD, 2010). Opening and closing of poles harvesting was practiced in Chwaka Bay but with the decisions exclusively made by the Government without community involvement. Mangrove harvesting required licences. People including non-village residents were given permits to sell mangrove poles, but there were restrictions on other uses such as lime making and bark collection. District Forest Officers and Forest guards were employed to enforce the mangrove management and conservation laws. The demands of local communities for wood products were relatively low and, therefore, this system was able to meet their needs up to the early 1970s despite the presence of formal regulations.

Under a rapid increase in human population, the demands for forest products increased drastically and the forests were continuously exploited (Masoud, 2000). Implementation of the State management regime required manpower and other resources that the Government failed to provide sustainably and thereby the management system became ineffective and mangroves remained largely open access and unprotected resources despite being legally recognized as forest reserves (Madeweya *et al.,* 2002). Weak implementation of the government reserve laws which were superimposed on the existing traditional management arrangements with the Government issuing permits to non-village residents for commercial exploitation further undermined the local management system (Mohammed, 2004).

Global recognition of the importance of coastal resources

With the increase in global recognition of the importance of coastal resources, a number of legal international instruments that have a bearing on the conservation and management of environmental resources were developed and designed under the auspices of United Nations (UN) to be adopted in the national policies and institutions of the UN member States. For example, the United Nations Conference on Environment and Development (UNCED) Earth Summit in Rio de Janeiro in 1992 urgently recommended that countries reorient their national forest policies to take into account the multiple uses and functions of forests in a holistic and balanced manner (United Nations, 1992). Currently, there are eleven International treaties and instruments [such as RAMSAR Convention, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention of Biological biodiversity] that demand implementation of some protection measures for mangroves (Polidoro *et al.,* 2010). These international treaties represent global obligations on resource conservation, which have strongly shaped the policies, laws and regulations that could operate at national and local levels. Tanzania is a signatory country to most of these international agreements and has strong obligations towards their implementation at the national and local level. Implementation of these international obligations has been addressed in Zanzibar through a number of international organisations and projects which have supported national forest conservation initiatives started in the last 34 years ago. For example, in 1980 the Finnish International Development Agency (FINNIDA) project worked with the Forest Department to help the Government to conserve forest reserves through increased control over the people and resources around the protected areas. The project also supported afforestation programmes whereby about 2000 ha of forests were planted throughout the islands (JCBCP, 1995). Despite these efforts, State management institutions were not effective in reducing forest resources degradation.

Forest Policy/legislation change and mangrove management regime shift era:

Between 1995 and 2003 the Jozani Chwaka Bay Project (implemented by CARE and funded by the Ford Foundation, and Global Environmental Facility) was introduced and worked with DFNRNR to support the establishment of a National Park by changing the conservation status of Jozani Forest reserve into Jozani Chwaka-Bay Conservation Area (JCBCP, 1995). The project also facilitated the forest policy reform which led to the formulation of the National Forest Policy and FRMCA No.10, 1996. One of the important reforms in these legislative tools was the legal recognition of the importance of involving local communities in conservation and management of forests. Thus, the Zanzibar National Forest Policy (RGoZ, 1996) and Zanzibar Forest Management and Conservation Act of 1996 (RGoZ, 1996a) are the main legal instruments that currently provide the basis for the protection, conservation and development of all forests including mangroves in Zanzibar. These legislative tools have put mangrove management into two main tenure arrangements operating at the national scale to manage the mangroves of Zanzibar.

One approach considers all mangroves of Zanzibar as forest reserves in which State legislation protects the mangroves. Under the State property regime, central government through the DFNRNR is the sole owner and decision maker regarding access and use rights of Zanzibar mangrove (RGoZ, I996; Saunders *et al.,* 2010). The policy implementation strategies on this management approach consider mangrove as an important ecosystem of high biological importance and thus its management requires permanent conservation as a forest reserve. This was intended to protect the biodiversity conservation function of forests and other environmental benefits.

Under this management system local communities around mangrove are considered to be outsiders, with no legal recognition on the access, decision-making and use. This approach has been in force since colonial times and is still the dominant approach to the management of most mangrove forests throughout Zanzibar. For example, this management system has been in practice to govern and give full protection of JCBNP which also included Mapopwe Mangrove forests in order to raise the conservation status of the park in 2004 (JCBCP, 1995). However, this nationalization of the mangrove forests had not been successful in reversing the trend in mangrove degradation (Mangora, 2011).

Consequently, these statutes provided legal recognition to allow the emergence of a second type of forest management regime involving a range of different approaches with varying levels of local stakeholders' involvement; including 'co-management', 'collaborative' or community-based management approaches to the management of forest resources of Zanzibar. These management approaches theoretically allows sharing of resource management responsibility and authority between diverse groups of local stakeholders including resource users and Government. Local communities were persuaded by government staff with the support of international donor projects, led by development or conservation agencies such as CARE and

WWF to formulate VCC and develop new local institutions approved by the Government (Finnie, 1997, 1997a and 1997b) for management of the forests. In this management approach communities are engaged in the management of community terrestrial forests or to assist Government on conservation of the forest reserves and nature conservation areas. For example, after the approval of community-based approaches for natural resources management in 1996, all Shehias around forested areas were persuaded to formulate VCCs in their villages as formal organisations responsible for all forest conservation and management. An advisory committee was then established in November 1995 as an umbrella organisation – which was then converted to a Non-Governmental Organisation called Jozani Environmental Conservation Association (JECA) (JCBCP, 1996). With regards to mangrove, the policy emphasized the need to involve local communities in the management of mangrove as forest reserves while exploring the provision of meaningful incentives for their participation. Such incentives included ecologically sound tourism activities and appropriate access to some forest products (RGoZ, 1996).

With an increased realisation of the importance of conservation the Zanzibar Government opened the door for more international donor supported projects to assist the country to achieving sustainable management of the resources and improve people's well-being (RGoZ, 1996). As a result, a number of donor-funded projects were observed to take place during this study period as important global stakeholders working closely with national scale stakeholders to achieve their interests in mangrove and other forest resources. Such projects included the Marine and Coastal Environment Management Project (MACEMP) funded by the World Bank and JICA between 2007 and 2010. MACEMP in Zanzibar was administered under the Fishery Department to contribute to a global objective of developing an ecologically representative and financially sustainable network of marine protected areas and build United Republic of Tanzanian's capacity to measure and manage trans-boundary fish stocks. The project also aimed to achieve sustainable management and use of marine resources through enhanced revenue collection, reduced threats to the environment, improved livelihoods of participating coastal communities and improved institutional arrangements (World Bank, 2005). To implement this objective MACEMP has worked to control illegal fishing practices especially in Chwaka Bay, provided resources for regular management activities of mangroves, provision of expertise whenever necessary, including building capacity of the government staff and villagers dealing with mangrove conservation. MACEMP also supported the preparation of the new Zanzibar

Mangrove Management Plan, development of small income alternative activities and provision of modern fishing boats all around coastal areas of Zanzibar (SONARECOD, 2010).

To put more restrictions on the uses of mangrove wood products the DFNRNR put a complete ban on harvesting any mangrove products through a moratorium on issuing permit throughout the islands, while advocating the uses of mangrove through exploitation of non-extractive mangrove ecosystem services (Field discussion with national scale stakeholders, 2013).

More recently in 2010 CARE, through partnership with DFNRNR, introduced *Hifadhi ya Misitu ya Asili*, HIMA, a pilot project under Reducing emissions from deforestation and forest degradation ($REDD^{+}$) to address global interests in carbon sequestration and help forest dependent communities around JCBNP to gain access to carbon market funding to support their efforts to protect and restore the forests (HIMA, 2010). To start with HIMA initiated an intensive campaign on the introduction of this project in all villages around Chwaka bay and beyond by focusing on reviewing old COFMAs (all Finnie, 1997s) and VCCs to suit the standard requirements for successful implementation of projects. Very recently the project provided small carbon grants for all JCBNP villages ranging from 6,500,000TSHS (£2,600) to 10,500,000TSHS (£4,200) as incentives to conserve their terrestrial forests (Field observations, 2013). The initial focus of this project was on community terrestrial forests where four villages were chosen for the first piloting phase.

However, it was found that this management arrangement was also focused towards the management of some mangrove forests, especially in areas where mangrove forests were the dominant forest system and/or perceived to be of greater conservation value. For example, draft revised COFMAs were observed in all of the study sites suggesting the government's intention to include mangroves under carbon trading programmes in future. In addition CARE has also been working with other projects such as Women Empowerment in Zanzibar (WEZA) through local NGOs such as JECA and Jozani Community Development Organisation (JOCDO) to facilitate the negotiation process with communities and support savings and credit programmes in all villages around JCBNP and beyond. JECA is a voluntary association instigated by CARE and DFNRNR to represent all 11 villages around JCBNP including Pete, Michamvi and Charawe in a co-management arrangement operated by the park as a means of increasing bonding and the extent of community participation. This NGO also supports Park activities on conservation of biological resources through creating incentives and alternative income activities that will reduce dependence on forest resources (Ely and Makame, 1997).

In this context, although CARE is administering several activities in the area, there is no specific intervention that is directly focused on mangrove conservation and management but there are activities that are supposed to reduce dependence on forest resources in general. Other stakeholders are tourists represented by global tourist companies and individual tourists who have interests in Pete mangroves.

These two broad management regimes have been practiced simultaneously in Zanzibar to govern mangrove and have strongly shaped and diversified the institutional arrangements at the village level. This means that there is no single property right that is practiced alone at the village level; all of them consist of some elements of either of the two major management regimes practiced at the National level. More recently, a new management plan for Zanzibar mangrove systems has been prepared to enforce these rules and regulations (SONARECOD, 2010). However, neither the State nor the CBNRM approach or management plan of mangroves is effectively implemented to realise their intended objectives. As a result the mangrove management actions in Zanzibar have been characterised by the ad hoc implementation of activities and irregular enforcement of laws largely based on availability of donor funds and interests.

This chapter outlined the general information focused on policies, institutions and approaches used for natural resource management in Zanzibar. The next chapters, five, six and seven present empirical data from the case study findings of Pete-Jozani, Michamvi and Charawe respectively as framed by the resilience framework.

Chapter 5

PETE-JOZANI CASE STUDY

This chapter describes the Pete-Jozani mangrove SES. It starts with a contextual description of the area and the current state of the system with regard to structural components, functional relationships, continuity and innovation. It also presents the villagers views on indicators for resilient mangrove SES, changes in the Pete mangrove SES, drivers and impacts of changes in the Pete-Jozani system.

5.1 Pete-Jozani context

Pete-Jozani Shehia is composed of two small villages namely Pete and Jozani. The villages are located to the southeast of JCBNP along the Makunduchi main road, about 35 km from Zanzibar town at around 6° 15' S and 39° 24' E. Jozani and Pete villages are positioned to the East and West of JCBNP main entrance gate respectively. Administratively, Pete-Jozani Shehia falls within Southern district, South administrative region of Unguja. The leadership structure in the Shehia follows the standard political administration arrangements in Zanzibar (see section 4.2). Thus Pete-Jozani Shehia administrative structure has a wide variety of formal village organisations which are responsible for different social and economic issues within the Shehia.

The Shehia's population has expanded rapidly over the last four decades and is expected to double in the next 25 years (see section 4.5, Table 8). More than 75% of the population lives in Pete village where some of the farming and residential areas have extended within the park's boundary. The remaining population live in Jozani village which is composed of some of the abandoned farm lands used for monkey viewing and managed by the park authority.

Most of the residents are Muslim with their culture, shared beliefs and way of life influenced by Islamic laws, despite the presence of a small number of non-Muslims. Almost all non-Muslims are migrants from mainland Tanzania many of whom now have families born in Zanzibar. These migrants settled in the two villages attracted by the marketable forest resources which were easily accessible and traded along the main road in the past four decades.

Pete-Jozani Shehia covers approximately 3,822 ha, and is endowed with diverse natural forests such as coral rag, high forest vegetation and mangrove forests. The Shehia's close proximity to the core of Zanzibar's one and only National Park has resulted in most of the village land being allocated under different land use systems and interventions which have reduced the total village land and the community's access to forest resources (Figure 7). Thus about 622 ha of Pete-Jozani Shehia forms a part of JCBNP and 89.5 ha is owned by local residents but used by the park authority for monkey viewing. The owners of this land get compensation from the park through their union called *Umoja wa Wenye Mashamba ya* Jozani (UWEMAJO). The Shehia consists of tree woodlots covering 76.7 ha planted with *Casuarina equisetifolia* trees and 89 ha of agricultural land which has been sold to people from outside the village. The remaining area covers residential areas, open bush-land, agricultural and grazing land, long-established terrestrial forests under COFMA and mangrove forests.

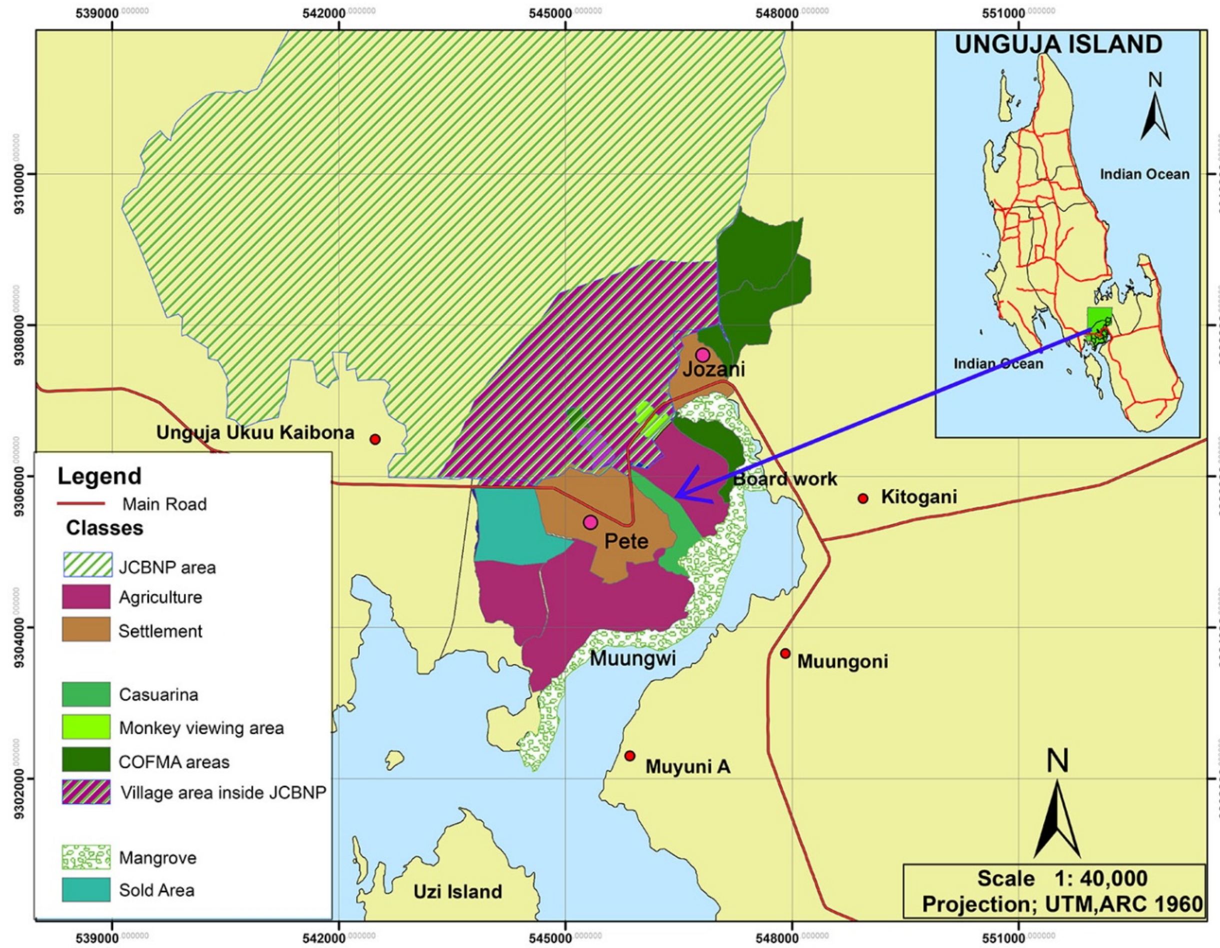


Figure 7 Location and land use map of Pete-Jozani Shehia. *Source: Adapted from DFNRNR.*

Pete-Jozani mangrove is not part of JCBNP but is located in Menai Bay; the second largest mangrove stand after Chwaka bay mangrove system in Unguja. Pete-Jozani Shehia has a total of 322 ha of mangrove forests comprised of two portions which are distinguished by differences in the intensity of vegetation cover and management priorities. These are mangrove forests close to the mangrove boardwalk toward Kitogani village and the mangrove forests located south of Pete-

Jozani Shehia toward Muungwi and Uzi village. Mangrove close to the boardwalk receives greater management attention from the village stakeholders and park authority as it serves as one of the most important tourist attractions for the visitors to the JCBNP. Mangrove of Pete were intensively harvested for supply of diverse provisioning ecosystem services in the past, but excessive cutting pressure has reduced the capacity of the forest to meet the demands of the village population. Agriculture, which is practiced in coral rag areas, is the most important livelihood activity in Pete. A significant number of farmers have recently adopted an improved fallow system of intercropping with permanent trees in their farms as an informal way of acquiring ownership of the village land. As a result some of the villagers who owned village land through this way have sold this land to village outsiders. This has increased the land and resource scarcity and led to difficulties for local people to meet their forest related needs. Alternative livelihood activities have been introduced by communities and higher scale stakeholders to reduce community dependency on natural resources around the park. However, with the limited areas of community coral rag forests and mangrove forests which are perceived by the communities to have been depleted in the last eight years most of the people are currently achieving their livelihood through small-scale agriculture, illegal exploitation of wood products in the National Park and through small-scale alternative activities. These activities are not considered by local people to effectively remove them from their dependency on the forests.

5.2 Current state of Pete mangrove ecological system

The ecological component of the mangrove SES is described using the mangrove structural characteristics composed of the mangrove tree species diversity, dominance, density, regeneration, tree size distribution, rate of cutting, basal area and standing volume.

5.2.1 Mangrove species diversity, dominance, density and regeneration

Out of the total 10 mangrove species reported in Zanzibar (Table 1) nine species were found in the Pete mangrove ecosystem. Mangrove forest in the vicinity of the mangrove boardwalk was found to have lower species diversity than the mangrove forest located at Muungwi village with species diversity indexes of 1.00 and 1.3 respectively. A total of seven mangrove tree species were found in mangrove areas close to the boardwalk while nine mangrove species were recorded at the Muungwi mangroves. *Ceriops tagal* (CT), *Rhizophora mucronata* (RM), *Bruguiera gymnorrhiza* (BG), *Sonneratia alba* (SA), *Avicennia marina* (AM), *Pemphis acidula*

(PA) *and Lumnitreza racemosa* (LR) were found in both sites while *Xylocarpus granatum* (XG) and *Heritiera littoralis*(HL) were recorded in Muungwi only.

Mangroves in both locations are dominated by three tree species. *C. tagal*, followed by *B. gymnorrhiza* and *R. mucronata* accounted for 99.2% and 84.9% of the relative density for mangrove trees close to the boardwalk and Muungwi, respectively. Mangrove at the boardwalk had only two abundant species; *C. tagal* followed by *B. gymnorrhiza* covering 59.1% and 29.6% of their relative tree density respectively. On the other hand, mangrove forest at Muungwi was dominated by three species of significant abundance represented by relative density value of 39.3%, 38.6% and 6.9% for *C. tagal, B. gymnorrhiza and R. mucronata* respectively. Thus based on species importance values (sum of relative abundance, frequency and dominance), *C. tagal* was the dominant species in both sites with the species importance value of 147.9% and 103.3% for mangrove of the boardwalk and Muungwi, respectively. Results from FGD with mangrove harvesters and beekeepers reported the decline of the availability of some mangrove tree species especially *P. acidula*, *A. marina* and *X. granatum;* indicating decline in mangrove species diversity.

Mangrove forest at the boardwalk was characterised by a relatively high number of mature plants and regeneration rates compared to mangrove at Muungwi. The average standing density of 4,210±572 trees/ha and regeneration of 46,188±7480 seedlings/ha were found in this mangrove. In contrast, mangrove of Muungwi had a lower density of mature plants and less than half the density of seedlings found at the boardwalk mangrove with values of 3,035±830 trees/ha and 18,049±5,587seedlings/ha. Regeneration was higher for the most abundant species in both sites and no seedlings were encountered for the least abundant mangrove species. For example, no seedlings of *A. marina*, *P. acidula* and *L. racemosa* were found in the boardwalk mangrove area and these species together with *H. littoralis* were found in insignificant proportions in Muungwi mangrove. Figures 8 and 9 indicate the average tree density and regeneration capacity of Pete-Jozani mangrove ecosystem.

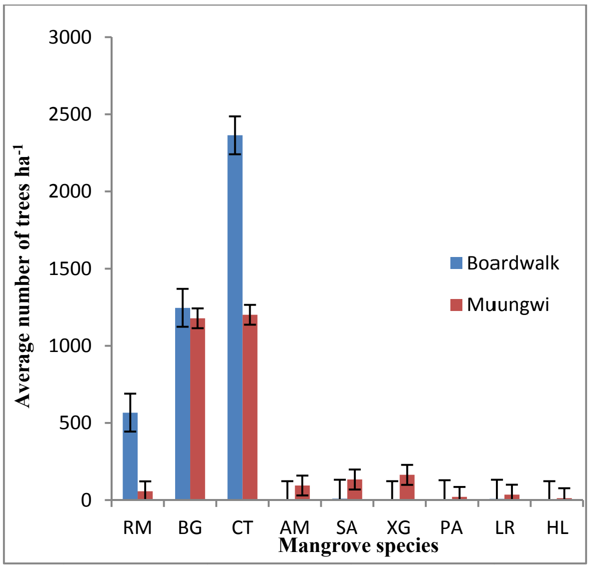


Figure 8 Mangrove tree species density in Pete

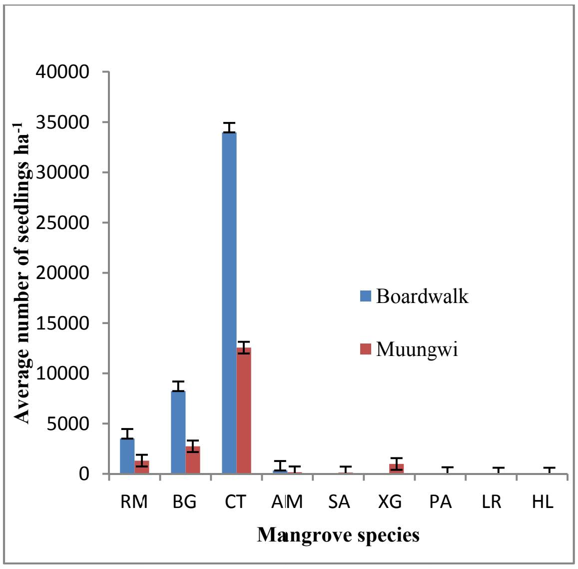


Figure 9 Mangrove seedling regeneration in Pete

5.2.2 Tree size distribution, basal area and standing volume of mangrove system

Results from the transect surveys indicated that Pete-Jozani mangroves were generally characterised by patches of young and early growing trees, except around the boardwalk where large sized trees dominate. The size-class structure at both localities showed the numerical dominance of smaller over larger trees. Despite the high density found in both sites, 86.2% and 91.5% of the mature plants for boardwalk and Muungwi mangrove respectively, ranged between the smallest diameter classes of 2-5cm (Figure10). The dominance of small sized trees has implications for the amount and quality of wood (reflected by total basal area and wood volume) of the system.

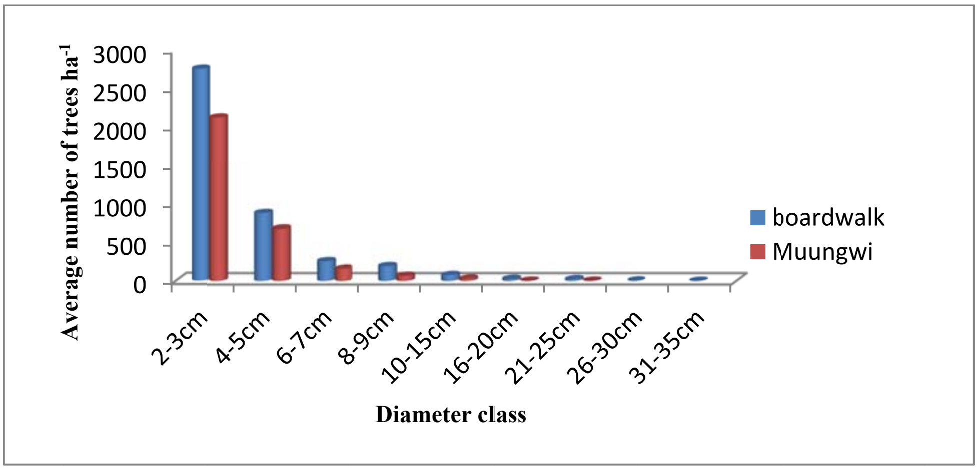


Figure 10 Size - class distribution of mature mangrove trees in Pete

Only mangrove stands very close to the boardwalk possessed closely covered mangrove trees of relatively large sized diameter. This mangrove had an average basal area of 5.83±0.99 m^2/ha with corresponding average standing volume of 23.27±7.87 m^3/ha. Mangrove forest close to the boardwalk was protected from any form of timber harvest, fishing or other form of extraction to maintain the attractive nature to tourists and other visitors around the boardwalk. However, the few larger trees surrounding the boardwalk represented a small fraction of the larger area and so make no significant contribution to the total basal area and volume. On the other hand, mangrove at Muungwi had an average basal area of 3.43±0.71 m^2/ha with a corresponding volume of 8.67±2.12 m^3/ha. Figure 11 indicates the volume distribution for each mangrove species in Pete.

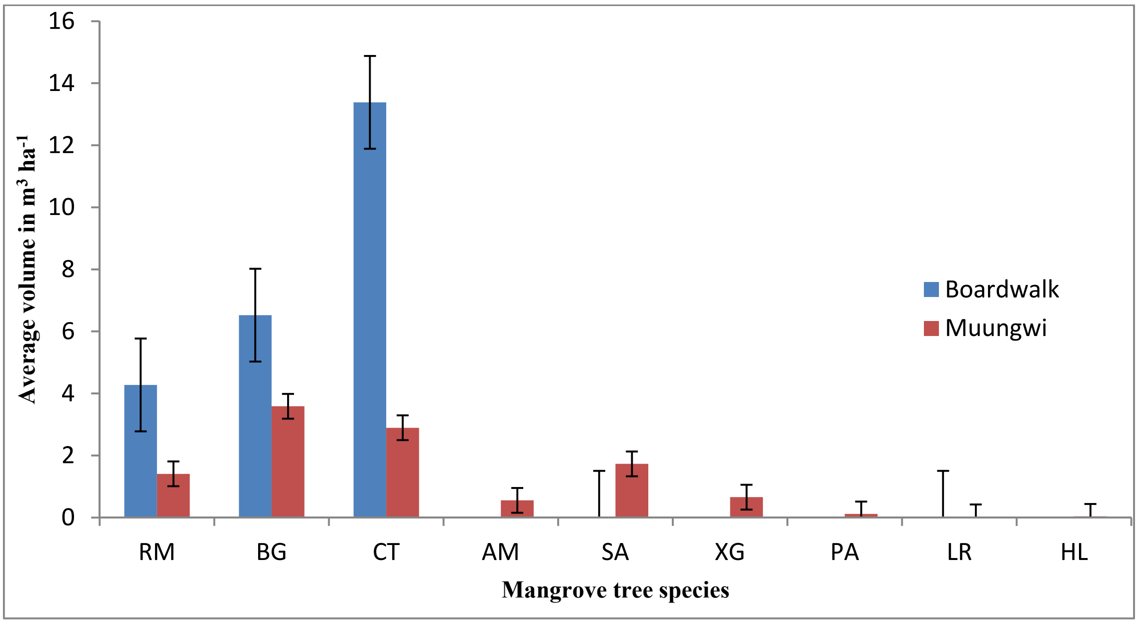


Figure 11 Mangrove tree volume distributions in Pete

5.2.3 Rate of mangrove cutting

Pete-Jozani mangrove ecosystem was found to have an average of 287±44 and 410±118 stumps per hectare for the boardwalk and Muungwi mangrove, respectively. *B. gymnorrhiza* was the most cut tree species in boardwalk mangrove accounting for 46.8% of the stumps while *C. tagal* was the most harvested tree in Muungwi mangrove represented by 47% of the stump density. Village members participating in the mangrove survey identified the number of stumps by age (Table 9). About 12.9% and 16.6% of the cut stumps in the boardwalk mangrove and Muungwi, respectively, exceeded more than five years in age, which indicated that there has been a significant decline in the rate of mangrove cutting in recent years. The results from focus group discussions confirmed that the rate of cutting has slowed down and some of the mangrove patches which were completely ruined have been left untouched for natural regeneration to take place. The decline in the rate of mangrove cutting does not necessarily mean that local communities have no longer an interest in cutting mangrove wood; rather it reflects the significant loss of the desired ecosystem services required in the society.

Table 9 Density of mangrove stumps by age in Pete-Jozani mangrove ecosystem

Stump age	Boardwalk		Muungwi	
	Stumps/ha	% of the total	Stumps/ha	% of the total
1 year	218	76.0	314	76.6
2.5 years	32	11.1	28	6.8
>5years	37	12.9	68	16.6
Total	287	100	410	100

Source: Mangrove surveys from this study

At the same time, despite the reported decline in the rate of mangrove cutting, the current rate of harvesting indicated by the number of stumps of one year age or less, (Table 9) shows that this is not sustainable. If the current rate of tree removal continues it will completely remove the number of mature plants in the next 19 and 9 years for the boardwalk and Muungwi mangroves, respectively.

5.3 Current state of Pete-Jozani mangrove Social system.

The Pete-Jozani social system is described by stakeholders, knowledge, interests and ecosystem services from Pete mangrove ecological system.

5.3.1 Stakeholders in Pete mangrove Social System

Pete-Jozani is comprised of a diversity of stakeholders at different spatial scales who are divided into two major groups. The stakeholders at global, national and district scales are composed of international donor projects, national department and district staff implementing their working programmes in Pete to achieve their interests in the Pete mangrove system (see section 4.8.2). Most of these stakeholders are responsible for management and conservation of mangrove resources through preparation and implementation of legal instruments to control the resources while improving wellbeing of the people depending on the resources (RGoZ, 1996). It also includes top-elected political leaders who have influence on budget and other resources allocation for forest conservation, tourists, town visitors and education and research organisations interested in Pete mangroves. The second group of stakeholders is at the local scale and includes individual village residents, village outsiders and household members who either have interests in the ecosystem services provided by mangrove or are involved in mangrove conservation and management activities. These involve users of mangrove wood provisioning services, beekeepers, mangrove rangers, fishers, seaweed farmers, Jozani village tourist guards (from National Park and private tourist investors), mangrove tree planters, and private tourist investors. Other local stakeholders for Pete mangroves were committees that follow a standard Shehia administration arrangement (see section 4.2) including UWEMAJO, JECA and JOCDO. The presence of a wide range of stakeholders provides clear evidence of the complexity of the society and heterogeneity of interests of different stakeholder in Pete mangrove ecosystem. In this way the two groups of stakeholders are further divided based on the location, activities, interests or influence of stakeholders in the system (Table 10). Thus Pete-Jozani stakeholders include those who were physically present in the Shehia such as local residents, employed JCBNP rangers and guards and those located outside the Shehia such as village outsiders, and district and national department staff and International NGO. These stakeholders represent their interests at different scales.

Table 10 Categories of stakeholders in Pete- Jozani mangrove social ecological system

	Location		**Activities/interests/influence**	
Scales	Inside the Shehia	Outside the Shehia	Primary	Secondary
Shehia/village	Village residents, NGOs and committees	Village outsiders	Village users of mangrove ecosystem services, village outsiders, Students	Village residents, local NGOs and committees, Mangrove rangers
District	Mangrove ranger	District Forest officer		District Forest officer
National	Employed JCBNP rangers and guards,	National department staff and NGO (e.g. WEZA, Tour operators, Training and Research organisations	DFNRNR	DFNRNR and other government departments, top-political leaders, Training and research organisations
International	Tourists	International Donors and projects, Tourists		International Donors and projects, Tourists

In addition, based on the stakeholders' interests in ecosystem services and/or activities Pete-Jozani society includes both primary and secondary stakeholders. Primary stakeholders have direct dependence on, or are involved in, exploitation of the resources, such as beekeepers and woodcutters both village residents and outsiders while secondary stakeholders benefit indirectly from the non-provisioning ecosystem services (e.g. village outsiders), and/or those involved in conservation activities and/or their activities/decision have influence on the supply of ecosystem services to other stakeholders (e.g. village and international NGOs).

5.3.2 Stakeholder's knowledge systems in Pete-Jozani Shehia

These stakeholders interested in the Pete mangrove system have different types of knowledge systems including those about the mangrove SES. The stakeholders have a wide range of scientific, traditional and local knowledge on mangrove species, uses of the ecosystem services and management approaches. Clear and concise classification of these knowledge systems is very complex because both local and traditional knowledge may, in some cases, incorporate elements of scientific knowledge and vice versa (Ericksen and Woodley, 2005). However, this study distinguishes these knowledge systems as described by others, who consider scientific knowledge as a modern or conventional western science acquired by formal education or book learning (ibid, 2005; Berkes and Folke, 1998). Traditional ecological knowledge is used to refer to a cumulative body of knowledge about the living being and their environment generated and evolved by adaptive process (innovation and feed-back learning) and transferred from one generation to another through people's long term experiences, practices and customary and religious beliefs (Berkes *et al.,* 2000). On the other hand, local knowledge can be used synonymously with traditional ecological knowledge (Gilchrist and Mallory, 2005) but in some cases is referring to place and practice-based experiential knowledge which is largely based on oral traditions (Ericksen and Woodley, 2005).

This study found that some stakeholders at global and national levels have modern scientific ecological knowledge which contributes to or influences their understanding of the importance, values, interests and the management decisions of Pete mangrove system. Most of their knowledge has been acquired through formal education systems via colleges and universities. On the other hand, the household interview results indicated that people living in Pete and Jozani villages have limited knowledge received from a formal education system. About 32.5% and 42.5% of the respondents have attained primary and secondary education, respectively, as their highest education level in Pete. Only 10% of the respondents have acquired formal knowledge from colleges and universities while 15% of the respondents never attended school. Although a significant number of local people have access to formal education in Pete-Jozani Shehia, some

VCC members who are also teachers confirmed that knowledge on mangrove conservation, biology and management is not covered at primary schools and only biological knowledge is slightly covered in secondary level education.

Pete-Jozani elders, some youth, beekeepers and people engaged in conservation activities were found to have a wealth of biological, management and economic uses of the mangrove system. The ecological knowledge on mangrove system acquired by Pete-Jozani communities has two sources; firstly, through the influence of modern scientific ecological knowledge transferred by the stakeholders from the national scale stakeholders and secondly, from their informal traditional ecological knowledge system. For example, during the conservation education programme conducted by stakeholders at national scale through seminars, village meetings, demonstrations and study visits, most of Pete-Jozani villagers attending these programmes received training on the value and benefits, economic uses, planting and conservation of the mangrove ecosystem.

On the other hand members of Pete-Jozani community perceived that traditional knowledge has been acquired through long-term accumulated experiences on use and conservation of the ecosystem and cultural characteristics from elders. For example, users of provisioning ecosystem services and some village elders have traditional biological understanding on different types of mangrove tree species known by local names and suitability of different mangrove species for different ecosystem services and environmental values of the ecosystem. Some of the beekeepers and mangrove harvesters have local knowledge on honey production and economic uses of wood products. The VCC secretary reported that some of the traditional management knowledge was associated with traditional beliefs. For example, he claimed that closely covered forest areas including mangroves were considered as 'bush' (*pori*) that need to be left untouched; which were then declared as sacred areas by the village leaders and the people were spiritually respecting these areas. Protection mechanism of these forests were associated with evil spirit (*Majini*) whereby people believe that any attempt to cut forest will stimulate the evil power that would lead to serious magical damage, illness or even death to violators. Some VCC members reported that the influence of spiritual beliefs was replaced by Islamic beliefs/knowledge because traditional thoughts associated with supernatural power are criticized and not compatible with the Islamic faith.

Despite the presence of multiple sources of knowledge, most of the respondents reported that the traditional management knowledge (the influence of Islamic leaders) was not being used in Pete and has not been recognised in the current mangrove management system. However, these findings are contradicted by some village leaders who reported that in critical situations the religious leaders conduct specific village meetings to advocate the wise use of forest resources using Islamic laws. Whilst these laws ought to be accepted and implemented by all Islamic believers, this is not guaranteed. Some of the Islamic believers may refuse to comply with them in order to meet their personal interests. For example, one of the Islamic leaders in Pete (Pete Mosque Imam) reported that he conducted a community training programme on the proper use of forests after Friday prayers, the idea having been accepted by elders' majority in 1996. Unwise use of forest resources is considered as a great sin in Islam and Islamic God (*Allah*) will put that offender in hell fire (Quran verse 2: 205). However, villagers realised that some groups of young residents opposed this belief by cutting the mangroves, claiming that forest is a resource that God created before humans in order to support their life.

5.3.3 Stakeholder's linkages and social cohesion

The national stakeholders for Pete mangrove forest were found to be involved in irregular implementation of their working programmes and closely linked to the VCC and other local organisations in Pete. For example, Pete-Jozani VCC members have been working closely with different organisations at higher scales which introduced a number of civil society groups and local NGOs to address different forest conservation and development issues in the village. Such organisations include JECA which run JOCDO, a saving and credit programme across all villages surrounding JCBNP; UWEMAJO, a farmers' association whose lands are affected by red *colobus* monkeys (*Procolobus kirkii*); and all other VCC members around the National Park who are assisting park management and receiving ecotourism benefits generated from JCBNP. In addition MACEMP supported mangrove conservation in Pete through employment of mangrove rangers and provision of modern fishing boats. The NGO CARE international has been working on several different issues in Pete in the past (see section 5.7 on changes) but at the time of this study, it was working with other projects such as WEZA through local NGOs based in Pete (JECA and JOCDO) to mobilise the community to participate in conservation of JCBNP and support saving and credit programmes in all villages around JCBNP and beyond.

Whilst the VCC should work and serve as a link between the higher stakeholders and those representing the interests of the village majority (section 4.2), this has not been the case for Pete VCC. The consensus from village youth and some elders during a Pete Shehia development meeting (Pete-Jozani Shehia meeting, April, 2012) was that Pete VCC failed to establish good linkages and coordination to Pete residents, lacked transparency, and made independent decisions without seeking any consensus or advice from the village members whom they represent. Village conservation meetings were reported by village youth and some village elders to be rare events in Pete and also claimed that the VCC members made decision on the uses of the collected revenues in their own interests. In this Pete-Jozani Shehia development meeting, the majority of participants admitted that they have never been contacted for their advice or decisions since the establishment and operation of the mangrove boardwalk project in Pete in 1997 despite the large amount of revenue collected and used for development activities on their behalf. For example, it was highlighted during the village meeting that the important decision on the renovation of the mangrove boardwalk done in 2010 in Pete was done solely by VCC members without seeking the Pete villagers' consensus on the use of the village money.

In addition, it was pointed out by representatives of the village youth group that most VCC members and other members who are participating in village development activities are the Sheha's close relatives which discouraged other people to participate in village development programmes. This situation has created strong conflicts between local residents, VCC members and the Shehia administration which has weakened the level of trust and synergy between the community members and may have contributed to inefficiency of local mangrove management arrangements in Pete. It is important to note that, Pete old VCC was abandoned and replaced by a new one in 2013. However, the process of reformation of the new CVV was not unique to Pete but a general move for all Hima village project areas in Zanzibar to suit the standard requirements for successful implemention of REDD project (section 4.8.2).

5.3.4 Ecosystem services supplied by Pete mangrove ecological system

Pete mangrove ecosystem is an important resource that offered diverse ecosystem services to different stakeholders within and across spatial scales. The type and level of supply of ecosystem services depends on the state that the system is in. Mangrove ecosystem services from Pete mangrove include cultural services (ecotourism, research and education), regulating services, supporting and a very limited supply of provisioning services.

a. Provisioning services

The dominance of small sized mangrove plants in Pete has lowered the quality and amount of wood available (See section 5.2.2) which determines the type of wood provisioning services that can be supplied to different stakeholders. Small sized building poles, beekeeping and medicine are the current provisioning ecosystem services provided by Pete mangrove. Fortunately, with the exception of cutting, these are the types of direct mangrove utilization allowed and compatible with by-laws in Pete (Finnie, 1997).

All of the stakeholders interviewed in Pete agreed that mangrove is not intentionally harvested for the supply of charcoal, fire wood, lime or other wood provisioning services because the ecosystem has no wood resources of reliable size and quality to supply valuable products desired by village stakeholders. During a FGD with members of VCC, one respondent narrated that:

'*Hatutumii koko kwa sababu haipo kwa vile huwezi kuvuna ujiti wa koko wenye thamani'* – that is 'we are not using the mangrove because the mangrove trees do not exist since there is nothing of economic value you can get from it'.

Although the mangrove ecosystem cannot provide the desired quality of wood products, the high level of dependence of the Pete community on mangrove resources makes them necessarily use the ecosystem to meet some of their subsistence energy needs. Thus, the results from FGD indicated that about 5% of the Pete-Jozani communities were using fire wood and charcoal from mangrove wood through the irregular extraction of old mangrove stumps and collection of remains of old mangrove branches for firewood or charcoal making.

Availability of fuel wood energy is an important aspect for meeting cooking energy demand and income; villagers reported meeting more than 95% of their demand from terrestrial forests. Results from household interviews in Pete indicated that small size building poles (withies) are the only mangrove products available in Pete mangroves (Table 12) which are obtained through either illegal harvesting or under special permit by the VCC. Availability of low quality mangrove wood provisioning services has reduced the total number of village residents who wereformerly dependent on mangrove as their main income or for household consumption. One member of the VCC reported that mangrove poles from Pete are only cut to meet specific or emergency needs/problems of local people and is done under the close supervision of the VCC. For example, local communities in extreme financial deficit can be allowed to cut mangrove poles if they have no other alternatives to meet their household needs which cannot be met at farm level.

Despite the limited supply of building poles from Pete mangrove system, mangrove poles are continually used in the village to meet the demand of house construction. These are not necessarily harvested from Pete mangrove system but mostly brought from Zanzibar town. Results from the household survey indicated that 47.5% of respondents use mangrove poles for roof construction materials, 7.5% of the respondents use them as material for window frames while 10% of respondents use mangrove poles for wall construction. Proportions of people using poles from other sources for house construction are provided in Table 11.

Table 11 Proportion of people using wood materials for house construction in Pete-Jozani

Uses of building poles	**Sample size (Households)**	**Percentage of respondents using mangrove poles from town**	**Percentage of people using poles from terrestrial forests**	**Percentage of people using non-mangrove sawn timber from town**	**Others bricks, metals, mud (%)**
Building material for roof frame	40	47.5	27.5	25	0
Building materials for window	40	7.5	40	17.5	35%
Building materials for wall	40	10	20	0	70%

Beekeeping is an important provisioning service provided by the Pete mangrove system which has attracted many of the villagers recently. Results from household interviews indicated that about 27.5% of Pete households were engaged in beekeeping activities both for subsistence honey production and for selling (Table 12). Beekeeping is practiced by both men (69.4% of the total households had members engaged in beekeeping as reported by male household respondents) and women as individuals and as an association with a total of 500 beehives. Some individuals and associations have got external financial support from the Participatory Agriculture Development and Empowerment Project (PADEP) and Zanzibar Beekeeping Association (ZABA) to run the business in both terrestrial and mangrove forests. Beekeeping in Pete has been shown to yield significant economic benefits of an average monthly income of 84,000TSHS (£33.4) for a beekeeper who produced an average of 6 bottles per month and sold at a unit price of 14,000TSHS (£5.6) (Table 12).

Results from FGD with beekeepers indicated that beekeeping activities in mangroves (Plate 1a and b) have been perceived as a new way of getting direct benefits that if supported has the potential to shift people away from cutting the mangrove wood.

Plate 1 Beekeeping in Pete-Jozani mangroves using (a) traditional beehive and (b) modern beehive
Source: field survey, 2013.

One of the committed beekeepers in Pete confirmed that Pete mangrove ecosystem plays a significant role in beekeeping activities and it is estimated that about 80% of the hives have been set inside the mangrove in order to use the nectar from the mangrove and surrounding vegetation for honey production, while only 20% are found in terrestrial forests. He was very optimistic about the economic benefit that beekeeping is generating to support people's livelihood activities. For example, it was estimated that for a committed beekeeper with an average number of 80 hives can generate an annual average income of 5,200,000TSHS (£2,080). However, there are only two committed beekeepers with slightly higher numbers of beehives in Pete.

The provision of medicinal products is an important ecosystem service provided to Pete communities. About 7.5% of the respondents reported that they used mangrove products for curing stomach-ache by using seeds and or bark of *X. granatum* mangrove species. Other reported activities performed by Pete villagers in or close to the mangrove ecosystem include crab harvesting that is done on a very limited scale and seaweed farming (Table 12). Most seaweed farming is done by women (for 88% of the total households their members were engaged in beekeeping, as reported by female household respondents) in the village who also participate in collection of cockles (*chaza*-oysters) within the ecosystem, while fishing by men is mainly done in areas close to Uzi village in the far south of Pete village.

Table 12 Economic benefits from provisioning mangrove ecosystem services in Pete

Ecosystem services	Subsistence					Selling				
	% of households	No of hhs	Monthly harvest/hh	Monthly income equivalent /hh in TSHS*	Annual income equivalent/hh in TSHS*	% of households	No of hhs	Monthly harvest/hh	Monthly income/hh in TSHS*	Annual income/hh in TSHS*
Withies	2.5	7	not regular							
Beekeeping (bottles)	27.5	79	1.1	15,866	190,392	27.5	79	6	84,000	1,008,000
Crab (kgs)	2.5	7	1	3,500	42,000	2.5	7	13	45,500	546,000
Seaweed (kgs)						22.2	64	70	26,052	312,624

*1 GBP (£) = 2500 TSHS at the study time. 1 kg of seaweed was sold for 350TSHS, 1 kg of crab was sold for 3,500TSHS and I bottle of honey was sold for 14,000 TSHS in the village. *Source: this study*

b. Cultural services

Being located on the periphery of JCBNP Pete mangrove has become an important ecosystem for recreational services in the form of ecotourism. A stretch of boardwalk has been constructed inside the mangrove forest and serves as an additional attraction for tourists and other visitors who come to visit the park (Plate 2). The mangrove boardwalk was constructed in 1997 in collaboration with CARE International to generate income for the farmers whose lands are allocated and used by park authority or affected by red *colobus* monkeys (*Procolobus kirkii*) which are a major park attraction. This investment, which cost US$ 8,000, was made in order to achieve cooperation between the Park Authority, surrounding communities and other stakeholders (Masoud, 2001) through benefit sharing. Pete VCC is the main local organisation which entered into agreement with DFNRNR to run and maintain the boardwalk.

Plate 2 Pete-Jozani mangrove boardwalk. *Source: field survey, 2013*

This study found that mangrove ecotourism services through the boardwalk in Pete have been formalised by the Park Authority and payment for recreational services provided through the boardwalk is mandatory for all park visitors regardless of whether they visit the mangrove boardwalk or not. From the total of the park entrance fee for each visitor in Jozani, 3USD is counted for visiting the mangrove boardwalk. An average of 6,085 visitors enjoyed recreation services provided by the mangrove ecosystem every year between 2006 and 2011 which corresponds to an average annual revenue of TSHS 27,385,612 (Note the exchange rate at the time of this study 1 $ was = 1,500TSHS). The amount of revenue generated from the boardwalk for the past six years is given in Figure 12.

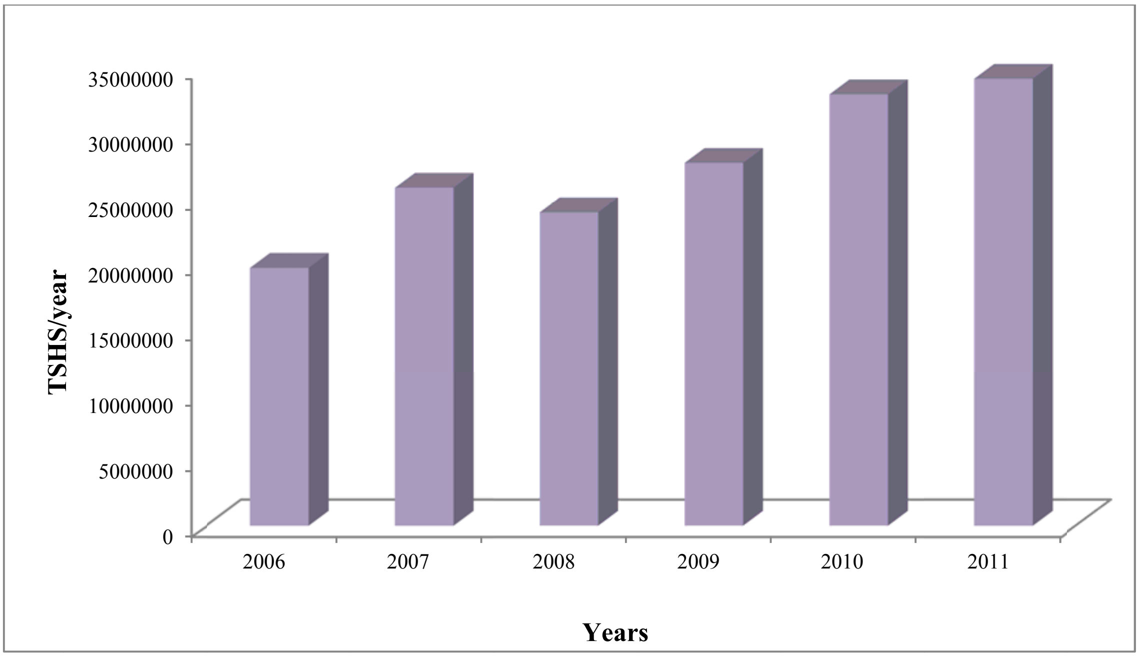


Figure 12 Mangrove boardwalk revenue 2006-2011. *Source: From DFNRNR files*

The collected revenue is retained for six months before it is distributed to the intended beneficiaries in two instalments every year. Income generated from the boardwalk is shared by different stakeholders across spatial scales after the removal of running costs. Important beneficiaries include Pete VCC which receives 40%, UWEMAJO 30%, JECA 20% and DFNRNR 10% of the total money generated from the mangrove boardwalk. Table 13 indicates the total annual amount of money from the boardwalk distributed to different stakeholders from 2006-2011. However, a total of all revenues of 72,141,047TSHS[2] collected in five instalments from July 2008 up to December 2010 were not paid to the intended beneficiaries. Instead this money was saved and out of that a total of 51,347,350TSHS used to meet the cost of major boardwalk renovation/reconstruction expenses done in 2010. The remaining funds of 20,793,697TSHS were used to cover boardwalk running costs up December, 2010.

Revenue generated from the mangrove boardwalk has to be used for special purposes defined and agreed between the stakeholders. For example, the money given to UWEMAJO is used by individuals whose farms are affected by *P. kirkii*, while the money given to Pete VCC is used to contribute to community development projects aimed at benefiting the whole community

[2] These are funds indicated in Table 13 covering the sum of revenue collected in second half in 2008 all revenue for the year 2009 and 2010.

(Masoud, 2001) such as construction or improvement of schools, clinics, mosque and electric line installation in the village.

Table 13 Mangrove boardwalk revenue distribution from 2006 to 2011

Year	Boardwalk running costs	Pete VCC	UWEMAJO	JECA	DNRNR	Total
2006	7,121,851	5,021,275	3,765,956	2,510,637	1,255,318	19,675,037
2007	12,491,255	5,335,456	4,001,592	2,667,728	1,333,864	25,829,895
2008	7,289,327	6,657,962	4,993,471	3,328,981	1,664,490	23,934,231
2009	11,246,054	11,847,999	3,892,527	5,923,999	2,962,000	35,872,579
2010	13,854,610	9,310,312	6,827,340	4,655,156	2,327,578	36,974,996
2011	13,841,400	8,127,890	4,045,159	4,065,945	2,031,972	32,112,366
Total	65,844,497	46,300,894	27,526,045	23,152,446	11,575,222	174,399,104
Percentage	37.7550661	26.5488141	15.783364	13.2755533	6.6372027	100

Source: DFNRNR monthly reports: 1 GBP (£) = 2,500 TSHS at the time of this study.

Pete mangrove has become a popular tourist site that has attracted other people to invest in the tourist business in the village. Apart from recreational benefits generated from the boardwalk, a few other tourist-related small-scale private investments were observed in the village related to the mangrove ecosystem. For example, mangrove ecotourism services include a mangrove tortoise viewing project run by UWEMAJO and bull cart transportation to mangrove forest accompanying a bird viewing project run by a private tourist investor in the village.

Despite the fact that this money is generated from the mangrove resources there is no direct benefit accruing to the individuals or household members whose livelihoods were directly depending on provisioning services from mangrove. Villagers from Jozani village claimed that the collected money from the boardwalk was not fairly distributed to support village development projects between the two villages and this weakens the relationships, networks and the interests of Jozani residents to engage in mangrove planting activities. This represents multiple and competitive interests between the stakeholders at the local scale which has implications for the management of the ecosystem and resilience of the social system.

Apart from tourism services, Pete mangrove boardwalk was used for education purposes. People from different education organisations such as schools, colleges and Universities were found to visit the boardwalk for attainment of their learning desires.

c. Regulating and supporting mangrove ecosystem services

Regulating ecosystem services are the benefits obtained from ecosystem processes such as pollination, nutrient cycling, air quality regulation and maintenance of biodiversity for ecosystem function and resilience (MEA, 2005). The results from the field observation in Pete mangrove ecosystem showed that there were diverse insect pollinators, such as bees, and other marine animal and plant species which signify the biodiversity value of the system. However, these ecosystem services were not recognised by most of the Pete residents. For example, only 7.5% of the household respondents reported on the importance of their mangrove for climate regulation, reflecting the role of mangrove in carbon dioxide sequestration (*hewa ukaa*) and regulation of the microclimatic condition of the village. The reported limited types of these ecosystem services have contributed to the low value that the local communities place on these ecosystem services or low interest in the supply of these services as the villagers do not consider they derive benefits from them.

Supporting and protecting services are those that are necessary for all other services such as coral reef protection, soil formation, photosynthesis, primary production, nutrient cycling and water cycling (Walter, *et al.,* 2008). Most of the Pete-Jozani respondents were aware of the importance of these ecosystem services supplied by mangrove ecosystem. Respondents from household interviews reported that their mangroves play significant supportive and protective roles particularly the provision of fish breeding sites (supported by 90% of the respondents); control of strong wind from reaching their village and beach erosion (agreed by 85% of the respondents); provision of habitat for *Procolobus kirkii* monkeys; good scenery for tourism (60%); and protection of coral reefs (15%).

5.3.5 Stakeholders' interests in Pete mangrove ecosystem

Stakeholders have diverse and at times opposing interests in Pete's mangrove ecosystem services. KIIs with stakeholders at international, and most of stakeholders at district and national scales, indicated that they have a strong interest in regulating, supporting and cultural (ecotourism and education) services provided by Pete mangrove ecosystem. In particular, they were interested in nature conservation for biodiversity, protection of the coastal environment, fish breeding sites and maintaining the ecological integrity of the system. They were also interested to conserve the mangrove to provide potential research areas and other environmental services unique to the mangrove ecosystems and provision of habitat for red colobus monkey (*P. kirkii*) and marine organisms. These ecosystem services are very important to these stakeholders because they support the development of mangrove boardwalk ecotourism services which generate income crucial for resolving JCBNP-Pete community crop raiding conflicts and support park conservation activities in the area. In addition, international organisations have strong vested interests in mangrove regulating ecosystem services especially for carbon sequestration and protection of coastal erosion (HIMA, 2010 and field discussions, 2013). Their interests were evidenced by the mushrooming of international donor projects to support the conservation of forests including mangrove ecosystem for the supply of ecosystem services. These international interests are in line with the government's interests, as indicated by their acceptance of international policies and programmes and their implementation at different national and local scales. Although these stakeholders have little interest in provisioning services from the focal study area, they have benefited through collection of payments from ecotourism generated by the mangrove boardwalk (Table13). Other stakeholders at national scales such as traders of mangrove products have strong interests in provisioning services from Pete mangrove especially honey and mangrove wood products when available.

This study found that local communities in Pete have strong interests in the provisioning services of firewood, charcoal, and other ecosystem services that provide direct economic benefits to them. Their interests were evidenced through their efforts to rehabilitate the degraded mangrove ecosystem mainly through planting of mangrove seedlings of economic importance to generate desired wood-based provisioning services in future. In addition, the observed on-going low rate of illegal selective cutting of mangrove poles and extraction and collection of dead mangrove wood for fuel wood together with expansion of beekeeping and tourism activities indicate high interests of local people in provisioning services from the mangrove ecosystem (see section 5.3.4).

It is apparent that the interests of some Pete-Jozani residents are closely related to the interest of other stakeholders at higher scales because the exploitation of non-wood mangrove ecosystem services ensures nature conservation of the mangrove ecosystem. However, these interests may also be conflicting with the interests of mangrove wood cutters. For example, the provision of ecotourism ecosystem services by the boardwalk mangrove in Pete is attained through better conservation of mangrove scenery around the boardwalk that attracts tourists and other visitors to the area. This ecosystem service is in conflict with the provisioning services of wood material which attracts individual mangrove wood harvesters considering that they are not receiving direct benefits generated from ecotourism for their household income. This has necessarily caused conflicting interests between the involved stakeholders. Similarly, villagers interested in non-wood mangrove ecosystem services like medicine collectors, fishermen, tourists, beekeepers and those engaged in mangrove conservation such as mangrove planters, mangrove rangers and other mangrove conservation organisations, especially JECA, UWEMAJO and VCC, have interests in conserving the mangrove ecosystem. The provision of these ecosystem services is in conflict with the interests of mangrove wood cutters, traders and village outsiders who need to extract mangrove wood in order to meet their desired interests. These conflicting interests might exist in the short term but possibly become less in the longer term if the reliable alternative energy and income sources become available to the dependants of mangrove wood provisioning ecosystem services.

5.4 Interactions

Pete-Jozani mangrove SES identity was found to be characterised by several ecological and social relationships which explain the interactions of the system. Interaction in ecological system was related to animal-mangrove plant interactions that influence productivity of mangrove ecosystem services. One of the important insect-plant interactions found in Pete was the appearance of insect pests, larva of *Lasiocampidae* possibly *Streblote* spp. or *Gastropacha* spp. cf. lappet moth in young planted *Bruguiera gymnorrhiza* species in mangrove system close to Jozani village in June 2012 (Plate 3). This study observed a small outbreak of this insect in several newly planted mangrove areas on Pemba Island especially at Micheweni and Michenzani villages in 2011. This insect larva was mispelt in Zanzibar Forestry Department report as *Luciocampidae spp* and referred to as the ‘mangrove worm’.

Plate 3 Larva of *Lasiocampidae* in Pete-Jozani mangrove

Another animal-plant interaction observed in Pete was between mangrove plants and honey bees which are important for the production of honey in Pete mangrove system. In addition, an interaction between crabs and mangrove seedling propagules was observed which can have a significant impact on the establishment of mangrove species by destroying mangrove propagules and preventing regeneration (Dahdouh-Guebas *et al*., 1998). However, no data were collected in this study to indicate the influence of these animals on ecosystem productivity.

5.4.1 Mangrove property right regimes

Pete-Jozani mangrove social system interactions are described by a combination of property right regimes that govern ownership, access, uses and management of mangrove ecosystems. Diversity of stakeholders and their interests in mangrove ecosystem services is associated with a diversity of institutions operating between and across spatial scales.

The results from FDGs and KIIs with village elders indicated that Pete consists of a diversity of formal and informal institutions which represent diverse forms of property rights and sectoral interactions between and within the Shehia. Pete has strong informal institutions of Islamic laws given in the Quran and Islamic Hadith that govern the behavioural norms of families, community and society and determine how people interact with the ecosystem around them. Most of the village elders reported that there are specific Islamic laws related to natural resources conservation including those specifically advocating the wise use of forest resources (e.g. Quran 2:205). These laws were used by religious leaders to educate the communities and have contributed significantly to the way the Pete communities understood, used and conserved their forest resources. However, the influence of Islamic leaders on the current mangrove management system has been very low because these informal institutions have not been recognised and considered in the management system. The observed reality was that most laws and regulations that governed Pete-Jozani mangrove have been very much influenced by a wide range of formal institutions operating at higher global and national scales (see section 4.8.2 and the following section) with little recognition of communities' cultural laws and practices.

Pete mangrove was found to be managed under formal community-based forest management approach. The local communities through the VCC were persuaded by the Government and non-government staff together with the support of international donor projects such as CARE and WWF to develop new local institutions approved by the Government (Finnie, 1997) for management of the mangroves (and other natural resources) since 1996. The institutional rules (COFMA) of the mangrove forest in Pete were strongly shaped and influenced by the National Forest Policy (RGoZ, 1996) and Forest Resource Management and Conservation Act No.10 of 1996. These statutes form the framework for the rules that villagers create to "co-manage" the mangroves and other forests in Zanzibar (see section 4.8.2). In this partnership arrangement the Government through the DFNRNR is the owner and controller of the mangrove resources, while Pete villagers carried out all mangrove management works especially patrols and planting of the mangrove. The recent introduction of the HIMA project has put more village forested areas and all mangrove area under high protection zones with the complete ban of any extractive uses in the mangrove including the collection of dry wood and leaves by the surrounding communities (Revised COFMA, 2011).

Field observation indicated that the formal approval of these laws and regulations associated with the availability of financial incentives from mangrove boardwalk and other small-scale benefits was initially encouraged by Pete VCC members and other residents on the management of mangrove resources. However, all of the respondents contacted in Pete claimed that there has been irregular government enforcement, monitoring and follow-up of mangrove management laws and plans in Pete since the termination of the first Jozani-Chwaka Bay Conservation Project (JCBCP) in 2001. This is due to persistent limited financial resources experienced by the DFNRNR after donor support finished. The old VCC (see section 5.3.3) and its institutions were thought by the villagers to be very powerful and have made decision on all the relevant issues regarding the Pete mangrove management and conservation. However, the results from FGD and Shehia development meeting in 2012 indicated that the VCC has less decision making power, is ineffective and unable to enforce the approved by-laws especially in the absence of donor support. Instead their members were engaged in conservation activities that generate direct benefits to them without village consensus. This situation necessitated the local majority to ask for immediate re-formulation of a new VCC in Pete in 2012[3], a situation which indicated the ineffective decision making power of VCC. For example, when Pete village leader (Sheha) who is also a chairman of VCC was asked to abandon the old VCC and formulate a new one during this meeting he said:

"Naweza nikazivunja kamati zote zilizoko katika Shehia yangu na kuunda nyengine, lakini sina mamlaka ya kufanya maamuzi na kamati ya uhifadhi – ina wahusika wake serikalini" That is "I can abolish all administrative organisations within my jurisdiction and formulate the new ones but I don't have power to do the same for the VCC – the responsible personnel for restructuring are from the Government".

There are also strong interactions between ecological and social systems. For example, in Pete the ecological process of nectar-feeding animals particularly bees may influence the economically important production of honey. Socially managed mangrove systems ensure that forests remain intact enough to maintain the persistence and movement of bees to effectively produce honey. Likewise ecological processes of insect pollinators that increase mangrove productivity are maintained to promote mangrove cover that is necessary for the maintenance of the aesthetic value of mangrove which is important for tourism.

5.5 Innovation

Innovation is also crucial to mangrove SES identity which according to resilience scholars is explained by diversity of ecological and social systems (see section 3.2.1)

In Pete ecological innovation is explained by diversity of mangrove tree species which have influence on ecosystem performance and identity. In particular ecological innovation in mangrove system is related to the introduction of novel mangrove tree species or increase in the performance of less common species in responses to ecological disturbances in the ecosystem which influence the tree diversity. High adaptation of mangrove tree in their growing habitat represents the major limitation to the number of non-mangrove species able to thrive in their habitat and therefore not provide a conducive environment for ecological innovation. However the lack of a persistent soil seed bank of true mangrove species decreases the probability of a full recovery by mangrove tree populations after large scale disturbances and increases the chances of invasions of mangrove-associate species (Harun-or-Rashid *et al.*, 2008), which reduces the

[3] At the end of 2012 DFNRNR in collaboration with HIMA project abolished the old VCC in Pete and in other village around JCBNP and it was replaced by the new VCC in 2013 which apart of addressing conservation issue in the Shehia has to meet the requirements for HIMA project (See 5.8).

mangrove tree species diversity. Pete mangrove ecosystem exhibit low tree species diversity dominated by two species - *C. tagal,* and *B. gymnorrhiza*. Mangrove harvesters reported the decline on availability of less dominant-mangrove tree species in the ecosystems due to excessive cutting in the past (section 5.2.1). Although this is the most consistent feature of the mangrove ecosystem that the vegetation itself has low species diversity (Tomlinson, 1986) but there is general acceptance that loss of mangrove tree species diversity reduces its capacity to cope with disturbances and leads to lower resilience of the system (Brown, 2007)

Decline of the availability of less dominant mangrove tree species, may lower the diversity of mangrove in Pete which may undermine the resilience of the mangrove through a reduction of functional redundancy of mangrove species. For example, a greater resilience through enhanced functional redundancy would have been achieved if Pete mangrove ecosystems would have enough *Avicennia*, *Sonneratia* and *Pemphis acidula* which are all colonisers and provide functional redundancy after disturbance (Brown, 2007). If any one of these species is not present the same function can be performed by another of the species.

Innovation in a social system is explained in this study by diversity of functional actor groups, knowledge systems, institutions and diversity of livelihood activities. That is the more different types of actors and institutions there are the more functions are performed. Despite the diversity of actors, and knowledge and institutions found in Pete social system (see section 5.3.1 and 5.4.1), most of the villagers stated that there is low level and irregular coordination between Government and local communities who mainly become active when there is donor support. It is suggested that the current management arrangement failed to recognise the role of cross scale interaction on engagement of different institutions for management of Pete mangrove, despite the presence of informal institutions in the area. In this context, the participation of local communities alone in conservation of mangrove gave a feeling to local people that the Government has left them with a high conservation load without ensuring realistic decision making power with regard to the resource ownership and management.

5.5.1 Livelihood activities and income sources in Pete

Pete-Jozani Shehia is characterised by community members who are engaged in diverse livelihood activities in response to a decline in the availability of valuable mangrove wood products. Household interviews indicated that, among several livelihood activities performed by Pete villagers, agriculture followed by terrestrial wood cutting are the most important economic activities engaged in by the majority of Pete residents. Table 14 indicates the diversity of economic activities by gender[4] with their corresponding monthly income in Pete-Jozani Shehia. The variation of level of participation on different livelihood activities by different gender is grouped as F = female activity, M = male activity, B = both gender in relatively equal proportion, BM = both with more male participants, BF = both with more female participants.

Table 14 Pete-Jozani livelihood activities by gender

Livelihood activities	Gender	Number of respondents (Sample size)	Percentage of respondents	Monthly average income (TSHS)
Agriculture	B	40 (40)	100	111,250
Terrestrial wood cutting	BF	23 (40)	57.5	142,368
Small-scale enterprises	BF	18 (40)	45	58,450
Beekeeping	BM	16 (40)	40	84,000
Employment	BF	11 (40)	27.5	186,666
Seaweed farming	F	9 (40)	22.5	26,428
Butterfly farming	B	7 (40)	17.5	106,500
Farmers compensation UWEMAJO	B	6 (40)	15	58,571
Woodlots harvesting	BM	5 (40)	12.5	106,000
Drivers	M	3 (40)	7.5	100,000
Fishing	BF	2 (40)	5	42,500

Source: Pete Household interview, 2013

Agriculture is the most important livelihood activity in Pete engaged in all of the households and performed by both male and female members of the society. The dominance of agriculture shows a clear shift (section, 5.8) of the Pete community from mangrove and terrestrial wood cutting which dominated during 1995-2005 (JCBCP, 1996, Othman, 2005). Agriculture is focused on diversification of agricultural production within the limited available land with great emphasis on production of crops that have direct market value such as banana, sweet potatoes, and cassava.

Next to agriculture is terrestrial wood cutting for selling as firewood and charcoal which engages 57.5 % of the people. Results from FGD with VCC reported that the introduction of saving and

[4] Dominant gender engaged in different livelihood activities was based on consensus from FGDs.

credit schemes that encouraged women participants has been the main factor that served as incentives for women to engage more on terrestrial wood harvesting for selling firewood than males. Women participants during FGD concurred that they are harvesting or trading firewood to get money for running micro-credit groups and contribute on meeting basic household needs. While cutting of terrestrial forest for selling firewood is done all year round, charcoal production is mainly done when there is a need for quick money to meet household emergencies. However, both activities reach a peak when there is a specific community event that needs a large amount of money to be accomplished. Such events include meeting *Eid el-Haji* and *Eid el-fitri* ceremony expenses, marriage ceremony or meeting the expenses of taking care of a sick person. Terrestrial wood cutting is carried out in small community forest areas or illegally done in the JCBNP and is engaged in by relatively few people compared to agriculture.

Small-scale enterprises have been further developed by a number of village residents who reported that some of these activities are new enterprises in the Shehia. These activities included small-scale livestock keeping, stone extraction for gravel making (*uchimbaji wa mawe kwa ubanjaji wa kokoto*) (mostly done by males), small village shops, trading of food and forest products, handcraft (traditional hat and mat making) and establishment of tree nursery woodlots which involves both gender groups.

Other livelihood activities engaged in by Pete residents (Table 14) have been developed to diversify livelihood options in the village in order to reduce dependence on forest resources. Some of these activities have been developed with the support or advice of the Government and non-government organisations working in Pete such as WEZA, PADEP, and CARE in collaboration with village associations. A link between social and ecological innovation has been achieved in Pete by the introduction of new ecosystem services (boardwalk ecotourism and beekeeping) that can be sustainably used and marketed, yielding additional income to the communities whilst providing incentives for mangrove conservation. CARE is an international NGO working with HIMA piloting REDD$^+$ in collaboration with DFNRNR and has also introduced a carbon selling project that will potentially allow the community to protect their forests while enjoying benefit through selling carbon (section 4.8.2). The project has also provided Pete communities free tree seedlings as one among greenhouse gas mitigation measures to meet their wood demand and serve as income sources for the people in future. The project has also provided small amounts of capital to a few Pete communities engaged in butterfly farming, and working community to support the use of efficient cooking stoves in the village. However the project is at an early stage for the local communities to realise the benefits through selling of carbon.

5.5.2 Livelihood strategies and income contribution by wealth status of households

About 85% of interviewed Pete-Jozani residents depended upon three to five sources of income and only15% of the community had just one to two income sources. These activities have been found to give an average monthly income of TSHS 354,175 per household which is lower than the average monthly income of TSHS 450,000 reported by villagers (during field discussions) to be required to prevent people from cutting the forest including the mangrove forests. This village consensus indicated direct linkage between local community livelihoods and dependence on forest resources. Among the common livelihood activities, terrestrial commercial wood cutting contributes 40.2% of total monthly household income while agriculture has a relatively low contribution of only 31.4% of the total income (Figure 13) despite the large number of people engaged in it. These two activities together with small-scale enterprises, employment, butterfly farming and fishing form part of non-mangrove income sources contributing 89.8% of the total household income.

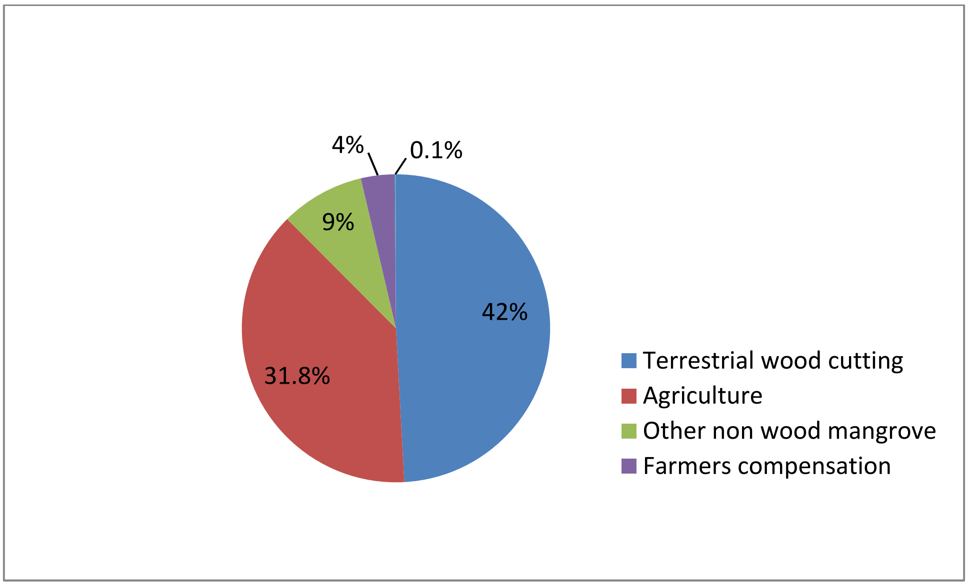


Figure 13 Proportions of monthly income contribution in Pete-Jozani households

Mangrove ecotourism contributes 2.9% (farmers received compensation from boardwalk revenue through UWEMAJO), other non-wood mangrove ecosystem services (beekeeping and crab collection) contributes 7.2% while seasonal cutting of mangrove poles contributes only 0.1% of the total household income. The domination of young mangrove trees has reduced the supply of provisioning services to the stakeholders so that the ecosystem makes little contribution to the total household income.

Whilst the mangrove wood provisioning ecosystem services make little contribution to the household income an analysis of the average monthly household income contribution from other mangrove ecosystem services by wealth status of the households indicated that the proportion of household income derived from all mangrove ecosystem services varies across the wealth groups (Table 15). Income from mangrove ecosystem services made more contribution (10.2%) to the total household incomes of the poor households than the wealthier households while no forest income is obtained by the poorest households in Pete. Both richest and poor households received more or less equal amount of income indicating the importance of the ecosystem services to all wealth categories in the society.

Table 15 Average monthly household mangrove income by wealth groups in Pete Jozani Shehia

Wealth groups	Sample size	Average monthly household income (TSHS)	Average income contribution from wood harvesting (%)	Average monthly income from mangrove ecosystem services (TSHS)	Average monthly income contribution from all mangrove ecosystem services (%)
Richest	5	573,000	0	29,796	5.2
Rich	12	403,250	0	14,517	3.6
Poor	20	287,400	0.3	29,314	10.2
Poorest	3	101,666	0	0	0
Total	40				

NB: all mangrove ecosystem services = include incomes from wood harvesting, crabs, beekeeping and ecotourism. *Source: surveys for this study*

Despite the large number of organisations working in Pete village to diversify livelihood activities there was a low level of coordination of their activities (across scales). These activities have resulted in low economic returns relative to what is needed to reduce the dependence on mangrove resources.

5.6 Continuity

The continuity of ecological system depends on the presence of small changing variables (ecosystem memory) that enhances ecosystem organisation after disturbances. This ecosystem memory in ecological system includes the presence of sufficient amount of seed bank and biological legacies that remain or are promoted after disturbance to facilitate ecosystem reorganisation (Cumming *et al.,* 2005). However, mangroves do not possess a soil seed bank (Fransworth, 2000; Harun-or Rashid *et al.*, 2008) that can be buried in the soil and escape the disturbance events. This is because mangrove species have viviparous and crypto-viviparous germination and recalcitrant seeds that do not persist for a long period in the soil (Fransworth, 2000). Thus the importance of seed bank species on mangrove tree species recovery is rarely emphasised (Harun-or-Rashid *et al.,* 2008). Instead the availability of propagules of mangrove species is considered as an important mangrove ecosystem memory that facilitates mangrove ecosystem recovery and continuity after disturbances (Sherman, *et al*, 2001; Harun-or-Rashid *et al.,* 2008).

In Pete, where the community has a high level of subsistence needs, five variables have been used as indicators that enhance ecosystem recovery and the continuous supply of diverse ecosystem services after the decline of the supply of wood provisioning ecosystem services. The observed high number of mature viviparous mangrove plants in Pete mangrove forest ensures production of a viable number of propagules that will enhance natural regeneration of seedlings and facilitate continuity of the mangrove ecosystem after disturbance. Reforestation is one of the critical activities in Pete to facilitate the rate of re-organisation of mangrove in degraded areas. It was reported during a focus group discussion that more than 80% of Pete mangrove has been planted by local communities which facilitated the continuity of mangrove system. In addition the low rate of selective cutting carried out in Pete created small gaps which encourage regeneration for *Rhizophoraceae* family that are better able to exploit large openings through seed dispersal and establishment and therefore ensures continuity of the mangrove ecosystem after disturbances. Although the empirical data are lacking, beekeepers perceived the presence of a viable number of bees that source the nectar from the mangrove plants for honey production and other insect pollinators will ensure continuity through continuous production of honey and mangrove wood products. However, the presence of newly reported insect pests in newly planted mangrove stands as noted in Pete might cause serious threats to the continuity of the system.

Socially, continuity of Pete-Jozani mangrove social system is enhanced by the presence of effective institutions that encourage linkages between actors from different scales, allow sharing of knowledge and cultural practices to increase harmony, synergies and trust among the involved stakeholders which will enhance mechanism for knowledge transfer. Currently the mechanism for knowledge transfer depends on irregular formalised knowledge transfer techniques through seminars, village meetings, demonstration and study visits done by higher scale stakeholders and school education system. Villagers also reported that the continuity of the social system will be enhanced by the presence of institutional support for development of viable alternative livelihood opportunities that are economically capable of supporting people's livelihood needs in the loss of mangrove provisioning services. The current situation where Pete has become more connected to the global tourism market and its potentiality to benefit through carbon markets are important variables that will contribute to the continuity of the system if well managed. In addition the continuity of Pete-Jozani social system will be enhanced by the availability of alternative ecosystem services to ensure the continuous supply of desired ecosystem services. For example, the availability of imported mangrove poles from Zanzibar town ensure continuous supply of desired poles products despite the decline of the availability of quality poles from Pete mangrove system.

5.7 Villagers views on resilience indicators of Pete mangrove SES

Establishment of threshold levels beyond which the ecosystem can be judged to have entered into an alternative state is a key requirement in resilience analysis. Identifying thresholds in general and resilience thresholds in particular can be extremely difficult, requires as far as possible the availability of reliable and precise scientific data integrated in mathematical models to provide limits towards which the resilience can be assessed (Tagtow and Robert, 2011). However, in the limited study period and in Pete where the mangrove system is less researched there is insufficient scientific data which meant that it was not possible to identify precise thresholds for resilience measurement. In the absence of such data and given the importance of establishment of measurable variables for assessing resilience, practical mangrove social and ecological indicators were established.

These indicators were developed using the approach described in section 3.8. Table 16 below provides Pete-Jozani villagers' views on simple and practical resilience indicators describing the desired resilient characteristics of the system with corresponding interpretations based on the defined and presented mangrove social ecological variables. Note that categories (variables) in the first two columns and last column in Table 16 were presented by researcher and interpreted according to the most frequently cited literature, while variables in column three were the result of a participatory process.

Table 16 Villagers' views on resilience indicators of Pete Mangrove SES

Mangrove SES attributes	**Defined resilience variables**	**Villagers' views on indicators for desired resilient system**	**Interpretations on the desired mangrove SES**
Mangrove structure	Mangrove area/cover	- All respondents reported resilient mangrove will have the same mangrove area but occupied by closely covered mangrove trees in most of its areas.	Resilient mangrove has closely and intensively covered mangrove trees.
	Mangrove tree species diversity	- Most of the VCC members felt that resilient mangroves should have common tree species important for provision of wood products. - Beekeepers required resilient mangrove ecosystem should have many species that can provide good views and be used for hanging beehives.	Mangrove ecosystem will be resilient if it would have a good proportion of keystone species that define the ecosystem.
	Average tree density/ha	-Village elders and representative VCC members viewed that resilient mangrove will have as many mature trees as possible to provide sufficient building poles and other wood products. -Mangrove planters from Jozani village required mangrove with many trees that will protect village from being washed out by the sea.	Mangrove has sufficient number of mature trees to improve the supply of desired ecosystem services.
	Dominant tree sizes	All respondents viewed that resilient mangrove will have large sized mature trees.	Resilient mangroves should have large sized mature trees that are capable of producing enough seedlings and balance the supply of ecosystem services.
Mangrove function	Appropriate mangrove ecosystem services / amount of wood to be removed.	- VCC members and Islamic leaders felt that resilient society will control the level of harvesting and only allow this to meet seasonal village needs. - Uses of mangrove for beekeeping and ecotourism considered to be suitable way of using mangrove as reported by beekeepers. - Mangrove tree planters required	Pete villagers stressed the need of having low dependence on wood provisioning ecosystem services while increasing uses and dependence on non-extractive ecosystem services. In a situation where harvesting is necessary the rate of cutting of mangrove wood should be very low to meet the emergency subsistence village needs.

		a kind of mangrove benefit that will provide direct financial benefit to individuals.	
Interaction	Plant- animal interaction	Not answered – respondents were not able to explain any plant – animal relation in the system.	Diverse plant-animal interactions are found in the ecosystem. However local communities were not able to recognise them.
Innovation	Planting/natural colonisation	-VCC members, tree planters, and beekeepers reported that their planting should be done in degraded areas to repair the forest (*kuurudisha*). -All respondents agreed that full protections of mangrove areas from cutting (such as beekeeping ecotourism area around the boardwalk) is required for forest new re-growth (k*uuhuisha msitu*) -Villagers views on diversity of species is the same as indicated above.	Villagers also viewed that their mangrove requires full protection especially those areas used for ecotourism, beekeeping and dominated with young plants and mangrove planting in seriously degraded areas.
Continuity	seedlings/ha	Village elders, VCC members and mangrove planters required that mangrove forest should have enough seedlings (*miche*) for self-regrowth (*kuchipua*) of ecosystem	Resilient mangrove has enough propagules to re-generate the system after disturbances.
Social structure	Diversity of stakeholders, relationship and their interests	All respondents agreed that resilient system will have good cooperation with other people (e.g. village outsiders, village residents and local NGOs) and government organs responsible for mangrove management.	Resilient system should encourage active participation of different stakeholders from different scales.
	Knowledge systems	VCC members and Islamic leaders felt the communities should have clear understanding/knowledge on the importance of mangrove forests in order to provide incentive and know how to conserve the mangroves.	Stakeholders should have diverse mangrove knowledge systems which are in the management system.
	Knowledge sources	-VCC members agreed that government institutions in collaboration with VCC and other NGOs and Park Authority should carryout regular training. -Village elders, Islamic leaders viewed that village elders and their knowledge should be	Resilience system should recognise the importance of mangrove knowledge from multiple sources.

		considered in the management.	
Social interactions	Management institutions	Jozani VCC representatives required that Jozani National Park authority should help to resolve conflicts. -VCC felt that sustainability will be achieved if the Government and other partners interested in mangrove conservation will not leave the conservation burden to communities, and communities should be given incentives to manage the forests through co-management. -Village elders agreed that communities should be given power to make decisions and own the mangroves.	-Management institution will bring about a society with a low level of conflicts, positive and harmonious relationships, high level of synergies/connectedness, and high level of involvement of different institutions and their knowledge. -Villagers suggested that effective management system ensures continuous resources availability for regular implementation of their agreement with local communities.
Innovations	Economic options	-All contacted respondents felt that the society should be supported by the Government and other development partners to have diversified and economical alternative sources to remove Pete community from cutting forests as income sources.	-Resilient community will have diversified income sources that would give direct benefits to individuals and be capable of removing the majority of local people from depending on direct cutting of mangrove plants.
Continuity	Mechanism for knowledge storage and sharing	A few Islamic leaders viewed that to achieve sustainable management Government and other partners intrested in mangrove conservation should recognise the importance of Islamic laws. That is if the Islamic leaders at higher scale will cooperate with Islamic leaders at the village scale, will provide greater support and allow sharing and influence of Islamic knowledge on management of the forest.	-Resilient system should have a mechanism of knowledge sharing and transfer so that the society has sufficient knowledge on the value of the resources. The use of Islamic leaders to advocate Islamic laws that promote conservation of forest resources should be part of the other methods for knowledge sharing.

5.8 Dynamics of the Pete Mangrove SES and Adaptive Cycle

Understanding system dynamics is important for sustainable management and conservation. This section presents the anthropogenic changes that have occurred in Pete mangrove SES using a combination of two approaches. Pete mangrove SES dynamics are presented using a historical profile of the system which identifies periods of major events that changed the system and continue to shape it (Resilience Alliance, 2010) which are then grouped into defined phases of change as described by the Adaptive Cycle (Gunderson and Holling, 2002). Using the historical data on the relatively undisturbed state of Pete mangrove which were mainly provided by the villagers in combination with field work and other scientific data a historical picture of change emerges in Pete mangrove SES depicting three different time periods as shown below.

Resource rich era (1920s to early 1990s)

According to a number of village elder's views Pete-Jozani Shehia was rich in resources between 1920s to early 1990s, with a relatively low population which placed limited demand on forest products for household needs. Most of the people were farmers and others were employed in brick making industries (Williams and Basha, 1996). The Village had plenty of accessible village forest resources of intensively covered coral rag forests and other large patches of high forests including Jozani forests and mangroves to meet people's livelihood needs (key informant results). Results from FGD with village elders and KIIs indicated that in this period Pete had a thick closely covered mangrove system, capable of supplying desired ecosystem services to the stakeholders. Villagers reported that their mangrove was dominated by taller and larger diameter mangrove trees of the size of mature coconut trees with substantial and diverse fish and other marine resources. Due to the availability of wood products from other forest ecosystems, especially coral rag forests, villagers considered mangrove forests as a bush that cannot be harvested to provide income for the households. In this context, FGD results with mangrove planters confirmed that mangrove was used at low scale by village men who selectively harvested mangrove for provision of high quality building poles (*boriti* and *nguzo*) and sawn for timber production, only for home uses. Other mangrove provisioning ecosystem services which benefited local communities were fishing of specific mangrove fish species (*chandaza, chewa, tasi, changu, changebare*), crabs and collections of marine cockles (e.g. *chuwale, chaza,*) along the beaches.

The village elders' consensus was that these services were easily available around the mangrove because of a low population which had little dependence on the ecosystem. They also reported that besides a well-covered mangrove forest in the area commercial bark harvesting practiced in

Chwaka bay done by the colonial government was not practiced in Pete but operated in other areas of Menai Bay including Unguja Ukuu, and Muungoni mangroves.

The wealth of forest resources drew the government attention to conserve some of these resources which resulted in some of the village land being included under protected areas (see section 4.8.2). For example a total of 198 hectares were purchased from village chief by the colonial government and managed as a forest reserve in 1960 (Masoud, 2000). This was then expanded by the Government to 2,512 ha that together with all mangrove forests was declared as forest reserves by the Zanzibar Government in 1965 (constitutional order, 1960). Thus following this declaration the management of forests was under State property regime, enforced through patrolling by employed district administrative forests officers (DFO) and forests guards to control illegal cutting practices in all types of forests (see section 4.8.2).

FGD results with village elders reported that some of the village land was taken by Government to form Jozani Forest reserves during the 1960s, but Pete had large terrestrial forested areas that were still accessible to the local communities together with the large agricultural areas up to 1990s. In addition despite the declaration of Jozani as a forest reserve, there was limited enforcement of the forest reserve laws which served as an incentive for the Pete communities and attracted more people to the village to exploit the forest resources. In this case the consensus from the field respondents indicated that the formal mangrove management system was not recognised by the local people and all village resources were managed traditionally before and during the British colonial time.

During FGD with VCC members the Pete-Jozani Shehia leader narrated the traditional management arrangement which existed in this period. 'Pete resources were under the respected elders committee who were responsible for addressing all critical community issues including protection of village forests, making decision on matters pertaining to the village and resolving conflicts when they arose. There were no written laws but the resources were governed through daily people's cultural activities influenced by Islamic laws and traditional beliefs up to early 1990s. The society was very united which contributed to the success of the management system.'

Regarding forest management, consensus from FGD with beekeepers indicated that the closely covered forest areas (excluding Jozani forest) were declared as sacred areas by the village leaders and community members were spiritually respecting these areas as worship areas. One of the committed beekeepers reported that beekeeping was practiced in these highly respected areas as strategies to protect them from overharvesting. One old mangrove cutter stated that some trees were defined as worship trees such that people were afraid even to touch or disturb them by any means. These management practices were reported to be associated with magic *(uchawi)* issues although the idea was opposed by religious leaders (see section 5.3.2). The majority of the respondents concurred that the opening and closing harvesting season practiced in Chwaka bay was not practiced in Pete but the ecosystem was considered as bush forest which was important for supporting fishing production and supply of desirable provisioning ecosystem services for home uses.

According to the Adaptive Cycle concept the mangrove ecosystem was under conservation phase (K) of the Adaptive Cycle (Figure 2) up to 1990. In this phase the Pete mangrove was characterised by a high level of natural capital composed of a high amount of stored nutrients/standing wood biomass which in turn maintained the supply of the desired ecosystem services to stakeholders. The social system was strongly united through their shared values and norms which enabled them to make collective decisions on how to conserve and use the forest resources which were not under considerable pressure. The system was also defined by the maintenance of strong connections between local residents and mangrove resources through subsistence and personal use of mangrove poles.

Resource degradation and restriction era (early 1990s to 2005)

Up to the 1990s Pete villagers reported to experience slow population growth as a result of internal migration from Makunduchi, Jambiani, Bwejuu, and Michamvi villages in early 1920s and from mainland Tanzania in 1960s (see section 4.5) by people who were attracted by the availability of marketable forest resources and its accessibility. The growth of population was correlated with an increased demand for forest resources (Figure 14) which consequently led to an increase in the number of villagers engaged in terrestrial wood harvesting for commercial production of firewood and lime (Williams and Basha, 1996). Thus in this period wood cutting was the major livelihood activities engaged in by Pete and Jozani people in response to higher population growth followed by expansion of subsistence agriculture through shifting cultivation (ibid). These activities were considered to increase the cutting pressure and degradation on the coral rag forests and forest reserve (JCBCP, 1997).

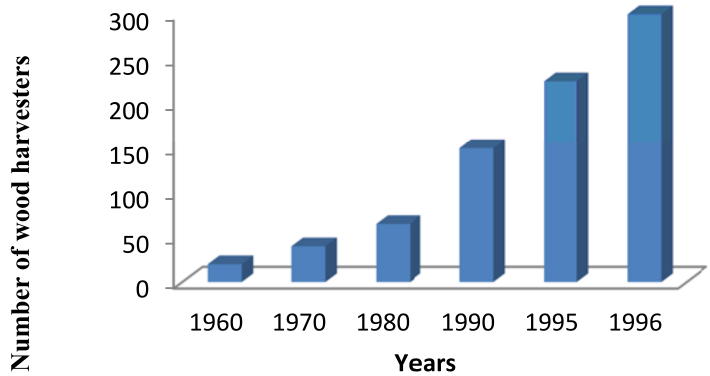


Figure 14 Forest dependants in Pete-Jozani between 1960 and 1996.

Source: Williams and Basha, 1996

With the increased global realisation of the importance of conservation of world forest resources, a number of international donors supported projects in the island, worked closely with the Forest Department in Zanzibar to assist the Government to address the problem of forest overharvesting especially in protected areas (section 4.8.2). Jozani Chwaka Bay Project (funded by CARE and Ford Foundation) was introduced and working with DFNRNR between 1995 and 2003. This project among other things, influenced policy and legislation shifted toward the establishment of a National Park and changes of forest management regime from the State to community-based management institutions (JCBCP, 1996). These policy changes marked a period of wide scale disturbance that was perceived by Pete residents to cause serious resource degradation and restriction to Pete-Jozani communities. In 1990 the government interest in establishing a National Park was achieved by firstly expanding the area under Jozani Forest reserve from 2,512ha to 5,000 ha whereby large forested and agricultural land of Pete-Jozani Shehia was converted and made part of Jozani forest reserve (JCBCP, 1995). This was a pre-set strategy for establishment of the National Park with the aim of increasing the area under conservation and promoting ecotourism in 1995 (ibid) in the island. Secondly, donor support helped the Government to establish more restrictions to control illegal cutting activities whereby the surrounding communities especially Pete were prevented from harvesting forest products as fuel wood and wild game (Ely and Makame, 1997). In this context, harvesting of terrestrial forest products slowed down in 1996 and villagers started to experience difficulties in obtaining the intended products from the required species (Pete PRA, 1996). Moreover, the Reserve protects some animals (*Procolobus kirkii*) that damage farmers' crops while generating funds through ecotourism without any compensation to Pete communities (JCBCP, 1997). Pete-Jozani village elders reported that they experienced a significant decline in agricultural production in their farms and some of them were completely abandoned, which in turn discouraged farmers to continue farming due to increased damage by monkeys. Village elders narrated that the government decision to convert farmers’ forested land and some of the agricultural land into a conservation area was not accepted by the majority of the local communities. This situation created strong conflicts between Pete-Jozani Shehia and the conservation area authority over the use of village land between 1990 and 1996 (Ely and Makame, 1997).

Consequently the Government was forced to take some measures to resolve the conflicts and support the mission to create and develop Jozani Chwaka Bay Mangrove nature conservation and achieve sustainable conservation of forest resource (ibid). Several innovations were introduced with the support of donor agents including construction of the Pete mangrove boardwalk and the promotion of mangrove boardwalk ecotourism services (see 5.3.4) involving the Pete community in many activities in the park conservation and development programme (section 5.3.3) and engaging it in the early piloting phase of CBNRM arrangement for management of mangroves including other forests (see 5.4.1). The introduction of CBNRM in Pete represents a regime shift from complete State governance to a management system that allowed participation of villagers in management of the forest (section. 5.4.1) during this period. However, what actually occurred were the imposition of more restrictions on access and the use of the resources, by putting all Pete mangroves under full conservation zone without giving them ownership including the total ban on selling of mangroves (Finnie, 1997). Pete communities were also engaged in the development of alternative income sources such as the provision of free seedlings for establishment of tree woodlots and a small-scale nursery during a FINNIDA project and supporting community development projects during the CARE project (JCBCP, 1997).

However, the communities viewed that these interventions were not effective to provide realistic economic incentives to contribute to people’s livelihood and prevent them from cutting forests. They reported that these policy changes combined with the lack of reliable alternative resources or reliable livelihood activities, with an increasing population and high demand for forest products (accelerated by market availability) have resulted in mangrove harvesting being by far the most important livelihood activity in Pete between 1996 to 2005. This also coincided with the period when donor projects ended which made the government staff less active and unable to continue with the activities introduced by the project. The result was that there was an incentive for the local communities to continue cutting mangrove (FGD with VCC). Pete mangrove was intensively harvested for subsistence and commercial supply of fuel wood and poles which was reported by experienced mangrove cutters to contribute about 60% of the total household needs of Pete villagers. This was the major direct driver that caused changes to the vegetation structure of Pete mangrove during this period.

Under this high mangrove cutting scenario, respondents from FGD and interview results confirmed the changes reported by other study (Othman, 2005) that in this period Pete residents shifted from being terrestrial wood cutters to mangrove harvesters and the economic survival of a large proportion of both men and women were largely dependent upon mangrove resources. Villagers observed an increased number of village outsiders from Kitogani, Muungoni, Uzi and Unguja Ukuu who were using mechanized fishing boats for quick transportation of the illegally extracted mangrove wood products (especially Muungwi –area close to Uzi) and therefore accelerated the rate of destruction. There were also changes in the type of mangrove provisioning services from building poles only to harvesting of mangrove wood products for fire wood, charcoal, building poles and lime which attracted these stakeholders. The mangrove harvesting rate was high at an average of 2,241 stumps per ha which was three times higher than the rate of mangrove cutting of 777 stumps per ha observed in Pete in two decades ago (Ngoile and Shunula, 1992). This high rate of cutting transformed the Pete mangrove ecosystem from being a mangrove tree dominated stand to one dominated by stumps and seedlings (Othman, 2005).

The excessive rate of cutting was species specific for specific uses. For example, FDG results with tree mangrove harvesters and planters indicated that mangrove tree species known by communities to have low water content (*P. acidula*/*Kiraramba* and *X. granatum*/*Mkomafi*) and relatively straight fibres were heavily cut for fire wood. Similarly the mangrove species that were perceived by communities to be dense and grow into thicker boles like *R. mucronata and B. gymnorrhiza* were preferred for charcoal and lime making while *C. tagal* were harvested for poles production.

According adaptive Cycle concept, in this period the mangrove ecosystem moved into collapse/creative destruction phase (Ω phase) of Adaptive Cycle (Figure 2) characterised by the rapid loss of natural capital through cutting of mangrove for excessive supply of wood provisioning ecosystem services. The ecosystem changed from mature tree dominated mangrove into undesired stump dominated mangrove system marked by reductions in mature mangrove trees, number of mangrove tree species and associated macro-fauna and therefore unable to supply the desired ecosystem services.

Resource scarcity toward re-organisation era (2005 to 2012)

Between 2005 and 2012, it was observed that the decline of the supply of desired mangrove wood products decreased the livelihood diversity but created an opportunity for Pete social ecological system to develop and adopt new ways of rebuilding the lost ecosystem services. Results from the FGD discussion with VCC members concurred that Pete communities realised the need to conserve the mangrove and engage in alternative income activities after they had lost their mangrove resources. As a result the VCC together with the majority of villagers under the consultation and participation of DFNRNR staff became very active in replanting the mangrove system at the end of 2005 to restore the degraded mangrove. In addition some of the mangrove patches which were completely ruined were left untouched for natural regeneration to take place which allowed the ecosystem to move toward the current re-organisation phase. Consensus from FGDs indicated that some of Pete community members searched for a quick way of getting money in response to the decline of the availability of mangrove wood products mainly through selling coral rag forests and a large portion of agricultural/village land to village outsiders, which increased scarcity of the village resources. Meanwhile, various efforts were made by the Government to look for the resources that would enable it to support conservation and regularly implement their activities (Masoud, 2000) following the donor collapse in 2003. Government efforts were coincided with the emergence of a number of International donor conservation projects and NGOs in the Island. Between 2007 to the time of this study other donor interventions were found in Pete such as MACEMP, CARE through WEZA and HIMA, (section 4.8.2) which supported government efforts to increase restrictions on the use of JCBNP resources by local communities following its declaration on 2004. These projects also worked with Pete communities to develop alternative income sources (section 5.5.1) to help to diversify people's livelihood opportunities. For example it was observed that nine saving and credits groups have been established in Pete by CARE. These groups involve a total of 204 people, 68% of these being women. More recently Pete received small carbon grants of 6,500,000 TSHS (£2600) as incentives to support conservation activities and diversify income sources for the special need groups such as widows, elders, and communities with high dependence on terrestrial forests.

According to the Adaptive Cycle concept Pete-Jozani mangrove SES has moved into re-organisation and renewal (**α**-phase) under the back-loop of the Adaptive Cycle, reflecting gradual regime shift after disturbances which is the current state of social ecological system. Under this phase local communities reported to experience several changes following undesirable state regime of mangrove system, some of them entail system reorganising. About 80% of the interviewed respondents agreed that there is a decline of mangrove harvesters and significant loss of desired mangrove ecosystem services, in particular availability of good quality poles timber and fishing, while 68 % of the respondents confirmed that there is a shift in the uses of mangrove ecosystem services focused on the exploitation of non-wood/extractive mangrove ecosystem especially beekeeping and ecotourism. For example, mangrove poles are of great importance and are used especially for roof construction (Table 11) but mostly bought from Zanzibar town indicating significant loss of this service from the village. Villagers also reported during FGD to experience decline of village land, reduced access to forest related products, and an increase in resource scarcity. With regard to mangrove management all of the respondents from FGD confirmed that they have noted the replacement and or combination of State management regime being replaced by the formalised CBNRM which is now managing mangroves. Other observed social changes are the increase of stakeholders working in the village who have different interests in ecosystem services.

Respondents from household interviews and FGD with VCC members and village elders reported that these changes have caused significant impacts to the Pete social system. Villagers noted a clear shift of people’s livelihood activities where the majority of village residents shifted from mangrove cutters to agriculture production as indicated by 100% of the interviewed household engaged on farming activity. The farming system has changed from shifting cultivation for production of food crops to a *‘shamba’* system, in which farmers intensified agricultural production on the available limited agricultural land by the introduction of permanent commercial tree crops especially lime, mango and establishment of *Casuarina equisetifolia* plantations.

Other social impacts reported by villagers include the increase of development of livelihood activities with low economic returns (57.5% of the respondents) which has increased the hardship of communities to meet their livelihood needs (agreed by 50% of the respondents).

In this case consensus from all FGD indicated that the introduced projects are not sufficient with low impact due to the relatively small numbers of people accessed in relation to the total population. The introduced projects were established with small capital and therefore generated benefits that are not sufficient to supports people's livelihoods.

The unavailability of desired mangrove products to meet the need of stakeholders is another impact stated by 65.2% of the household respondents. Consequently the majority of Pete residents meet their wood related needs through illegal harvesting in the JCBNP, as agreed by 90% of the household interview respondents, or purchased from towns which are imported from mainland Tanzania (see Table 11). Villagers also reported that they have an increased awareness of the conservation of forest resources.

The increased village resource scarcity has been reported by villagers to cause strong conflict between Pete and Jozani villages, with the majority of Jozani villagers claiming unfair distribution of village benefits/funds especially those from the boardwalk and other village benefits. The conflict was also between those supporting (VCC members, tree planters, beekeepers) and opposing (e.g.wood harvesters) conservation. This situation has reduced the level of synergies, trust and respect among the villagers.

The most of the contacted respondents reported that current underlying drivers that have caused social changes include the high population growth with dependence on forest/mangrove ecosystem services, poverty, international tourism and a national market for honey and wood products, lack of reliable alternative income sources, and inefficiency of the management system in the village. People's culture and perception that forest harvesting is the quick way of getting money also contributed to these changes.

FGD consensus with village elders and beekeepers reported the potential drivers that might have future influences in the social system include the current drivers together with international carbon market availability and technological development of alternative energy sources (e.g. improved cooking stoves) and reliable income sources.

With regard to changes in the mangrove ecosystem, about 90% percent of the household respondents indicated that there has been a decline in mangrove tree cover and this was also the consensus in the FGD. There were changes in areas covered by mangrove which has been reduced from an estimated mangrove area cover of about 400 ha in 1997-1998 (Akil and Jiddawi, 2001) to the current estimate of 322ha. There were also changes in species composition from a *R. mucronata* dominated mangrove stand (Shunula and Whittick, 1999; Akil and Jiddawi, 2001) to a *C. tagal* dominant mangrove system (section 5.2.1). Mangrove harvesters and beekeepers reported a decline of less dominant mangrove species especially *P. acidula, X. granatum* and common fish species in the mangrove ecosystem.

These changes have been reported to have caused significant impacts to the mangrove system. FGD participants and 80% of respondents from the household interviews reported that the decline of mangrove tree cover has resulted in a reduction in the availability of mangrove fish species such as *mafiro, changubare, kamba wa koko and chuwale*), indicating the decline of ecosystem productivity. Other related impacts include decline of the size of dominant mature plants from the size of mature coconut trees which was once available to the small sized poles (withies) as reported by 76% of the respondent. Villagers also experienced the increase of beach erosion (22% of the respondents) and the appearance of insect pests on the planted mangrove areas.

The majority of respondents from FGD and KII reported the current direct drivers that have caused these ecological changes include the excessive cutting of the mangrove experienced in the past which was fuelled by a number of underlying drivers including lack of alternative income sources, poverty and inefficient management system. The changes in species dominance were perceived by villagers that have been attributed partly by the afforestation activities performed by Pete residents as a management intervention to restore the ecosystem system which was previously degraded. The presence of system memory (from the number of propagules in the ecosystem from the remaining mangrove mother plants) has contributed to the gradual reorganisation of the system.

Respondents from FGD with VCC members and village elders reported the potential future drivers of changes in mangrove ecosystems. These include the current ecological pressures and underlying drivers together with outbreak of insect pests which can damage or kill the newly planted mangroves if planting continue.

Chapter 6

MICHAMVI CASE STUDY

6.1 Description of Michamvi mangrove SES

Michamvi Shehia covers 1,604 ha and is located in the Central district of the Southern region, south east coast about 60 km from Zanzibar town. The Shehia comprises two villages of Michamvi Pingwe and Michamvi Kae. Michamvi Pingwe, is located to the east of the road, and is the largest village (66% of the Shehia's residents) while the smaller Michamvi Kae village is located at the edge of Michamvi Peninsular on the southern coast of Zanzibar close to Vijichuni community protected mangrove (Figure 15).

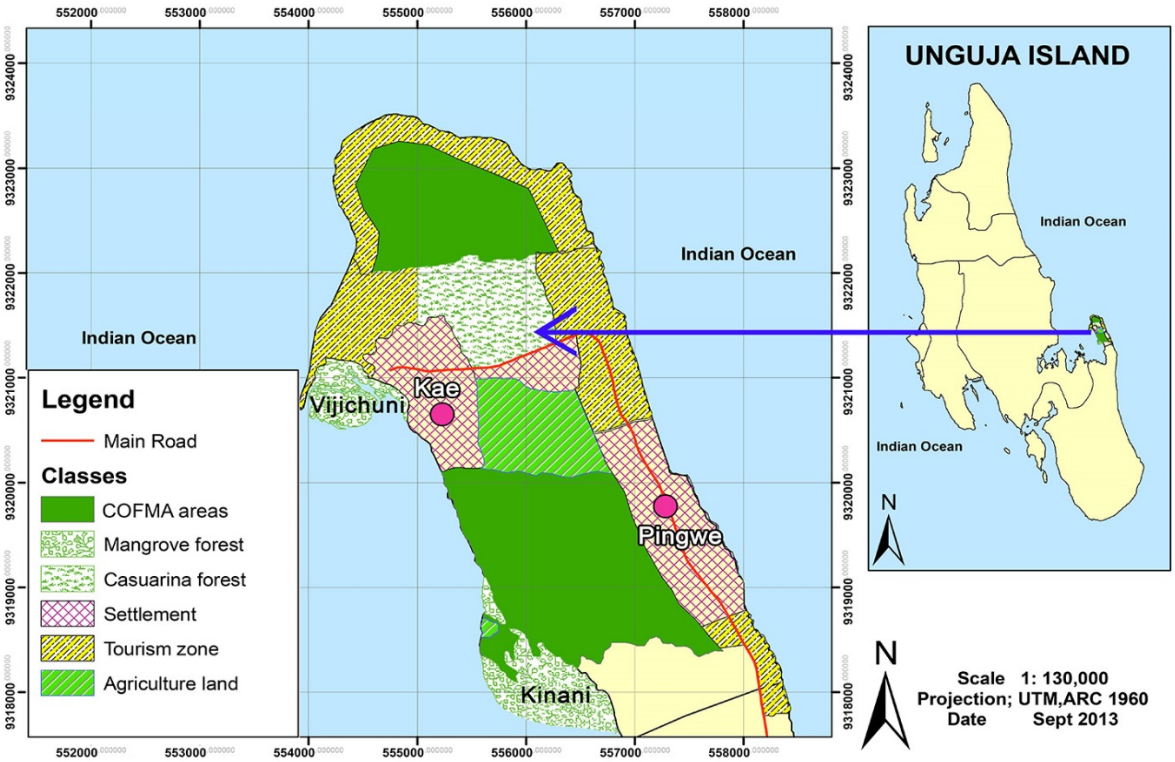


Figure 15 Michamvi Shehia physical features. *Source: Adapted from DFNRNR.*

Michamvi Shehia is within the main tourism zone of the South east coastline of Zanzibar that stretches out into the coastal area within the Chwaka bay. Although Michamvi Shehia is not a part of JCBNP it is one among the villages surrounding the park and is engaged in some park management and conservation programmes. The area is characterised by its long coastal area with sandy beaches together with diverse natural vegetation cover. The vegetation is predominantly coral rag forests including large patches of high terrestrial forests, coconut dominated forest along the coasts, *Casuarina* plantation areas, and mangroves (Finnie, 1997a).

The Shehia has experienced a rapid expansion in tourism and associated livelihood activities. Important village facilities such as a school and primary health provision were developed in 2003 and the main road was improved to tarmac level in 2009. Government interventions to promote tourism sector attracted hotel investors and other people in search of employment opportunities which resulted in a rapid population increase from 501 individuals in 1988 to 1650 residents in 2012. The increased tourism investment and improved infrastructure has meant the Shehia is rapidly undergoing land use changes. All the village land is officially government property and so local people are not allowed to sell the land, but several tenure systems exist in Michamvi where local residents through customary laws own, inherit and sell the land to others. Using these laws, large coconut dominated coastal areas (within 500-600m from the sea) that local people inherited through their elders have been sold and converted to uses associated with tourism. The Shehia also includes an area along the main road and beaches which are completely dominated by large tourist hotels, villas, resorts, guest houses and restaurants (Plate 4 a and b).

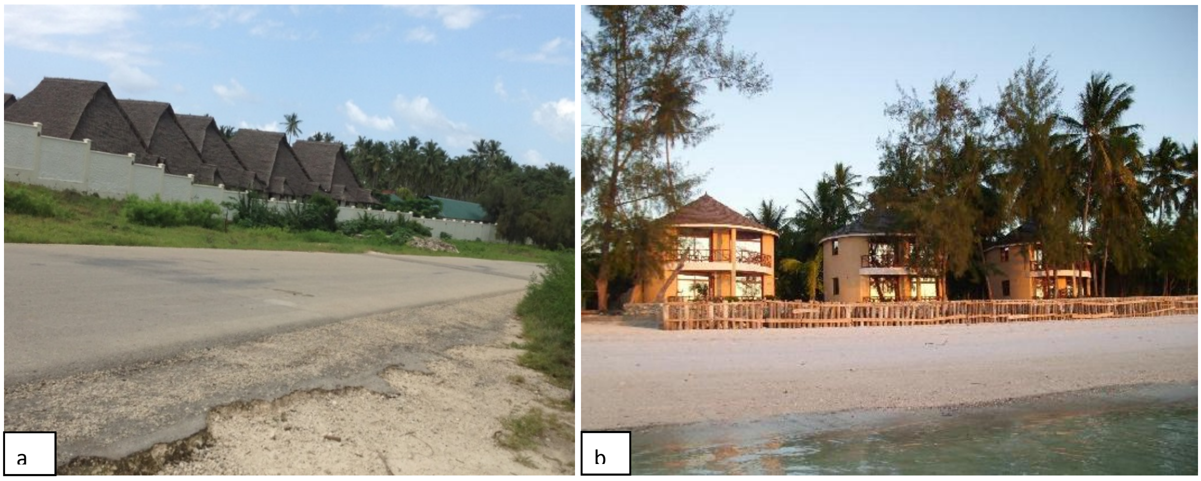


Plate 4 Tourist hotel construction in Michamvi Shehia (a) along the main road and (b) along the beach. *Source: this study, 2013*

Other village areas consist of 548 ha of coral rag and high terrestrial forests that are considered to be under the high protection zones while 122 ha are under *Casuarina equisetifolia* plantations. Michamvi has a total of 125 ha of mangroves out of which 86 ha are for Kinani government managed forests while 39 ha are occupied by Vijichuni community protected forests (Figure 15).

Fishing and tourism are the most important livelihood activities in the village. Despite the presence of large forested areas with a relatively large number of people, local communities have a low dependence on mangrove ecosystem services as sources of income for their livelihoods.

Leadership structure in the Shehia is in line with and influenced by the standard political administration setting in Zanzibar (see section 4.2). However, apart from the diverse formal village organisations, most of the Shehia governance is also strongly influenced and directed by the informal village organisation made up of a mixture of village elders and energetic members of the society. Administratively all of the Shehia mangroves are within Kinani mangrove block; one of the mangrove management blocks forms the Chwaka Bay mangrove. However, Michamvi residents have put the mangrove forests under two management priorities. Kinani mangrove located to the south of the village received low management priority and is considered a government forest by Michamvi local stakeholders and Vijichuni community mangrove represents a portion of mangrove of high management priority for Michamvi residents. The latter mangrove portion is located inside the high tourism economic zone. A section of this mangrove was clear felled in 2003 in an aborted attempt to initiate the construction of a tourist hotel.

6.2 Current state of Michamvi mangrove ecological system

The two mangrove stands of Kinani unprotected blocks and Vijichuni community-protected mangroves form the major entity that makes up the ecological component of the system. Kinani mangrove considered in this section refers to the portion of Kinani mangrove block within Michamvi Shehia. The current state of the ecological system is described by mangrove tree species diversity, dominance, density, regeneration, tree size distribution, rate of cutting, basal area and standing volume.

6.2.1 Species diversity, dominance, density and regeneration.

Michamvi mangrove ecological component was found to be composed of nine mangrove species; six of them being identified in Kinani and nine in Vijichuni mangrove. *Ceriops tagal, Rhizophora mucronata, Bruguiera gymnorrhiza, Sonneratia alba, Avicennia marina* and *Xylocarpus granatum,* were found in both sites while *Pemphis acidula, Heritiera littoralis and Xylocarpus moluccensis* were only recorded in Vijichuni. Although Kinani has fewer mangrove species than Vijichuni both mangroves were relatively diverse as expressed by relatively high values on the species diversity index of 1.4 for Kinani and 1.3 for Vijichuni. This is because the measure of species diversity is little affected by addition or loss of rare species and it emphasizes common species (Smith and Smith, 2001). Mangrove from both sites was found to have four species which could be classed as abundant based on their respective Effective Number of Species (ENS) values of 4.1 and 4.0 for Kinani and Vijichuni, respectively. The major constituent species in both sites were found to be *C. tagal, R. mucronata* and *B. gymnorrhiza* represented by 83.8% and 90.9% of the relative density for Kinani and Vijichuni mangrove stands, respectively. *A. marina* was the fourth most abundant species with a relative density value of 7.9% for Kinani and 3.6% for Vijichuni mangrove. Thus based on species importance values (sum of relative abundance, frequency and dominance), *C. tagal* was found to be the most dominant species at both sites with the species importance values of 95.4% and 102.7% for mangrove of Kinani and Vijichuni, respectively. *R. mucronata* was the second most dominant species followed by *B. gymnorrhiza* in Kinani, and the converse was true for the Vijichuni mangrove. Other species such as *X. granatum* and *S. Alba* were represented by a range of intermediate proportions in both sites (Figure 16).

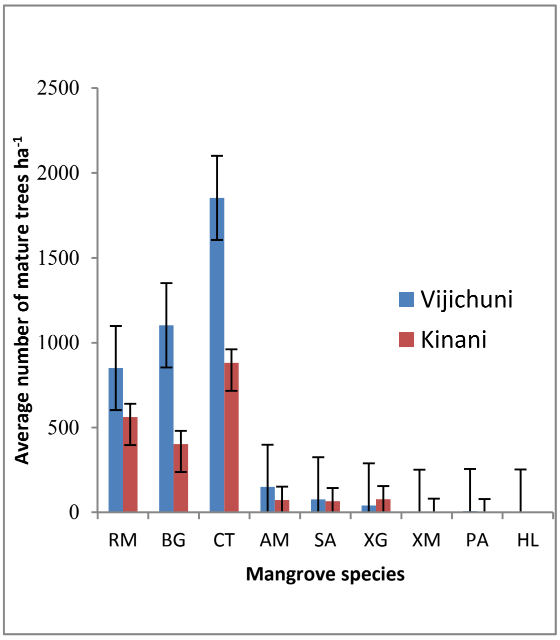


Figure 16 Density of mature mangrove in Michamvi

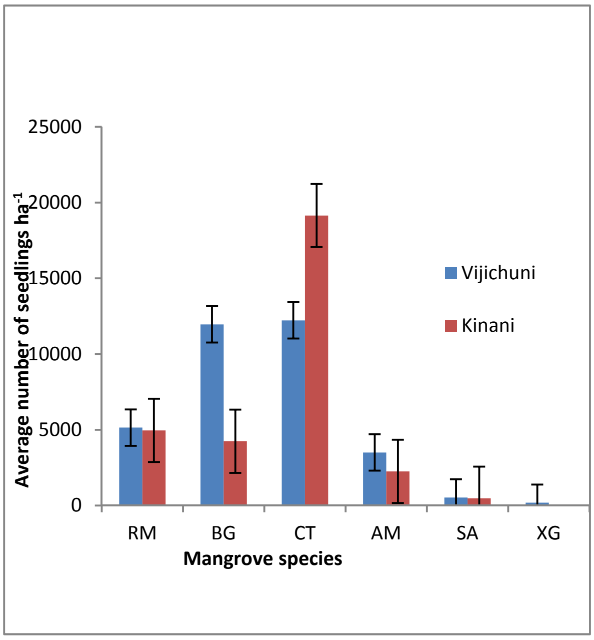


Figure 17 Seedling density by species in Michamvi mangrove

Vijichuni mangrove was found to have a relatively high density of mature trees and regeneration rates compared to Kinani mangrove (Figures 16 and 17). The average standing density of 4,110±1,166 trees/ha and regeneration rate of 33,117±5,509 seedlings/ha were found in Vijichuni mangrove. In contrast, Kinani mangrove had half the density of mature plants and slightly lower seedlings/ha than Vijichuni mangrove with values of 2,064±372 trees/ha and 31,076±6283 seedlings/ha. Regeneration was higher for the most abundant species in both sites whereas no seedlings were encountered for the least abundant mangrove species such as *X. granatum* in Kinani and *X. moluccensis, Heritiera littoralis* and *P. acidula* in Vijichuni (Figure 17).

6.2.2 Size distribution, basal area and volume of mangrove trees

Vijichuni mangrove was characterised by intensively covered mangrove forest, perceived by local communities to represent the natural appearance of a mature mangrove ecosystem. Only 48.1% of the standing density fell under diameter class between 2 - 5 cm while 51.9% of the mature trees fell in the diameter class of 6cm and above. In contrast, about 70% of standing density from Kinani mangrove fell in the small diameter class between 2 - 5cm and 30% of mature plants were found beyond this range (Figure 18).

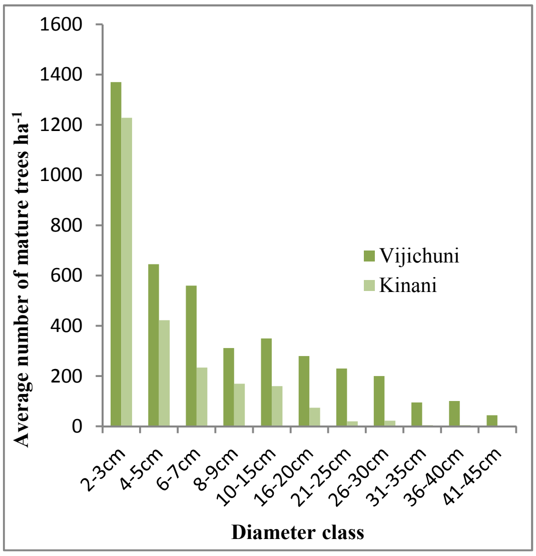


Figure 18 Diameter distribution in Michamvi mangrove

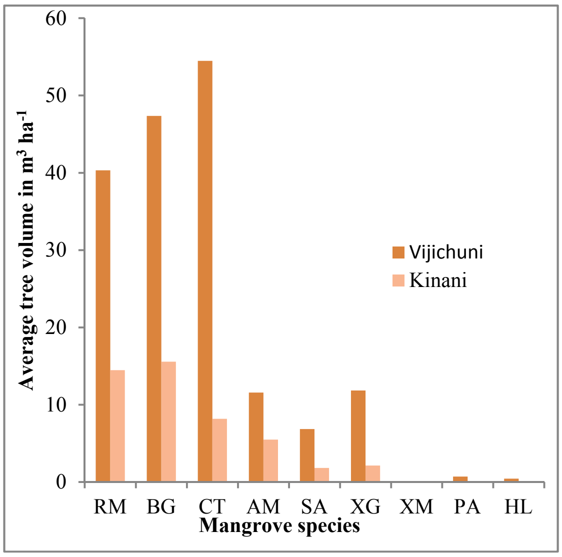


Figure 19 Mangrove tree volume in Michamvi

Vijichuni mangrove forest represented a mangrove system with a good proportion of larger sized mature plants. The observed diameter distribution has a direct influence on the total basal area and volume of the tree which, in turn, determines the type of wood provisioning ecosystem services that an ecosystem can provide. Mangrove of Vijichuni was found to have higher basal area and volume than Kinani which was statistically significant different at $p = < 0.0001$. An average basal area of 28.82±4.5m^2/ha with corresponding average volume of 173.51±39.74m^3/ha was found for Vijichuni mangroves. On the other hand Kinani mangrove trees were found to have an average basal area of 9.97±1.17m^2/hectare with a corresponding average volume of

37.07±6.33m^3/hectare (Figure19). The large scattered and taller mature plants in Kinani were considered by the villagers to be unsuitable for pole production.

6.2.3 Rate of tree removal in Michamvi mangrove forests

Vijichuni mangrove was found to have a relatively low rate of mangrove cutting with an average of 197±57stumps/ha. Out of these stumps about 30% were categorised by villagers as exceeding more than five years of age which indicated that there is a significant decline in the rate of mangrove removal in recent years. This rate of mangrove cutting in Vijichuni mangrove differs significantly compared to the rate of mangrove harvesting in Kinani mangrove ($p = < 0.0001$). Thus Kinani mangrove has been under a high rate of tree cutting in recent years, as indicated by an average of 953±101 stumps/ha. Only 5% of the observed stumps were reported by villagers to be more than five years old. Villagers claimed that the value of this mangrove has degenerated to the extent that it has lost its natural vegetation structure and is now dominated only by bushy stands with scattered old mature plants, saplings and seedlings. *Ceriops tagal* is the most cut mangrove species in both areas represented by 54.8% and 49.6% of the total stumps cut in Kinani and Vijichuni, respectively (Figure 20).

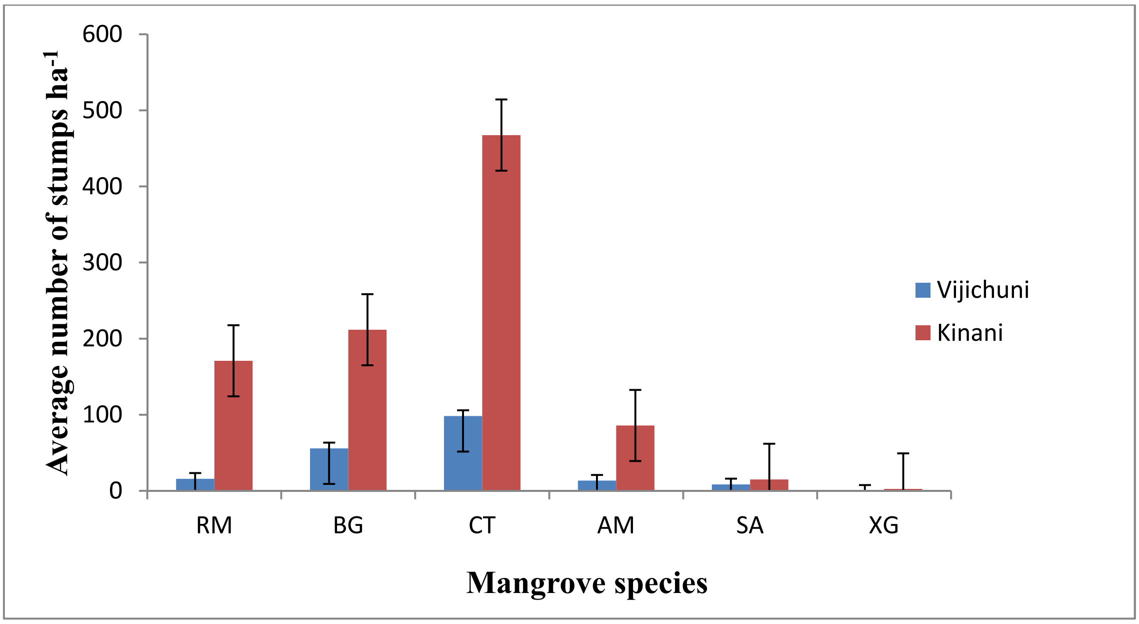


Figure 20 Removal of mangrove trees in Michamvi mangrove forests

Given the relative age of stumps/ha (Table 17) and the average density of mature mangrove Kinani mangroves, the current rate of tree removal reflected by the density of one-year old stumps, is not sustainable.

Table 17 Density of stumps by age in Michamvi mangrove forests

	Vijichuni		Kinani	
Age of stumps	Stumps/ha	% of the total	Stumps/ha	% of the total
1 year	99	50	840	88
2-5 years	39	20	66	7
>5 years	59	30	47	5
Total	197	100	953	100

Source: this study

If the harvesting rate continues all of the mature mangrove will have been extracted from Kinani in the next three years. On the other hand, the current rate of tree removal in Vijichuni forests mangrove (Table 17) is very low and is likely to give a sustainable output. If this harvesting rate is maintained, the forest can be sustainably harvested beyond 25 years and maintain a substantial number of mature plants.

6.3. Current state of Michamvi social System

Michamvi social component is described by stakeholder's knowledge, ecosystem services exploited from Michamvi mangrove ecosystem and interests of stakeholders in different mangrove ecosystem services.

6.3.1 Stakeholder's diversity, linkage and knowledge in Michamvi

This study found that the Michamvi social system has diverse groups of stakeholders across spatial scales. The first group was composed of international donor projects, district and national department staff who were implementing their programmes in Michamvi to achieve their interests (see section 4.8.2). It also includes top government political leaders who have influence on allocation of resources for conservation of mangroves and tourists interested in Michamvi mangroves.

The second group was represented by local scale stakeholders who varied between Vijichuni and Kinani mangrove forests. These two groups of stakeholders for Kinani and Vijichuni mangrove forests were further divided based on the location, activities, interests or influence of stakeholders in the system (Table 18). Thus Michamvi society has primary stakeholders, who are directly dependent on, or are involved in, exploitation of the resources and who may be living inside or outside the Shehia. The results from all respondents indicated that the primary stakeholders for Kinani mangrove were mainly individual and household members who lived adjacent to or outside Michamvi Shehia, especially those that came from Bwejuu, Ukongoroni, Charawe, Chwaka, and Marumbi Shehias. The stakeholders from these villages were reported to be involved in direct extraction of wood provisioning ecosystem services from Kinani mangrove. Apart from the village outsiders, people from Michamvi Kae and Pingwe villages were also primary stakeholders who had interests in the ecosystem services provided by Kinani mangrove systems. Primary stakeholders for Vijichuni mangrove included people from Michamvi Kae village only. Typical activities undertaken by this cohort of local stakeholders included individual mangrove harvesters, local tour guides, beekeepers, seaweed farmers and local tour operators, fishers and cockle collectors.

Table 18 Classification of stakeholders in Michamvi mangrove social ecological system

	Vijichuni mangrove forest				**Kinani mangrove forest**			
	Activities/interests		**location**		**Activities/interests**		**location**	
Scales	**Primary**	**Secondary**	**Inside**	**Outside**	**Primary**	**Secondary**	**Inside**	**Outside**
Village	Ecosystem service users in Michamvi Kae village	Outsiders, VCC, members	Michamvi Kae villagers	outsiders	Outsiders, few mangrove harvesters from Michamvi	Outsiders from Bwejuu, etc.	Few Michamvi mangrove harvesters	Outsiders
District		District Forest Officer		District Forest Officer		District Forest Officer		District Forest Officer
National		National department staff and NGO (e.g. DFNRNR		National department staff and NGO (e.g. WEZA		National department staff and NGO (e.g. DFNRNR		National department staff and NGO (e.g. DFNRNR
International		International Donors and projects, tourists		International Donors and projects, tourists		International Donors and projects		International Donors and projects

Michamvi society also included a wide range of secondary stakeholders who either benefited indirectly from the non-provisioning ecosystem services (e.g. Coastal protection, climate regulation), were involved in management and conservation activities and or their activities/decision have influence on the supply of ecosystem services to primary stakeholders for both Kinani and Vijichuni mangroves. These stakeholders were located at different spatial scales and may be living inside or outside the Shehia (Table 18). Secondary stakeholders at the village scales were employed as mangrove rangers, tourist investors and committees that follow a standard Shehia administration arrangement (see section 4.2). In Michamvi these included VCC (which was composed of representative members from both Pingwe and Kae villages), fishing committee, and representative members from JOCDO and JECA operating both in Pingwe and Kinani Village. Apart from the formalised Shehia committees Vijichuni village has an informal organisation made up of village youth and elderly members from Michamvi Kae only. This informal organisation was responsible for management of utilization and conservation of the Vijichuni mangrove system. Employed government department staff at district, and National scales, international NGO and donors represents secondary stakeholders at higher scales for Michamvi mangroves while tourists are global stakeholders for Vijichuni mangrove only.

6.3.2 Stakeholders' linkages in Michamvi SES

Despite the presence of diverse stakeholders in Michamvi, villagers reported that most of the international and national stakeholders were less involved and linked with local stakeholders in mangrove management and development interventions than in other case study sites. Village members from Michamvi through their representative committee members worked periodically with DFNRNR staff, civil society groups and local NGOs that were based in Pete to engage in and support park conservation programmes. For example, Michamvi has been working with JOCDO to run a saving and credit programme in the area. MACEMP worked with the fishery committee to control illegal fishing practices and supported fishery development through provision of a modern fishing boat. More recently, Michamvi in 2012 has been working with the HIMA project in the initial carbon project campaign (see section 4.8.2) to look for the potentiality of Michamvi forests to pilot REDD$^+$ projects in future. However, Michamvi Shehia was not selected for the final stage of piloting REDD$^+$, despite raising communities' expectations and potential conflicts in relation to this project (see below).

Results from key informant interviews (KIIs) and FGDs found that most of the residents were united and live in harmony with very few conflicts. One of the oldest Michamvi residents reported during one FGD that there was a strong linkage between the Shehia formal administrative structure headed by the Sheha and their committees and local informal organisations and the majority of people in the village community. This situation has strengthened the level of trust and synergy between community members and has contributed to the efficiency of local mangrove management arrangements in Michamvi.

6.3.3 Stakeholders' knowledge systems in Michamvi Shehia

Different groups of stakeholders interested in Michamvi mangrove system have different types of knowledge systems. The type and level of knowledge of stakeholders above the village scale were found to be the same as those described in the Pete case study (section 5.3.2). Local stakeholders in Michamvi were found to have both formal and informal knowledge related to forest management and conservation acquired from different knowledge systems. Household interview results indicated that about 82% of the respondents have accessed and acquired formal western education while 18% have never attended school. Respondents who attained primary and secondary level education as their highest level of education were in equal proportion, each accounting for 15.4% of the total respondents. There were no respondents who have acquired formal education to the college or university level in Michamvi. Results from KII with VCC members and primary school teachers indicated that the formal education system at a lower level did not include mangrove conservation, biology and management knowledge. They also reported that mangrove biological knowledge was slightly covered in secondary level education while conservation and management were known to be covered by colleges and universities.

Despite the low level of formal education attained by Michamvi residents, results from FGDs and field observation indicated that the majority of Michamvi residents especially village elders and leaders, religious leaders, youth members engaged in management and direct users of the ecosystem were rich in knowledge concerning the biology, management and economic use of the mangrove system. These Michamvi community representatives have scientific understanding on importance of mangrove for the provision of other ecosystem services, mangrove conservation and management acquired through the influence of the higher scale stakeholders as indicated on Pete case study (section 5.3.2). The traditional knowledge on mangrove uses, management and conservation represent another source of knowledge confirmed by the communities that are actively integrated especially on the management of their community mangrove forests. For example, village youth who engage in conservation activities and most of the contacted village elders have traditional biological understanding on different types of mangrove tree species known by local names, mangrove planting techniques, planting time and species selection, stump ages, recovery time, and suitability of different mangrove species for different ecosystem services. They also have the traditional knowledge on forest rights, ownership and conservation of the ecosystem. Few of the ecosystem users especially beekeepers have local knowledge on beekeeping and economic uses of other mangrove ecosystem services in the village.

Michamvi VCC secretary narrated during a FGD that:

Tumepata elimu ya usimamizi na uhifadhi wa mikoko kupitia wazee ambao walikuwa na elimu ya asili ambayo ilikuwa ikisambazwa kwenye jamii na kutumika kwa ulinzi wa uharibifu na upandaji mikoko kuhuisha maeneo yakiyoharibika. That is "we have acquired mangrove management and conservation knowledge through our knowledge holders (Village elders) who had sufficient tradition ecological knowledge that shared in the society and used for protection of mangroves against destruction and planting of mangrove to restore degraded areas"

In addition, most of the villagers reported that the Islamic leaders provided a significant contribution to advocate forest conservation knowledge in the society and are still recognised in the current management system. They typically conducted specific village talks in public places especially during Friday prayers to stress the need for the wise use of forest resources based on Islamic laws and values.

6.3.4 Ecosystem services generated from Michamvi mangrove ecosystem

The types and level of supply of ecosystem services depends on the state that the system is in (Hein *et al.,* 2006). The current bio-physical state of Michamvi mangrove system offered diverse ecosystem services to different stakeholders within and across spatial scales. The mangrove ecosystem of Michamvi was found to provide a wide range of ecosystem services including the provision of wood materials for different uses, cultural, regulating and supporting services. Some of the ecosystem services supplied by Michamvi mangrove forest were found to differ between Kinani and Vijichuni mangrove forests.

6.3.4.1 Provisioning ecosystem services in Michamvi mangrove

All of the stakeholders interviewed in Michamvi agreed that the mangrove forest of Kinani was heavily extracted for the supply of a wide range of mangrove wood provisioning services. This was confirmed by the high number of stumps/ha recorded in samples taken in the ecosystem (section 6.2.3, table 17). Villagers confirmed that Kinani mangrove was harvested mainly by village outsiders for provision of wood materials as building poles, fire wood, charcoal, lime making, and lumber/frames for making local beds. The reported main mangrove wood harvesters for Kinani mangrove were from the neighbouring Shehias of Bwejuu, Ukongoroni, Charawe, Chwaka, and Marumbi. The assistant Michamvi Shehia leader narrated during a FGD that:

"*Wanavijiji kutoka Bwejuu, Ukongoroni na Charawe ndio watumiaji wakubwa wa koko ya Kinani kwani hata tunapofanya doria na kesi zote zinazopelekwa polisi basi wahusika wakuu wanatoka katika vijiji hivyo na laiti kama vijiji jirani vingeacha kuitumia koko kama Michamvi basi ingekuwa salama".* That is "Village outsiders from Bwejuu, Ukongoroni and Charawe are the main users of Kinani mangrove because majority of the reported police cases of seized offenders who committed illegal cutting during mangrove patrols were residents from these neighbouring villages. And if in case these neighbouring villages would stop cutting mangrove like Michamvi residents, then it would be in safe situation."

On the other hand, villagers reported that Michamvi residents engaged in irregular harvesting of Kinani mangrove forest at a very low rate especially to meet individual emergency needs. Such provisioning ecosystem services include harvesting of building poles for repairing of old houses/furniture, pole replacement in the fishing boats, cutting of mangrove for boat construction materials (*mataruma)* and harvesting of few mangrove logs for bench construction in tourist hotels (see Table 20).

Whilst the extraction of mangrove wood provisioning ecosystem services from Kinani mangrove forest was undertaken by both village outsiders and a few Michamvi residents, mangrove harvesting in Vijichuni presented a completely different scenario. Despite intensive vegetation cover, Vijichuni mangrove was found to be under close supervision and only limited wood could be harvested by stakeholders after getting appropriate permission from the governing committee. Results from FGD and KIIs indicated that mangrove trees in Vijichuni mangrove ecosystem were only harvested to meet the emergency needs of Michamvi Kae residents, a few Michamvi Pingwe residents and in response to community development issues in the village. Residents from both inside and outside Michamvi Kae village can be allowed to harvest building poles after making a special request to the Michamvi Kae village elders committee. Approval for harvesting depends on whether the applicant is from within or outside Michamvi Kae, if the application is for allowable uses within limits set by the committee and the age of the applicant. Elderly Michamvi Kae residents applying for meeting emergency needs of building poles are more likely to be allowed after the committee verified the needs and extent of problem of the applicants than young applicants (KII with VCC secretary). Village outsiders (from Michamvi Pingwe) are only allowed to harvest building poles, up to maximum of ten poles under committee permission. The approved applicants should be accompanied by a member of the committee to show the applicant the specific areas where the poles can be extracted, and to check that the correct amount of allowable poles are harvested before they are removed from the forests. Thus harvesting of wood products was also achieved through irregular selective cutting of mangrove poles used in fishing boats (*pondo*-a small pole for punting, propelling a canoe) and house repairing or selling of mangrove wood products to secure village emergency financial needs. Income from selling mangroves supported community development activities such as maintenance of Quran madrassa, mosque and school buildings or the life of sick-older and poorest member in the village.

A low level of cutting mangrove wood by Michamvi residents does not mean that they are not interested in these ecosystem services but reflects the availability of mangrove and non-mangrove wood products from alternative source of supply of the services. For example, 23.2% of respondents from household interviews indicated that Michamvi residents were using mangrove poles as building materials for roof frames, and other uses sourcing the wood in Zanzibar Town while significant proportion of people use building materials from non-mangrove sources (Table 19).

Table 19 Sources of wood products used by Michamvi residents for house construction

Uses of building poles	Sample size (households)	Percentage of respondents using mangrove poles from town	Percentage of people using poles from terrestrial forests	Percentage of people using sawn timber from town	Others (%) blocks and stones
Roof frames	40	23.2	55.8	20.9	0
Windows	40	4.5	41.7	30.32	23.5
Walls	40	2.3	25.6	4.7	67.1

Beekeeping and medicinal plant materials were among the provisioning ecosystem services found to be harvested from Michamvi mangroves by some village residents (Table 20). Results from household interviews indicated that only 2.5% of Michamvi households were engaged in beekeeping activities both for subsistence honey production and sale. Similarly, 2.5% of the Michamvi household respondents reported that they extracted plant parts, especially bark and fruits of *X. granatum*, for curing stomach-ache (Plate 5)

Plate 5 (a) Fruits and (b) Seeds of *Xylocarpus granatum* used for curing stomach-ache in Michamvi Shehia. *Source: this study.2013*

Other activities performed in or close to the mangrove ecosystem as reported by Michamvi residents include seaweed farming and crab harvesting. Seaweed farming was mostly done by women in the village and sold to different seaweed trading companies such as Zanzibar East Africa seaweed company (ZANEA) and others. Some women in Michamvi also participated in fishing and gathering of shellfish such as *Terebralia* spp (*suka*/*tondo*) along the beaches. In addition villagers reported receiving income through irregular confiscation of the illegally cut mangrove forest products and conservation share from JCBNP.

6.3.4.2 Cultural services in Michamvi mangrove system

The relatively undisturbed nature of Vijichuni mangrove forest combined with its location along the coastal line in close proximity of tourist hotels in the village and the opposite side of Chwaka bay offers opportunities for development of ecotourism. One major attraction of this mangrove forest is the formation of a raised area of land made by accumulated sand along the beach (*funguni*) where a small shed has been constructed for short stopover of tourists during their visits. The tourists stay in this resting hut for few hours for food, drinks while others swim along the beaches and go for short walk in mangrove forests. These activities generate funds for Michamvi Kae residents through payments for this service.

Table 20 Economic benefits from provisioning mangrove ecosystem services to Michamvi residents

Ecosystem services	Subsistence					Selling				
	% of house-holds	No of hhs	Monthly harvest/ hh	Monthly income equivalent / hh in TSHS*	Annual income equivalent / hh in TSHS*	% of house-holds	No of hhs	Monthly harvest/ hh	Monthly income/hh in TSHS*	Annual income/hh in TSHS*
Building poles	not regular									
Big logs						10.3	33	10	100,000	1,200,000
Beekeeping (bottles)	2.5	8	1	10,000	120,000	2.5	8	10	50,000	600,000
Medicine	2.5	8	not regular							
Ecotourism (trips)						44	145	12	182,220	2,186,640
Crabs (kgs)	2.5	8	not regular			28.2	93	3	12,219	146,628
seaweed (kgs)						33.3	109	47.2	18,892	226,704

*1 GBP (£) ~ 2,500TSHS at the study time. I kilogram of dry seaweed was sold for 400 TSHS, 1 bottle of honey was sold for 10,000TSHS and a kilogram of crab was sold for 4,075 TSHS.

Mangrove ecotourism in Michamvi is a local community initiative and has not been formalised by the Government. In this arrangement Michamvi Kae residents reported during a FGD that they have entered into an agreement with Zan-Swed hotel located in Chwaka village (located on the opposite side of the bay) to send their visitors from their hotel to visit Vijichuni mangrove. A monthly amount of 320,000TSHS (£128) is paid by the hotel to Michamvi Kae development committee for these services except for the three months during the low tourist season.

Apart from this arrangement ecotourism is conducted on an individual basis by male Michamvi Kae residents with tourists walking along the Vijichuni mangrove guided by locals. Results from household interviews indicated that about 44% of Michamvi households were engaged in mangrove ecotourism which generated an average monthly income of 182,220TSHS (£72.90) per household (Table 20).

Mangrove ecotourism services in Kinani were currently not common but villagers acknowledged the potential of the forest for tourism and noted that the forest had been used by Michamvi and Bwejuu residents for ecotourism purposes. One VCC member during a FGD confirmed that there is a specific isolated mangrove area called *"Chaka la Kwawa"* which means Heron Bird Island that has considerable potential for ecotourism. Villagers reported that this island which is located between Michamvi and Ukongoroni Shehia provides a habitat for thousands of birds around the area and has been used as a sacred site in the past.

6.3.4.3 Regulating mangrove ecosystem services

Results from field surveys indicated that Michamvi mangrove provided both regulating and supporting ecosystem services to different stakeholders. Regulating mangrove ecosystem services observed in the field included the presence of diverse insect populations (including bees) and marine organisms reflecting the biodiversity value of the system. However, 90% of the household respondents were not able to recognise these ecosystem services. About 10% of the respondents reported that they felt their mangrove was important for climate regulation, reflecting the role of mangrove in carbon dioxide sequestration (*hewa ukaa*) and regulation of the microclimatic condition of the village.

Michamvi mangrove was also reported by villagers to provide diverse protecting and supporting ecosystem services in the area. Respondents from household interviews reported that their mangroves play significant supportive and protective roles particularly provision of fish breeding sites especially juvenile fish and prawns (supported by 70.0% of the respondents), preventing strong winds from reaching to their village (agreed by 62.5% of the respondents) and controlling beach erosion (57.5% of the respondents). Other supportive mangrove ecosystem services reported by Michamvi residents were the provision of habitats for other organisms especially migratory wetland birds and crabs (22.5%)) and protection of coral reefs (12.5%).

6.3.5 Stakeholders' interests in mangrove ecosystem services

The mangrove stakeholders in Michamvi were found to be associated with diverse and opposing interests in mangrove ecosystem services generated by the Michamvi mangrove ecological system. The observed variation of stakeholders' interests was not only across spatial scales but also between the ecosystem services supplied by Kinani and Vijichuni mangrove forests. Results from KIIs with government officials indicated that stakeholders at international and most stakeholders at the national scale had strong vested interests in regulating and supporting ecosystem services provided by Michamvi mangrove ecosystem like those reported in Pete case study (5.3.5). However, these stakeholders did not differentiate between the ecosystem services generated by Kinani and Vijichuni mangrove forests and had no interest in ecotourism benefits and provisioning services from the focal study area.

Interests of local community stakeholders varied with respect to Kinani and Vijichuni mangrove forests. There was consensus among village elders and VCC members in FGDs who indicated that stakeholders at the local level from Michamvi Kae village had strong vested interests in extracting ecosystem services from Vijichuni mangrove that they believed would have less impact on the mangrove. In particular the village elders and VCC members reported that Michamvi Kae residents were interested in conservation of Vijichuni mangrove for future generations and the provision of ecotourism services to generate revenue for village development. Likewise, Michamvi Kae villagers confirmed that tourists and tourist investors were particularly interested in the luxuriant plant growth provided by Vijichuni mangrove that gives visitors a sense of aesthetic satisfaction (Plate 6). These are the types of ecosystem services in which the stakeholders at a higher level were also interested.

Plate 6 Section of Michamvi Vijichuni mangrove forest showing luxuriant plant growth

Source: this study 2013

Other interests of Michamvi Kae people on Vijichuni mangrove were on availability of provisioning services to secure emergency village and or individual subsistence needs on mangrove wood materials from the forests.

The majority of stakeholders from Michamvi Shehia considered Kinani mangroves was not economically important to them with respect to the supply of wood provisioning ecosystem services; with the exception of a few people who exploited small amount of wood material from the forests (section 6.3.4.1). Thus, the general consensus from all respondents confirmed that massive cutting of mangrove wood for supply of fire wood, charcoal, lime production and building poles from Vijichuni and Kinani mangrove are of little importance to Michamvi residents in terms of their contribution to the household income. During FGD, one member of the conservation committee narrated that:

'Hakuna hata mtu mmoja katika Shehia ya Michamvi ambaye yeye anategemea kukata koko moja kwa moja kama ndio njia yake kuu ya kiuchumi kwa sababu huu sio utamaduni wetu'- That is 'there is no person who is totally engaged on mangrove cutting as his/her major income earning activity in Michamvi Shehia because cutting of mangrove for sale is not our tradition'.

Apart from ecosystem services that they perceived to generate direct economic value, local stakeholders at Michamvi reported a strong interest in the protective services provided by both Vijichuni and Kinani mangroves, especially protection from strong winds and waves reaching their village, control of coastal erosion and vulnerable ecosystems adjacent to the mangrove.

More recently stakeholders at Pingwe village reported that they were encouraged to join carbon trading activities through REDD^{+} project because Vijichuni Mangrove was recognised as a potential forest for a HIMA project. FGD with Michamvi Pingwe communities indicated that they were very optimistic and had accepted the concept of carbon trading which was motivated by a high expectation that they would get substantial financial returns for community development. However, this idea was in conflict with the Michamvi Kae residents who considered themselves to have exclusive rights to decisions on the uses and management of this forest. During FGDs Michamvi Kae elders and VCC members opposed the idea and were very worried about losing control and commitment to sustainably conserve this forest while allowing Government and other people outside their village to manage the forest.

Representative VCC members were not certain about the sustainability of market/buyer availability to purchase the stored carbon from the community forests after donor support had been withdrawn. Other concern raised by village elders was that they worried about losing income from ecotourism because the hotel owners might argue that they do not need to continue making payments if the community is receiving funds under a carbon trading scheme. Similarly, one of the oldest village residents claimed that during these discussions they had lost trust in the Government because they had previously experienced government programmes were unsustainable, and especially donor supported projects. In addition few respondents were convinced that the introduced project might promote forest degradation in the same way that other projects had, and therefore increased vulnerability of the mangrove to community destruction. Thus, despite higher Michamvi Pingwe community expectations for this pilot project, most Michamvi Kae communities were uncertain whether an introduced HIMA project would provide real benefits to people or create long lasting conflicts between the mangrove stakeholders.

6.4 Interactions

Michamvi mangrove SES identity is characterised by several ecological and social relationships. Interaction in ecological systems is related to animal-plant interactions that influence the productivity of mangrove ecosystem services. One of the most important observed animal-plant interactions in Michamvi was between mangrove plants and honey bees which may contribute to the level of honey production in the mangrove ecosystem. Another animal-plant interaction observed in Michamvi was between crabs and mangrove seedling propagules which can have a significant impact on the establishment of mangrove species, by destroying mangrove propagules and preventing regeneration (Dahdouh-Guebas *et al*., 1998). However, no specific studies were conducted in this thesis to measure the impact of these animals on ecosystem productivity.

6.4.1Mangrove management arrangements in Michamvi

Michamvi mangrove social system interaction is described by different property rights regimes that govern ownership, access, uses and management of mangrove ecosystems. The consensus from all FGDs and KIIs indicated that Michamvi mangrove was governed by a diversity of formal and informal institutions which represent diverse forms of property rights and sectoral interactions operating between and across spatial scales. The application and influence of these institutions on management of mangrove were found to vary between Kinani and Vijichuni mangrove systems.

6.4.1.1 Property rights, ownership and management of Kinani mangrove

Kinani mangrove was found to be managed under a formal State mangrove management approach which is dominant in Zanzibar with periodic minor involvement of surrounding communities through co-management approach operated at a national scale. Despite the presence of informal institutions (see below) these bylaws have not been applied and considered by all stakeholders in the management of Kinani mangrove.

Most laws and regulations that govern Kinani mangrove have been strongly influenced by a wide range of institutions operating at higher global and national scales. Consensus from all respondents from FGDs and KIIs in Michamvi reported that the Kinani mangrove ecosystem has been managed mainly under a State property regime whereby the Government is the main owner and decision maker on the access and uses of the resources. In this management arrangement villagers realised that the Government had abandoned the 'open and closed' management approach and imposed a complete ban on the extraction of any wood materials from the mangrove (see section 4.8.2). The enforcement of these laws in Kinani was achieved through irregular patrols done by a few forest guards and a patrol team from DFNRNR supported by external donor resources.

However, villagers claimed that the State management regime was inefficient which served as government incentives to partially involve local communities to support the Government's role in conservation of mangrove. CBNRM has become a standard procedure for management of forest resources (see section 4.8.2), whereby in Michamvi communities through the VCC were partially involved in performing activities that conserved Kinani mangrove resources without any legal recognition of their ownership, access, management and use of the resources. In this case although Kinani mangrove was managed under State property rights, local communities were encouraged to participate in the management through patrols and tree planting. The formulated COFMA in Michamvi was exclusively for management of terrestrial forest resources (Finnie, 1997a.) leaving the Kinani mangrove ecosystem under the State management regime with low government and community priority. Michamvi residents reported that under these arrangements they were only allowed to exploit mangrove ecosystem services that had little negative impact on the dynamics of ecological systems such as beekeeping, ecotourism, etc.

Despite the presence of these multiple institutions this study found that Michamvi communities with formalised VCC members have been very discouraged by the overall management approach and were not actively participating in management of Kinani mangrove ecosystem. This forest has remained solely with government institutions. In one of the FGDs the Michamvi Sheha summed up the perceived view of the forest as:

"Koko ya Kinani si yetu ni msitu wa serikali tangu asili kwa hivyo unavurugwa tu mali ya mpata mpatae" – means that "Kinani mangrove is not our property but is a government forest since historical times and therefore it is extremely degraded – it is a free resource"

In spite of the diversity of institutions governing Kinani mangrove, villagers noted that poor relationships and linkage between local community stakeholders and national stakeholders had resulted in the poor performance of mangrove conservation activities.

6.4.1.2 Management of Vijichuni Mangrove

Whilst the management of Kinani mangrove was influenced by the formal management institutions operated at a national scale, these institutions had little influence on the management of Vijichuni mangrove. This study found that Vijichuni mangrove has been largely managed under informal institutions developed by a strong informal village committee composed of village youth and elderly villagers of Michamvi Kae residents. These informal institutions are based on peoples' long term experiences, traditions, norms and cultural practices that govern their way of life and influence how they interact with the ecosystem around them. Village elders reported at FGD that through this management approach, Michamvi Kae society including mangrove management was governed by traditional village bylaws and regulations that have been agreed by the majority of village residents. The eldest village leader during this discussion stressed that according to their traditions, youth members of this committee should be engaged in voluntary work in mangrove conservation and management activities under the guidance and collective decision made by village elders. They also confirmed that the uses of mangrove ecosystem services are often governed by customary rights, traditional and heritage and they are often closely tied to the culture of the local communities. In addition, this local management arrangement included Islamic leaders who advocated conservation of mangrove forests using Islamic rules (section 6.3.3) and formalised Shehia conservation committee (VCC) members who participate in the management of the mangrove. Effective management of Vijichuni mangrove and use arrangements has been carried out solely by local communities themselves with very little direct involvement of stakeholders at international and national scales.

6.5 Innovation

Innovation is crucial to mangrove SES identity which according to some resilience scholars is explained by diversity of ecological and social systems (see section 3.2.1) Ecological innovation in Michamvi is considered in the same way as Pete case study (section 5.5). However, mangrove survey results indicated that Michamvi mangrove has a large number of high abundant mangrove species reflecting the high diversity of the system. Relatively high abundance of Michamvi mangrove species enhances greater chance of achieving a high level of diversity which is potential for increase of ecosystem functional diversity and redundancy and capacity to cope with disturbances in future.

Innovation in Michamvi social system is explained by diversity of functional actor groups, institutions and diversity of livelihood activities. The results from this study indicated that informal management arrangements for Vijichuni mangrove recognises the involvement and linkage of different actors and institutions in governing the mangrove especially at a village scale and therefore promotes functional diversity and redundancy of the management system. In this system villagers reported experiencing good social relationships and synergy among the society members with high levels of trust and a low level of conflicts. However, villagers claimed that high social unity has been to a large extent the result of community initiatives on active mangrove management and society development in the absence of direct involvement of stakeholders at international and national scales.

On the other hand despite the diversity of actors and institutions involved in the management of Kinani mangrove villagers reported that there was a low level of coordination within societal members presumed to participate in management activities because they have been discouraged by the prevailing management system. Similarly, villagers experienced very low and irregular levels of activity and coordination between government and local communities because government activity is strongly influenced by the availability of resources. In the same way the study found weak linkages between higher scale stakeholders and lower scale stakeholders associated with the improvement of reliable livelihood opportunities that reduced the level of dependence on mangrove resources in the village.

6.5.1 Livelihood activities in Michamvi social system

Michamvi Shehia social system is characterised by a high diversity of economic activities; most of them being developed by residents themselves with a minimum of support from stakeholders at higher scales. This study found that most Michamvi livelihood activities were independent of direct harvesting of mangrove wood provisioning ecosystem service. The observed kinds of livelihoods represented an important social innovation that provided Michamvi society with a new way of survival that increased the capacity of the community to cope and continue to exist without direct extraction of mangrove wood products. The results from household interviews indicated that among several livelihood members, fishing followed by tourism were the main economic activities engaged in by a majority of Michamvi residents. Table 21 indicates the diversity of economic activities by gender (based on agreements from FGDs) with their corresponding monthly income to the Michamvi social system. The variation of level of participation on different livelihood activities by different gender is grouped as F = female activity, M = male activity, B = both gender in relatively equal proportion, BM = both gender with more male participants, BF = both gender with more female participants.

Michamvi is traditionally a fishing community and fishing was the main income earning activity for 80% of the households. Villagers reported that it is common practice in Michamvi for both men and women members of the household to engage in fishing of two different types. The first type of fishing is practiced in deep sea by using fishing boats which represents about 60% of the total fishing activities in the village. Deep sea fishing is a male activity and is conducted in order to sell marine products to generate income to meet household needs. The remaining 40% of fishing involved the collection of cockles and octopus conducted in shallow water and in the mangrove areas by women and children.

Table 21 Livelihood activities in Michamvi social system

Livelihood activities	Gender	Number of respondents (Sample size)	Percentage of respondents	Monthly average household income (TSHS)*
Fishing	BM	32 (40)	80.0	189,375
Non-mangrove Tourism	BM	8 (40)	20	131,153
Ecotourism	M	18 (40)	45	182,220
Agriculture	BM	25 (40)	62.5	95,200
Seaweed farming	BF	12 (40)	30	18,892
Hotel food supplier	M	10 (40)	25.0	120,000
Crab collector	BF	10 (40)	25.0	146,628
Small-scale enterprises	BF	7 (40)	17.5	96,428
Drivers	M	6 (40)	15.0	170,000
Restaurant and Guest house owners	M	6 (40)	15.0	405,000
Beekeeping	M	1 (40)	2.5	45,000
Irregular mangrove harvesting	M	1 (40)	2.5	47,500
Non tourism-related employment	B	1 (40)	2.5	250,000

*1 GBP (£) ~ 2,500TSHS at the time of this study. *Source: Michamvi household interview, 2013*

Tourism (both mangrove and non-mangrove tourism) was the second most important activity in Michamvi with 65% of households engaged in this activity. Consensus from FGDs and KIIs confirmed that the development of the tourism industry in Michamvi has created part time employment for Michamvi residents and market opportunities for their products. Young male Michamvi residents were more engaged in tourism than females. The most common type of these part-time tourism related jobs engaged in by most male Michamvi residents include masonry work during hotel construction and maintenance and hotel boat tourist captain. Other activities engaged by males and few females were low-skilled low-wage posts such as hotel cleaners and gardeners. Villagers reported that one of the important contributions of tourism industry development in Michamvi is through provision of local market opportunities for trading their locally-made products. Such enterprises included selling fish at a good market price, trading of cooked food (*Maandazi*, breads, chips, etc.) by females around their homes and running tourist gift shops. Tourism market availability has allowed Michamvi communities to engage in mangrove ecotourism that trades the good aesthetic value of Vijichuni mangrove to create employment for male individuals and provides society with income. For example, the local community in Kae village have entered into a special contract with a tourist hotel to use their mangrove as a camping site for their visitors (see section 6.3.4.2).

In addition results from household interviews indicated that the development of tourism has resulted in other tourist-related livelihood activities for Michamvi residents (Table 21) such as hotel suppliers for food and marine products, car drivers, owners of local guest houses and development of small-scale enterprises in the village. Rope making, livestock keeping, local herbalists and carpenters are the common small-scale enterprises that were reported to be engaged in by Michamvi residents. Some of the developed small-scale enterprises have been achieved with support and advice from government and NGOs such as WEZA and JECA in collaboration with village associations. For example, results from wealth ranking studies indicated that about 198 of Michamvi residents have been engaged in seven savings and credit groups run by JOCDO, out of them 78.8% of the members were women. FGD discussion with members of these groups indicated that they used the saved money to support the small-scale enterprises indicated above.

Apart from the individual tourism related benefits Michamvi communities reported that they had entered into good relationships with some hotel investors who supported Michamvi community development activities (e.g. water supply in the village), arranged community tour guides and provided financial or material support to resolve emergency issues in the village.

Despite these direct economic benefits some village elders perceived that tourism did not contribute significantly to the village economy, nor did it provide permanent employment to Michamvi residents and may well cause long term, negative cultural and environmental effects in the village.

Parallel to tourism, agriculture in coral rag areas was found to be another important livelihood activity in Michamvi (Table 21). FGD discussions with the VCC indicated that most of the crops produced in the traditional shifting cultivation are for subsistence uses with the exception of maize that is sold in form of barbecue cubes at the village when farmers get a good harvest. However, with the presence of tourism market opportunities farmers started to shift from production of food crops only to production of crops that can fetch a good market value at tourist hotels. In this context there are significant numbers of local communities who have been engaged in planting permanent crops for commercial purposes. Such farming includes planting *Casuarina equisetifolia* (*mivinje*) trees to provide building materials for tourist hotel construction, and planting of *Citrus aurantifolia* (*midimu*) and *Mangifera indica* (*miembe*) trees in their farms. Other activities which were performed by a small proportion of Michamvi households include seaweed farming, beekeeping, and subsistence harvesting of terrestrial forest.

6.5.2 Mangrove dependence and household income contribution by wealth status in Michamvi

About 85% of interviewed Michamvi residents depended upon three to five sources of income and only 15% of the community had just one to two income sources. These activities have been found to give an average monthly income of 560,000TSHS per household in Michamvi. Among the common livelihood activities, other non-mangrove income contributes 59% of the household income (Figure 21). Among the non-mangrove income related activities fishing contributed 33.8% of total household income while agriculture contributed only 17.0% of the total income despite the relatively large number of people engaged in that activity.

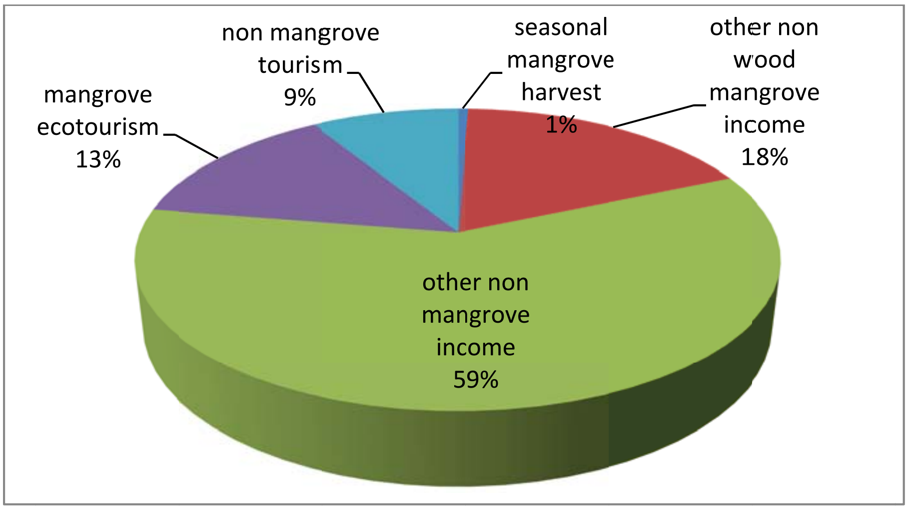


Figure 21 Percentage monthly income contributions by livelihood activity in Michamvi

Despite the greater exploitation of Kinani mangrove compared to Vijichuni, cutting of mangrove for wood provisioning services was done at a low rate by the people from both villages in Michamvi. Seasonal wood harvesting – for susbsistence needs of poles and boat construction materials (*mataruma*) together with a low level of harvesting logs for sale to tourist hotels contributed only 1% to the average monthly household income which indicated low dependence on these services to the villagers. On the other hand non-wood mangrove provisioning ecosystem servies (beekeeping and crab collection) and tourism were found to make significant contributions to household income in Michamvi society (Figure 21).

Analysis of the contribution of wood mangrove ecosystem services to an average monthly household income by wealth status of the households indicated that mangrove income from wood harvesting makes a small contribution to the poor households only. However income from all mangrove ecosystem services engaged by Michamvi residents is of importance to all wealth groups in the society (Table 22).

Table 22 Average monthly household mangrove income by wealth groups in Michamvi Shehia

Wealth groups	Sample size	Average monthly household income (TSHS)	Average income contribution from wood harvesting (%)	Average monthly income from mangrove ecosystem services (TSHS)	Average monthly income contribution from all mangrove ecosystem services (%)
Richest	6	1,188,333	0	17,824	1.5
Rich	7	727,857	0	11,645	1.6
Poor	23	433,695	1.4	32,960	7.6
Poorest	4	135,000	0	1, 255	9.3

NB all ecosystem services = include incomes from wood harvesting, crabs, beekeeping and ecotourism. *Source: this study.*

Poorest households received a lower mean monthly income from the mangrove forests than the other wealth groups, but mangrove income made a relatively larger contribution to the total household incomes of the poorest households in Michamvi.

6.6. Continuity of Michamvi mangrove social ecological system

Continuity of mangrove stands in Michamvi is enhanced by the presence of sufficient amounts of small changing variables that enable system re-organisation after disturbance (see section 3.2.1 and Pete case in section 5.6). In Michamvi four variables have been used as indicators of small changing variables that enhance the continuous supply of diverse ecosystem services desired by the community. In particular, the high number of seedlings/ha in Michamvi mangrove ecosystem provides an important indicator of the ability of the mangrove to re-organise. Conservation of degraded mangrove patches will create favourable growth conditions for natural colonisation of mangrove propagules and therefore promote the continuity of the ecosystem. Similarly, the observed high density of mature plants provides the capacity to produce sufficient numbers of propagules to re-generate the mangrove ecosystem following natural or artificial disturbance. The observed low rate of selective harvesting in Vijichuni mangrove system has created small gaps in tree coverage that would encourage regeneration of mangrove trees and therefore ensure continuity of the mangrove ecosystem after cutting. However, the observed excessive cutting of Kinani mangrove has created large open patches with a large number of stumps which threatens the capacity of Kinani to re-organise after disturbances.

Social continuity is enhanced by the presence of small changing social variables such as social memory that will remain to continue the system after disturbance. In Michamvi villagers felt that the continuity of Michamvi social system was enhanced by presence of their strong informal institutions that recognised and encouraged linkages between actors at the village scale and minimum participation of the higher scale stakeholders. This kind relationship increased harmony, synergies and trust and allowed sharing of cultural practices and knowledge among the village members. Under this institution village youth reported that the elders' mangrove knowledge gained from their parents and experiences is communicated to village youth and other society members through village meetings, stories between elders and their family members or when young people participate in harvesting, planting or management activities. Knowledge transfer was also reported to be achieved through stories among peers and through public talks in mosques done by Islamic leaders during Friday prayers. Other formalised method of knowledge sharing provided by stakeholders at higher scales are the same as in the Pete case study (section 5.6). Villagers also noted that the continuity will be enhanced by the presence of institutional supports for development of viable alternative livelihood activities independent of direct cutting of mangrove wood products. This social unity and cultural behaviour of not depending on mangroves has enabled the community members to diversify their livelihood activities with minimum government support from DFNRNR which ensured continuity of the SES. For example, the availability of diverse livelihood activities, especially the development of the tourism industry in Michamvi which do not involve direct cutting of mangrove wood in the mangrove ecosystem has helped to reduce the level of dependence on Vijichuni mangrove provisioning services and therefore ensure the continuity of the system. The availability of reliable alternative income sources was found to promote continuity of the system in a situation where the mangrove provisioning services are not available, especially good qualities building poles. The available livelihoods generate economic return that allowed Michamvi communities to cope and adapt to purchase different building poles from alternative sources such as from *Casuarina* trees or towns and therefore ensure the supply of the desired ecosystem to the stakeholders.

6.7 Villagers' perspectives of resilience indicators of Michamvi mangrove SES

Michamvi villagers developed resilient mangrove ecological and social indicators that explain the qualitative characteristics of desired state of resilient mangrove SES across all variables that maintain the identity of the system. These indicators were developed using the approach described in section 3.8). Table 23 provides consensus and some differences on views of the majority of the contacted VCC, village elders, Islamic leaders, and mangrove ecosystem users on simple and practical resilience indicators describing the qualitative characteristics of the desired resilient system with corresponding interpretations based on the defined and presented mangrove social ecological variables that define identity of the mangrove SES. Note that categories (variables) in first two columns and last column in Table 23 were presented by researcher and interpreted according to the most frequenty cited literature, while variables in column three were the results of a participatory process.

Table 23 Local stakeholders' views on resilience mangrove SES indicators of Michamvi mangrove

Mangrove SES attributes	resilience variables	Villagers' views on indicators for desired resilient system	interpretations on the desired mangrove SES
Mangrove structure	Mangrove area/cover	-Village elders viewed that resilient mangrove forests should increase in areas to cover the open areas which will provide natural appearance of the mangrove forests -Village Sheha and VCC stressed the area can be the same but should be full of tree cover.	Mangrove should increase in area and has closely and intensively covered mangrove trees to provide natural features of the ecosystem.
	Mangrove tree species diversity	-Village elders and VVC viewed that their mangrove should have many mangrove tree species to provide attractive nature along the beach. -A few VCC members required that mangrove should have common tree species that identify the forest.	Mangrove ecosystem will be resilient if it would have a good proportion of keystone species that define the ecosystem while other respondents required that resilient mangrove should have diverse mangrove tree species.
	Average tree density/ha	-Village elders and youth agreed that mangrove needs to have as many mature trees (*miti iliyopea*) as possible to produce enough seedlings (*mbegu*), sufficient wood related products when needed. -VCC member require mangrove with mixture of trees size building poles, other products and protects coastal areas and their houses from strong winds.	Mangrove system has sufficient good number of mature trees to produce enough propagules, produce desirable mangrove wood ecosystem system when needed balance the supply of other supportive ecosystem services.
	Dominant tree sizes	VCC members felt that the forest should be covered well by trees of all sizes that will be able to provide all benefits when needed.	Resilient mangrove will have intensive covered trees of all sizes that will be able to balance the supply diverse supply of ecosystem services when needed
Mangrove function	Appropriate mangrove ecosystem services / amount of wood to be removed	-Islamic leaders and VCC members felt that their mangrove should be protected for future generations and if used should be for non-wood benefits. -Village elders and youth members engaged in conservation stressed that the extraction of mangrove wood products should be only used after permission has been granted by the villagers for selective cutting for poles for subsistence needs	Michamvi villagers stressed the need of having low dependence on wood provisioning ecosystem services while increase uses and dependence on non-extractive ecosystem services. They felt that resilient society encourage uses that strengthen conservation while discouraging the uses that might have greater changes in the ecosystem. In a situation where

		only. Mangrove charcoal and lime making should be completely banned.	harvesting is necessary the rate of cutting of mangrove wood should be very low to meet the emergency subsistence village needs.
Interaction	Plant-animal interaction	Not clearly understood by the respondents	Diverse plant-animal interactions are found in the ecosystem. However local communities were not able to recognise them.
Innovation	Planting/natural colonisation	-Village elders agreed that planting should be done in degraded areas to increase area covered with more mangrove trees in open areas (*kuuhuisha*) - Other respondents were not clear on the whole idea. -Villagers views on diversity of species is the same as indicated above.	Villagers also viewed that their mangrove requires full protection especially those areas used for ecotourism, beekeeping and dominated with young plants and mangrove planting in seriously degraded areas.
Continuity	seedlings/ha	-Village elders agreed that mangrove forest should have enough seedlings (*mbegu/ miche*) that can be used for planting) to ensure mangrove cover more large areas in future. -Some Islamic leaders required that mangrove should be left untouched so that the some new mangrove re-growth (*machipukizi*) will appear and cover the forest.	Resilient mangrove has large number of seedlings and saplings to re-generate the system after disturbances.
Social structure	Diversity of stakeholders, relationship and their interests	-VCC viewed that Government will allow active participation of local scale stakeholders in decision making and resource sharing on mangrove management system. -Village elders and other VCC required that there should be a harmonious relationship, union among society members and government staff and a low level of conflicts.	Resilient system should encourage linkages and active participation of different stakeholders from different scales.
	Knowledge systems	-VCC consider the importance of communities’ knowledge together with the modern knowledge to be included in the management of the mangrove. -Village elders and Islamic leaders viewed that the knowledge they have is sufficient to sustainably manage the mangrove.	Stakeholders should have diverse mangrove knowledge systems and incorporated in the management system.

	Knowledge sources	-Village young required that the mangrove management need to incorporate knowledge from different sources especially from higher government institutions. -Village elders and Islamic leaders felt that knowledge from the local people should be more considered than the modern because the villagers are more familiar to their environment.	Resilience system should consider the importance of mangrove knowledge from multiple sources.
Social interactions	Management institutions	-Village elders and VCC required that the sustainable management will be achieved through the presence of strong village committee in the village whose members have full village control and decision on the uses and management of the resources. -Village youth and VCC members required that the Government should actively participate and collaborate with locals management system to provide sufficient resources for patrolling their mangroves.	Efficient management will be achieved through active presence of strong local organisations that that actively participate on decision making. Villagers suggested that efficient management system allow active participation of all stakeholders and ensures continuous resources availability for regular implementation of their agreement with local communities.
Innovations	Economic options	-VCC, Islamic and village elders required that the majority of the village residents close to mangrove forest have diverse income capital that are capable of meeting the basic household needs not directly depending on to the large extent the harvesting of mangrove wood. -Village elders stressed the resilience of society will also have the alternative income independent of fishing because of high dependence by people.	Resilient community will have diversified income sources that would give direct benefits to individuals and capable of removing majority of local people from depending on direct cutting of mangrove plants. This will be achieved if the society has the capacity to switch and adapt into new economic activities in the face of decline the availability of wood provisioning ecosystem services.
Continuity	Mechanism for knowledge storage and sharing	-Village elders and VCC felt that the society should have local elders and other people with knowledge on mangrove (Islamic leaders, conservation groups) who are willing and encouraged to share their knowledge to other village members. -The Islamic leaders stressed that they should be formally recognised and given incentive to participate on knowledge transfer in the society.	Resilient system should have a mechanism of knowledge sharing and transfer so that the society has sufficient knowledge on the value of the resources. The use of Islamic leaders to advocate Islamic laws that promote conservation of forest resources should be part of the other methods for knowledge sharing.

6.8 Changes in Michamvi mangrove SES

Michamvi mangrove SES has undergone various changes over a period of time. There is no specific, detailed and systematic social ecological study that had been conducted in Michamvi in the past. However, villagers were very familiar with their society and relationship to the surrounding resources and claim to remember the time of major events, and the changes that have taken place in the system. In this case using the village elders' knowledge and other village members together with general information available in Chwaka bay studies and other sources, an account of changes that Michamvi mangrove SES has undergone is presented reflecting three different time periods from the 1920s. Some of these changes differ between Kinani and Vijichuni mangrove forests.

Resources rich era 1920s to late 1980s

During colonial era in 1920s – Consensus from FGD with village elders indicated that in this period Michamvi was considered by village outsiders to be a very remote village. This contributed to the village having a low population despite the presence of the main road since the 1920s. This situation resulted a minimum socio-cultural interaction with outsiders which contributed to bringing out a strongly united society that was strictly bonded with their cultural habits, norms and values governed by traditions and Islamic beliefs.

The Shehia was endowed with marine and diverse natural vegetation cover of coral rag including large patches of high terrestrial forests, coconut dominated forests along the coasts, and mangroves (Finnie, 1997a). FGD with village elders confirmed that based on the culture and traditions of Michamvi residents they were not dependent on forests as their main income source. Villagers presented the view that from the colonial times to the mid-1980s farming was the main livelihood activity for the majority of residents who were mainly engaged in intensive growing of drought resistant crops through shifting cultivation in the coral rag areas. Among the diverse types of crops raised, millet was the most successful food crop in the villages. Other crops included sorghum, tall bulrush millet (*uwele*), maize (*mahindi*), green gram (*chooko*), and pigeon peas (*mbaazi)* which allowed the people to attain a high level of food security. Other livelihood activities for Michamvi residents were fishing, stone extraction and lime making for home construction. One village elder stressed that the availability of terrestrial forests allowed Michamvi residents to meet their diverse subsistence needs of fire wood and building materials in the village.

Between the 1930s and 1945 some Michamvi mangrove in the Kinani mangrove area was used as a trade commodity by the colonial companies for commercial bark extraction and pole harvesting for export (section 4.8.2). Although the total Michamvi mangrove area involved in this intervention is not clearly known, a total of 600ha of Kinani (part of Michamvi) and Ukongoroni mangrove forest was selected as commercially important areas for bark extraction (Griffith, 1950). Villagers reported that Michamvi residents harvested mangroves from Kinani to meet their household needs for poles for house construction and a few people were engaged in selling mangrove poles and bark in Chwaka market, especially in the season when they experienced a decline of agriculture production and fish earnings. On the other hand Vijichuni mangrove was only used to meet the seasonal small-scale wood related needs for Michamvi Kae people only.

Village elders FGD reported that despite the wide use of mangrove there was no formal management of forest resources in Michamvi between 1930s and 1947 and all forest resources were considered to be village property managed traditionally by Michamvi residents. However, Kinani and Vijichuni mangroves were governed by two different forms of traditional management. Whilst Kinani mangrove forest was managed under a joint traditional management of opening and closing harvesting system involving all villagers around the bay the same as reported for Charawe (see section 4.8.2 and 7.8), Vijichuni mangrove was managed traditionally by Michamvi Kae residents only without following opening and closing approach operated in the bay. Results from village elders FGD and KIIs indicated that Vijichuni mangrove was managed under full ownership and control by a strong informal local organisation made by village elders with their informal institutions (village by-laws and agreements) in the form of cultural practices and traditions that influenced the way that they managed the Vijichuni Mangrove. Michamvi residents felt that they have legal rights to own and manage the mangrove resources because they had planted them and were confident that their management approach was recognised and respected by the Government; a condition which has lasted until recently. To verify this one of the old men during FGD narrated that:

"During the colonial time some of the council leaders (*Mudiri*) showed an interest to take Vijichuni mangrove and put in the joint traditional system of opening and closing but without success because the idea was rejected by the Michamvi elders and others in our village"

There was consensus from all respondents confirmed that between the 1930s and 1947 Kinani mangrove was an intensively covered mangrove stand while Vijichuni was less densely covered with large open sand patches. According to the Adaptive Cycle Kinani mangrove was intact under conservation phase characterised by high storage of natural capital. In this period villagers reported that their mangroves were densely populated and dominated by thicker diameter mangrove trees suitable for pole production. On the other hand, Vijichuni mangrove was under the re-organisation phase, gradually changing and flourished toward the conservation (K) phase. According to village elders mangrove planting and conservation of the open area was the main management practices done by the local elders from Kae village. Villagers were committed in mangrove planting to protect the village from strong waves and winds and meet the village wood demand. Small patches were planted regularly overtime using the seedlings/propagules from mangrove around the bay together with other incoming propagules that colonised the area through natural colonisation process until the forest reached maturity around 1976.

In 1947 – the beginning of formal management arrangement for Zanzibar forest resources denied Michamvi residents full ownership of the Kinani mangrove but provided legal user rights on the uses of ecosystem services through an 'open and closed' harvesting system (see section 4.8.2, Charawe case). However, villagers realised that this management declaration has had limited influence on Vijichuni mangrove which continued to be managed by Michamvi Kae residents while Kinani was managed under a joint management council system. The mangrove resource was large and plentiful, the level of utilization was relatively low and the availability of quality poles remained high and benefited the wider community (Williams, 1998). Chwaka bay mangrove was then under traditional management by local councils made by selected Chwaka bay village members (slightly formalised by colonial administration) from 1947 until when the mangrove became forest reserves in 1965 (ibid, 1998).

After Zanzibar independence, in 1964, the Government declared that all mangroves were forest reserves where the management of Kinani continued be managed by the Government through an alternating 'open and closed' harvesting season (section as 4.8.2). Villagers reported that although this declaration gave them legal rights to extract poles under permit control but it denied them ownership and decision making rights on Kinani mangrove and reduced village resources under their jurisdiction. However, this government decision had no influence on Vijichuni mangrove which continued to be managed traditionally by Michamvi Kae people. Zanzibar gained independence from British in late 1963 which marked a collapse of commercial exploitation of mangrove for pole and bark following the collapse of British colonial power in the Islands. This situation perceived by Michamvi villagers had created a condition that gave enough time for Chwaka bay mangroves to self-organise and flourish towards a conservation phase.

A period of Zanzibar economic reform influenced by the World Bank and other donor agencies in the 1980s, (4.8.2) marked a time of the commencement of economic diversification for Michamvi residents. Consensus from FGD with village leaders revealed that in this period significant numbers of Michamvi fishermen received credit and loan facilities and modern fishing gear and outboard engines following the government intervention to conserve fish resources in Chwaka bay. The reform also coincided with the introduction of the tourist industry into Michamvi in the late 1980s (Zanzibar Tourism Policy, 2006) together with other new economic innovations especially seaweed farming which was introduced to Zanzibar in 1988. These interventions provided incentives that attracted the majority of Michamvi residents to engage in these new income generating activities. Thus villagers reported that between 1986 and the end of 1980s the majority of Michamvi residents shifted from depending on agriculture to seaweed farming (for women) and fishing for men as their main livelihood activities. Low agriculture productivity associated with high labour forces required in traditional farming, discouraged Michamvi to continue with intensive farming. However, villagers noted that although there were few tourist investors in the village, local people were not engaged in allied activities and therefore unable to exploit benefit from the trade.

Respondents from FGDs confirmed that up to 1976 vegetation cover of Vijichuni mangrove greatly increased which together with Kinani mangrove were in desirable state for exploitation by the community. According to the Adaptive Cycle both Kinani mangrove and Vijichuni mangrove were in the Conservation phase (K) as described above. During this time period Chwaka bay mangrove had 9 mangrove species (Leskinen *et al.,* 1997) with *R. mucronata* as the most abundant mangrove tree species (Shunula and Whittick, 1999). Despite the intensive coverage of mangrove, FDG with village elders confirmed that because of the availability of other village resources Michamvi people had very low dependence on commercial exploitation of mangrove products and few people were selectively harvesting mangrove for provisioning services of good quality mangrove poles for subsistence needs. Other mangrove provisioning ecosystem services benefited Michamvi residents were collection of dried mangrove pieces/branches for firewood, abundant availability of large-sized mangrove fish species, diversity of edible crabs and collection of octopus which was exclusively done by women.

Kinani mangrove persisted at this maturity stage up to early 1990s while Vijichuni changed rapidly in early 1977.

Resource restriction and degradation era – late 1980s to early 2000s

Between the late 1980's and early 2000's - Michamvi social system experienced a rapid population increase from 501 individuals in 1988 to 1,120 individuals in 2002 (section 4.5). The increase of population pressure as reported by villagers increased dependence on the fisheries resources which shifted majority of Michamvi residents to the use of destructive fishing gears and techniques in the bay. Fishing using destructive fishing gear (dynamite fishing and sandeel seine/dragnets of small hole sizes) and dragging techniques considered to be destructive, created serious conflicts and contributed to the decline of the total fish catches in the bay in the 1990's (Jiddawi and Ohman, 2002). Consequently in 1996, the Government took measures to address this situation by imposing a fishing ban to restrict harvesting of marine resources in Chwaka bay (De la Torre-Castro and Lyimo, 2012; Interview with village Sheha). This situation resulted in serious economic hardship for Michamvi residents who depended greatly on fishing for their livelihood (Jiddawi, 1997).

This management action corresponded during a period when donor-funded projects in collaboration with DFNRNR made remarkable influence on policy and legislative changes occurred in the Forest sector between 1996 to 2003 (section 4.8.2). Changes on forest management regime from the State to CBNRM in 1996 marked a period of forest management regime shift for management of terrestrial forests but had little influence on the control of degradation of forest resources. In this period Michamvi residents engaged in CBNRM approach for management of their terrestrial forests by firstly establishing a VCC and draft Resource Use Management Agreement (RUMA) as required by the law (see section 4.8.2; FGD with VCC) and assisting government through mangrove patrolling of Kinani Mangrove. However, Michamvi residents viewed that the formalised CNBRM had put more restrictions on the use and access to forest resources by designating significant village forest areas (Example, forest of Tongoni and Kongoni) that Michamvi residents were using for meeting wood related demand under the full conservation zone (Finnie, 1997a). At the same time villagers reported that the policy changes toward the establishment of JCBCA in 1996 by considering Mapopwe mangrove block alone as a part of the JCBCA which was then raised to National Park status in 2004, left Kinani mangrove under an open access management option of low priority that increased vulnerability to excessive cutting of wood provisioning services. Consequently the majority of the bay population was engaged in excessive mangrove cutting in Kinani mangrove block in order to meet their daily needs (FGD with village elders).

Government measures to reduce cutting pressure within the bay were to be achieved by collapsing management approach of alternative harvesting between Kinani and Mapopwe mangrove in 2000 (Ely *et al.*, 2000**).** However, this government intervention corresponded with the period when there were limited government resources to enforce these government laws (Madeweya *et al.*, 2002) and therefore they failed to achieve their intended objectives. Consensus from FGD with VCC confirmed that despite the development of diverse rules and regulations governing the mangrove, Michamvi residents were discouraged from continuing to conserve their Kinani mangrove forests because of the limited incentive to conserve them. Under the limited resources the Government was unable to carry out regular field patrols with communities, regular training, and provision of patrolling tools and facilities that acted as incentives for the local communities to participate on management. Instead, Michamvi residents were attracted to harvest mangrove wood after their fellow villagers around the bay engaged in cutting mangroves before them from 1996 to early 2000's.

According to the Adaptive Cycle concept in this period, Kinani mangrove ecosystem gradually moved into the collapse phase (Ω phase) of the Adaptive Cycle characterised by the loss of natural capital through cutting of mangrove wood for excessive supply of provisioning ecosystem services. Michamvi villagers reported that they observed several changes in this phase. In particular change in ecosystem services from provision of building poles only to intensive cutting of mature mother plants which were sold to the tourist hotels for making outdoor resting chairs. The mangrove was also harvested for production of sawn timber for furniture making or use for charcoal and firewood by village outsiders. They also experienced an increased number of mangrove harvesters from the Michamvi community whose majority had stopped from cutting mangrove in the early 2000's. A high number of mangrove harvesters were also observed from neighbouring villages who were reported to continue cutting Kinani mangrove up to the time of this study (see section 6.3.4.1). There was a change in species dominance for all Chwaka bay mangroves from *R. mucronata* dominated mangrove stands (Shunula and Whittick 1999) to *C. tagal* mangrove dominated mangrove stand (Jumah *et al.*, 2001) during this period.

A consensus from all FGDs and KIIs indicated that Vijichuni mangrove was intensively cut by Michamvi Kae residents much earlier than Kinani in 1977. This period of wood extraction followed government attempts to claim the ownership and control of Vijichuni forest, a situation which was not supported by locals. To seek revenge against the government decision Michamvi Kae residents decided to clear-cut a portion of Vijichuni mangrove which seriously reduced vegetation in the mangrove system.

According to the Adaptive Cycle excessive cutting of Vijichuni forest caused rapid changes in the ecosystem that moved it into collapse (Ω phase)/creative destruction phase of Adaptive Cycle (Figure 2) characterised by a loss of the systems natural capital. Villagers reported experiencing changes in ecosystem services from selective cutting of poles for subsistence needs to intensively cut for lime production, timber for furniture sawn for making bed frames and boat making structures for both home and for selling purposes by Michamvi residents. They also observed large numbers of mangrove harvesters from Michamvi Kae village. However, this disturbance occurred over a short time and local communities decided to close the ecosystem from intensive cutting for wood provisioning ecosystem service while replanting to regenerate the system (FDG with village elders).

Prosperous era 2003 - 2013

Consensus from all FGDs and KIIs indicated that Michamvi experienced massive development of tourism industry from the beginning of 2000 decade where large number of tourist investors engaged in a large-scale expansion and construction of tourist hotels in the Shehia. This development was simultaneously carried out with the improvement of other facilities and infrastructure such as electricity and road connections which was upgraded to tarmac level in 2003. VCC members confirmed that mass tourism development in their village marked a period of wide-scale accessibility of diversified tourist related alternative livelihood opportunities especially for young Michamvi residents from 2003 to date. They particularly emphasized the fact that tourism has created part-time employment and good market opportunities for selling their marine and agricultural products and consequently shifted the majority of Michamvi residents away from employment of cutting mangroves. Villagers have also benefited through Vijichuni mangrove ecotourism since early 1990. However this idea differs from village elders' opinion who claimed that tourism has had none or little benefit to Michamvi because it does not provide direct permanent employment to the natives but has caused significant social cultural and environmental disruption in the area.

Likewise in 2004, JCBCA, including Mapopwe mangrove blocks, was declared a National Park (RGoZ, 2004a) leaving Kinani under the former management status of forest reserve. The management of both mangrove blocks does not allow harvesting of any wood products following the collapse of 'closing and opening' management system of mangrove harvesting seasons between Kinani and Mapopwe mangrove blocks since in 2000 (Ely *et al.*, 2000). At the same time Michamvi communities were encouraged (through co-management arrangement section 4.8.2) to assist the Government to protect these forests (RGoZ, 1996a). Unfortunately these measures corresponded with the period when there were limited government resources to enforce these government laws and programmes between 2003 and 2006 (KII with government officials). Subsequently, Michamvi VCC and local communities were discouraged to participate in mangrove conservation which served as an incentive for the Michamvi village outsiders to continue cutting mangrove for provisioning services (FGD consensus with VCC).

During MACEMP project time in 2007 – 2010, the project in collaboration with Department of Fishery strictly enforced fishery laws to control illegal fishing gear and practices within Chwaka bay. Discussion with VCC members indicated that this exercise caused limited impact to the livelihood of Michamvi fishermen because most of the small-scale fishers were adopted and engaged in different tourism business in response of these restrictions. A few powerful fishermen adapted to the situation by buying modern fishing vessels that enabled them to fish in deep sea outside the bay. At the same time DFNRNR enforced the ban on harvesting of mangrove products in the bay by stopping permits being issued throughout the islands in 2007. However, this management decision was reported by village elders to have had limited effects on Michamvi peoples' livelihoods since the majority of Michamvi have very little dependence on mangrove wood resources for meeting their livelihood needs.

In the 2010 HIMA in collaboration with CARE and DFNRNR piloted methods for reducing emissions from deforestation and degradation ($REDD^+$) through community forest conservation (section 4.8.2). Although Michamvi is not among the first four $REDD^+$ pilot villages, the village is being considered for wider scale application of this project in common with other villages around JCBNP. To match with the standard requirements of this project a new VCC was formulated and draft COFMA revised and submitted to the Government to include Vijichuni mangrove and part of Kinani mangrove apart from other terrestrial forests (Draft revised COFMA, 2012b). However, the idea of involving Vijichuni mangrove in REDD$^+$ has not been accepted by Michamvi Kae residents who are worried about losing ownership and control over the resources. In 2013 Michamvi also received a small carbon grant of 6,500,000/= (£2,600) from HIMA to support conservation activities, diversify income sources for the special needs groups and support Shehia development activities (Field observation). In addition the HIMA project in collaboration with other NGOs such as JECA and WEZA has established small-scale credit and saving groups to empower local people to manage money more effectively and develop small-scale enterprises that will not be dependent on wood products from the forest (section 6.5.1).

Consensus from all respondents questioned suggests that although these interventions have not been effective in controlling illegal cutting of Kinani mangrove they have further increased the capacity of Michamvi residents to diversify and adopt alternative incomeactivities not related to forests and therefore brought in a more desirable social prosperous state.

According to the Adaptive Cycle concept (Gunderson and Holling, 2002) the current phase of change varies significantly between Kinani and Vijichuni mangrove ecosystems. Kinani mangrove is still in the back-loop of the Adaptive Cycle under release phase (Ω - omega) whereby the system is experiencing excessive and rapid loss of mangrove vegetation through excessive cutting of wood materials mainly by village outsiders (see above). Consensus from FGD and VCC confirmed that they experienced changes on an increased extraction of mangrove wood in Kinani mangrove for the supply of provisioning ecosystem services by the village outsiders while the cutting by Michamvi residents have decreased. They also reported that the decline in mangrove vegetation cover for Kinani mangrove.

These changes were found to cause significant impacts to the Kinani mangrove ecosystem. Villagers reported that the quality of the harvested products has declined and the ecosystem cannot produce poles of desired quality. They also reported they have experienced decline of mangrove associated fish and crabs, and attractive nature of the ecosystem.

On the other hand Vijichuni is currently in the conservation phase (K) of the Adaptive Cycle characterised by high levels of natural capital (high amount of stored nutrients/standing wood volume) which maintain the mangrove structure at the maturity stage (see section 6.2.3). Several changes have been observed in this phase. Specifically, villagers noted domination of large-sized mature plants (70% of the respondents) and an increase in mangrove vegetation cover into the areas where no mangroves had been observed before (agreed by 60% of the respondents). However, some of the villagers reported that some mangrove patches that existed in 1977 had disappeared due to intensive cover of sand close to the beach but these have been compensated for by the high rate of colonisation and planting of mangrove areas which make the total increase of the mangrove area. This findings are supported by other study noted the total Vijichuni mangrove area of 29.2 ha in 2000 (Jumah *et al.,* 2001) to the current reported area of 39.0 ha. The rate of mangrove cutting has declined from 791 stumps/ha (Jumah *et al.,* 2001) to the current rate of 179 stumps per ha while regeneration has increased from 31,500 seedlings/ha (ibid, 2001) to the current rate of 33,117 seedlings/ha.

The observed changes have caused significant impacts on the ecosystem. About 72.5% of the respondents confirmed that the decline in cutting of their mangrove contributed to provision of good scenery and attractive nature of the forest. Fifty percent of the village respondents also said that the high vegetation cover of the mangrove maintained a good diversity of marine organisms in the ecosystem.

Regarding changes in society, 72.5% of household respondents confirmed that there were significant reductions in the number of Michamvi residents depending on mangrove harvesting for their household income. They stressed that the uses of ecosystem services had changed from extractive wood to non-extractive uses as supported by 70% of respondents. Whilst there were no reported changes to the management of Vijichuni mangrove, villagers observed a clear change in the management system of Kinani mangrove from State management, that allowed some uses of mangrove products to the more restrictive management that limited uses of any extractive mangrove wood ecosystem services. However, with no or very limited enforcement of these laws across the spatial scales, the local community perceived that the ecosystem is managed ineffectively as open access with low conservation priority increasing vulnerability and leading to further degradation.

These changes have been caused by different underlying drivers including availability of reliable alternative income activities independent of mangrove cutting (as agreed by 75% of the respondents), the presence of mechanisms for conservation knowledge sharing that have increased awareness in the village (supported by 57.5% of the respondents). Other reported drivers for these changes include the availability of the tourism market and high population growth with high dependence on Kinani mangrove causing significant pressure in the ecosystem. The direct drivers that caused ecological changes in Vijichuni mangroves include increase in planting activities (agreed by 80% of the respondents) and a people's will and culture to conserve the mangroves.

FGD consensus with village elders and youth groups reported the potential drivers that might have future influences in systems. These drivers include some of the current underlying drivers such as high population growth and availability of tourist market, availability of alternatives to wood and other income sources. Another driver reported by villagers was changes in management arrangements for governing mangrove resources. Potential direct drivers for ecological changes reported by villagers include high extraction of mangrove wood products and climate change.

Chapter 7

CHARAWE CASE STUDY

7.1 Charawe context

With a total area of 3,100 ha, Charawe Shehia is located in the central district of Southern region of Unguja at the end of road that runs from Jozani toward the eastern side forming the JCBNP boundary on the east (Figure 22). The Shehia closely borders the southern edge of Chwaka bay to the east of JCBNP to the extent that some of the village land - including Mapopwe mangrove - forms part of the park. Charawe is one of the oldest villages in Unguja and was extremely isolated due to poor road infrastructure up to 2009 when the road was slightly improved. There is no regular public road transport in and out the village despite the recent road improvement and crossing Chwaka bay using small canoes toward Chwaka Shehia is the most common means of transport for Charawe residents.

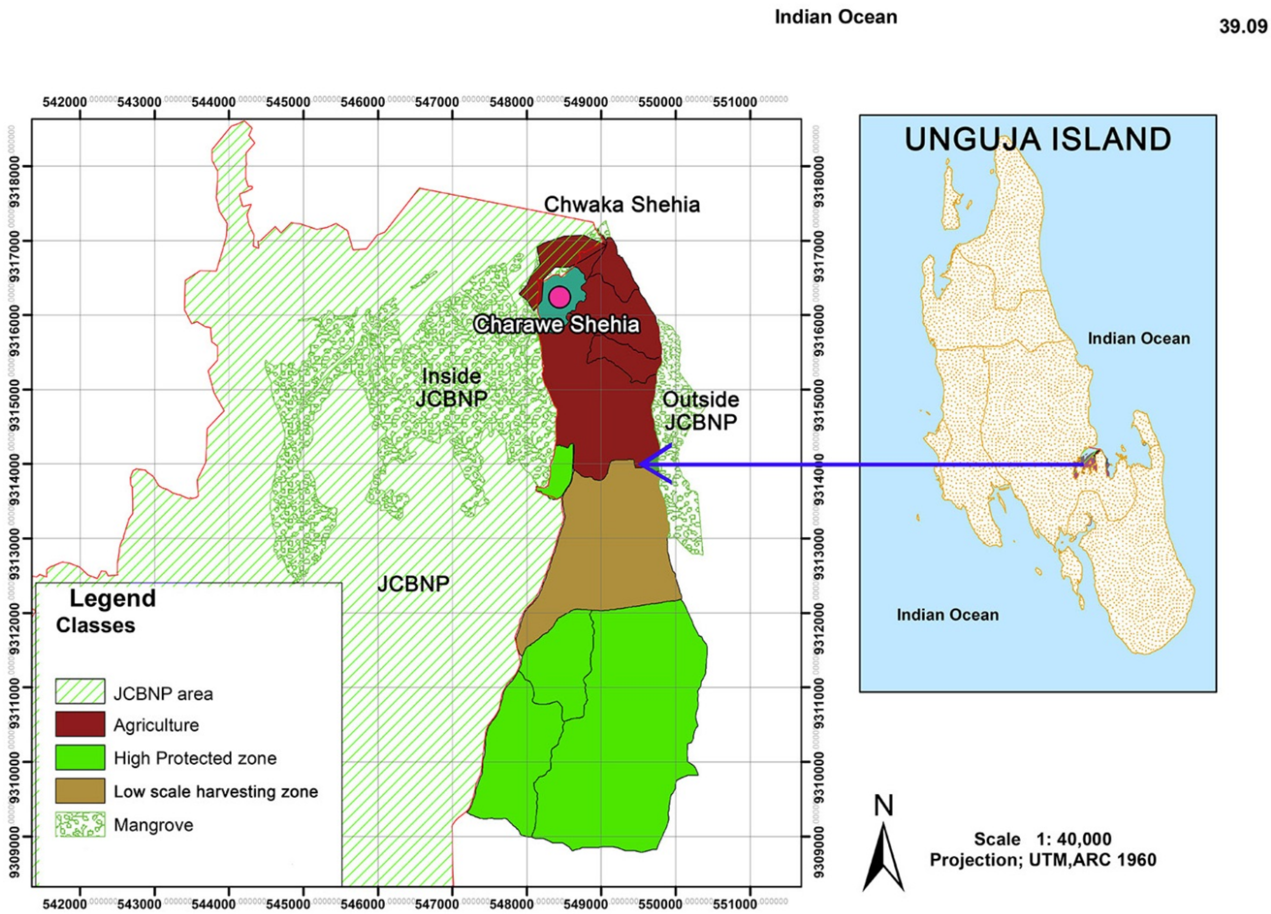


Figure 22 Map of Charawe and land use categories. *Source: Adapted from DFNRNR*

Village land is officially government property. However, Charawe villagers have traditional access to the land to use for farming and harvesting of wood products. There were no reports of land having been sold by villages in Charawe Shehia, unlike Pete and Michamvi Shehias. Most of the village area is covered by coral-rag forests with some patches of bushes with emergent trees and large areas of mangrove forests. Due to its closeness to the park the Government has put Charawe village land under a different land use management plan since 1996 which focuses on control of commercial uses of forest resources. In 2011, a total of 1,180 ha have been allocated under community forest conservation (COFMA) programmes, out of which 809 ha are under full conservation zone status for piloting carbon credit selling projects and 303ha of terrestrial forests have been set aside for low scale harvesting of wood products for subsistence needs (Draft revised COFMA, 2012). About 20.1 hectares have been used for tree woodlots establishment while other village land is being used for farming.

Charawe mangrove forests cover a total area of 866.72 ha, out of which 755.25 ha is mangrove forest within JCBNP (Mapopwe block) and the remaining 111.47 ha is mangrove located outside JCBNP (Kinani block). These two mangrove stands are not only geographically separated by the village, they are also formally managed under different levels of priority especially by the stakeholders at higher scales. These mangroves are managed by the Government either as forest reserves (Kinani mangrove outside JCBNP) or under high conservation status within the JCBNP (Mapopwe mangrove). Communities are encouraged to participate in management of mangrove forests in both locations without any user rights to harvest any wood products. Kinani is considered as a shared forest between Charawe and Ukongoroni village which borders Charawe to the east.

The Shehia has recently experienced restrictions on the uses of fishery resources following government efforts to control the use of illegal fishing techniques within Chwaka bay. The alternative income generating activities not related to forests are limited. The majority of the population (just over 1000 in 2012) have a high dependence on wood cutting, both from terrestrial and mangrove forests. Wood cutting is their primary cash earning activity, while income from fishing is considered as secondary and agriculture is practiced mainly for subsistence. The number of wood cutters has drastically increased with the increase in population. Most of the harvested wood products are sold in the village to traders who are coming to the villagers to buy the products or traded in town in specific wood selling areas.

Some of the harvested mangrove poles pass to Chwaka by sea before they are transported to town.

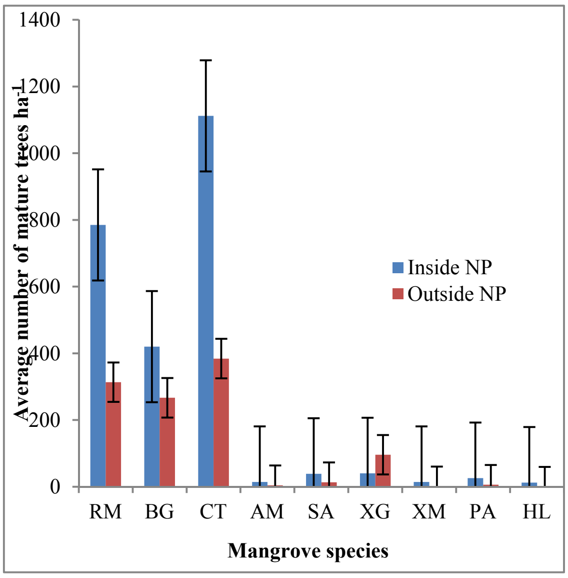
7.2 Current state of Charawe mangroves ecological system

Charawe mangroves, inside and outside National Park, form the major entity that makes up the ecological component of the system. Charawe current mangrove ecological component is described by the mangrove tree species diversity, dominance, tree density, regeneration, tree size distribution , rate of cutting, basal area and standing volume.

7.2.1 Mangrove species diversity, dominance, density and regeneration.

A total of nine mangrove species were found in Charawe mangrove ecosystem. Nine species were identified in mangrove inside JCBNP while eight species were found in mangrove outside JCBNP. *Ceriops tagal, Rhizophora mucronata, Bruguiera gymnorrhiza, Sonneratia alba, Avicennia marina, Xylocarpus granatum, Pemphis acidula* and *Xylocarpus moluccensis* were found in both sites while*, Heritiera littoralis* were recorded in mangrove inside JCBNP only. The species diversity index was 1.3 and 1.4 for the mangrove forest inside and outside JCBNP respectively. Mangrove inside JCBNP was less diverse with only three abundant species as indicated by their respective effective number of species (ENS) value of 3.6. On the other hand mangrove outside JCBNP was more diverse with four abundant species with an ENS value of 4.0.

These mangrove areas were mainly covered by *R. mucronata*, *C. tagal*, and *B. gymnorrhiza*, represented by 94.11% and 79.7% of their relative density for mangrove inside and outside JCBNP respectively (Figure 23). *X. granatum* was the fourth relative abundant species with relative density value of 7.9% in mangrove outside JCBNP only. Thus based on the species importance values (SIV), the dominant mangrove species of Charawe mangrove area inside JCBNP were *Ceriops tagal,* followed by *R. mucronata* and *B. gymnorrhiza (Rhizophoraceae* family*)* with the SIV of 114.4%, 95.5% and 57.8% respectively. The dominant mangrove species in Charawe mangrove area outside JCBNP were *C. tagal, B. gymnorrhiza, R. mucronata,* (*Rhizophoraceae* family) with the SIV of 91.1%, 80.8% and 80.2%, respectively. Other species such as *A. marina, S. Alba P. acidula, and X. moluccensis* were found in very small proportions in both sites and *H. littoralis in* mangrove area inside JCBNP only while *X. granatum* was represented by a range of intermediate proportions in mangrove outside JCBNP. FGD with mangrove harvesters reported the decline on availability of less dominant tree species especially *A. marina* and *X. granatum.*



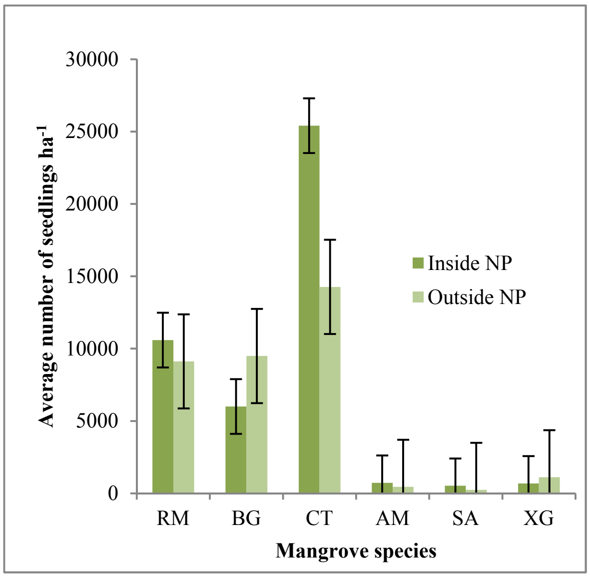


Figure 23 Density of mature mangrove in Charawe **Figure 24 Mangrove seedling density in Charawe**

The average tree density and regeneration varied between mangrove inside and outside JCBNP. Mangrove inside JCBNP has a relatively high number of mature plants and regeneration rates compared to mangrove outside JCBNP. An average standing density of 2,462±424 trees/ha and regeneration rate of 43,932±6235 seedlings/ha were found in this mangrove. In contrast, mangrove outside JCBNP has less than half the density of mature plants and lower seedlings density than that found inside JCBNP with values of 1,084±140 trees/ha and 34,841±5955 seedlings/ha. Figure 23 indicates the average tree density by mangrove species. Despite the relatively lower standing density in mangrove outside JCPNP the forest has a high seedling ratio compared to the mature plants than mangrove inside JCBNP. Regeneration was higher for the most abundant species of *Rhizophoraceae* family in both sites whereas no seedlings were encountered for the least abundant mangrove species such as *P. acidula*, *H. littoralis X. granatum* and *X. moluccensis* (Figure 24).

7.2.2 Size class distribution, basal area and standing volume of the mangrove system

The tree size-class structure showed that mangrove inside JCBNP has a larger proportion of small sized mature plants than mangrove outside JCBNP. Mangrove trees under size-class between 2cm to 5 cm were represented by 76.5% and 65.8% of density of mature trees for mangrove area inside and outside JCBNP respectively (Figure 25). Although inventory data shows a larger proportion of small sized mature mangrove tree inside JCBNP, this forest has a significantly large mangrove area dominated by large sized and taller mangrove mangroves trees (focus group discussion results and personal field observation). However, only a small number of plots were surveyed in the area of larger trees as the villagers concealed it from the survey team because this was the area where charcoal and firewood harvesting was being done.

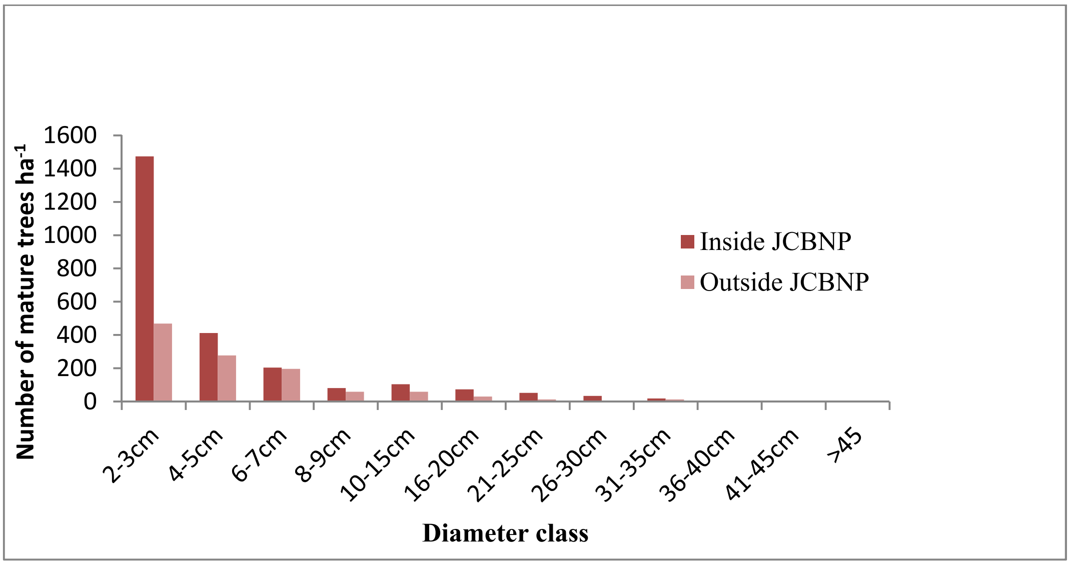


Figure 25 Tree diameter distribution in Charawe mangrove forest

Mangrove of Charawe was found to have an average basal area of $12.82m^2$/ha and $6.85m^2$/ha for mangrove inside and outside JCBNP respectively. Average standing volume for these mangrove areas was found to be $38.09\pm12.9m^3$/ha and $32.54\pm14.68m^3$/ha for mangrove area inside and outside JCBNP respectively. 94.2% of the standing volume in mangrove inside JCBNP has been contributed by the mangrove from *Rhizophoraceae* family. *R. mucronata* has high standing volume contribution of 54.4%, while 28.5% contributed by *C. tagal* and 11.3% by *B. gymnorrhiza*. On the other hand *B. gymnorrhiza* represented 29.2% of the standing volume followed by *R. mucronata* and *C. tagal* that contributed 28.8% and 22% respectively of the average standing volume per ha in mangrove outside JCBNP (Figure 26)

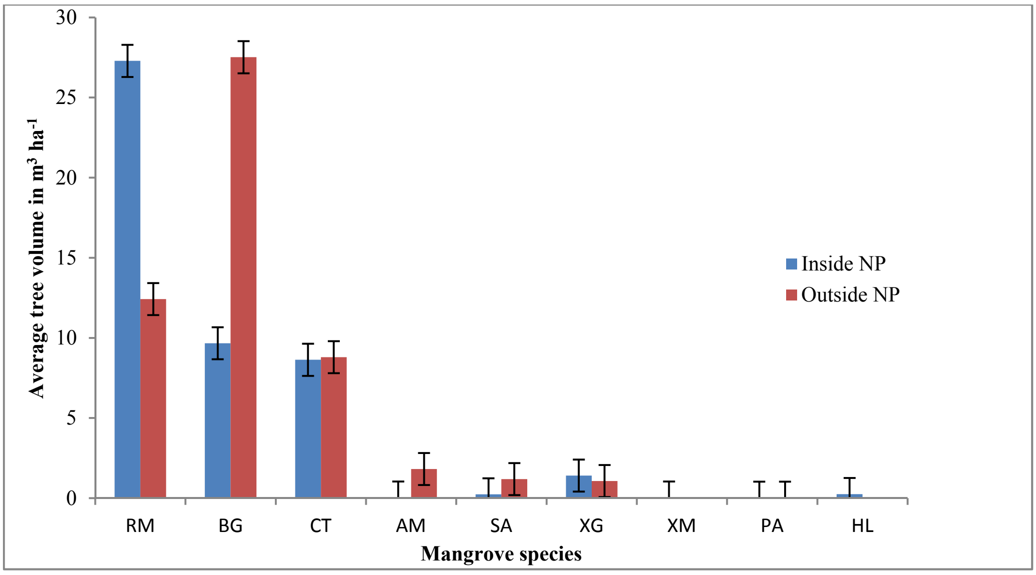


Figure 26 Tree volume in Charawe mangrove forest

7.2.3 Mangrove harvesting in Charawe

Both mangrove areas in Charawe experienced high rate of tree cutting as indicated by an average of 1,052±130 stumps/ha and 1,035±125 stumps per ha for mangrove area inside and outside JCBNP respectively (Figure 27). *C. tagal* is the most cut tree in both locations accounting for 44.5% and 57.1% of their relative stump proportions for mangrove inside and outside JCBNP respectively.

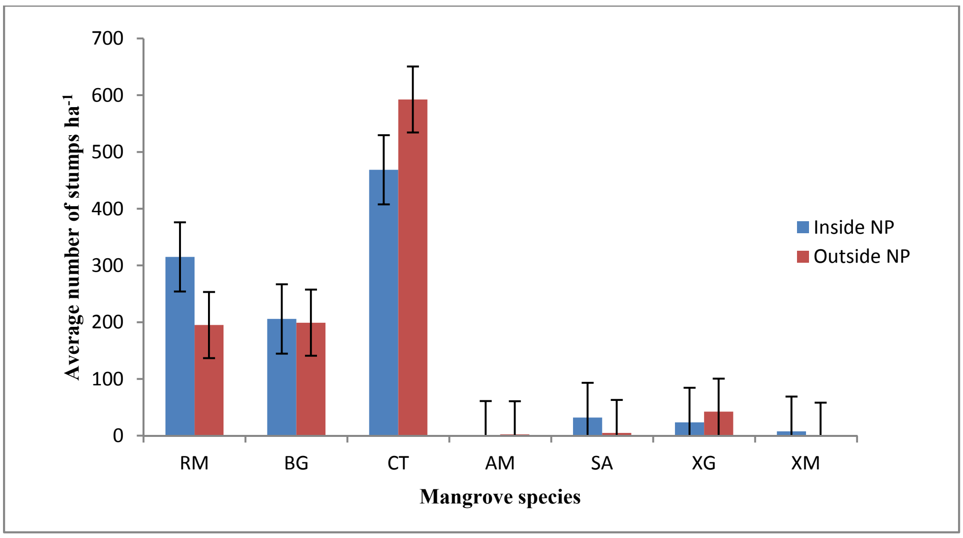


Figure 27 Rate of mangrove tree removal in Charawe mangrove forests

The analysis of density of tree removal by age (Table 24) in relation to its standing density suggests that the current rate of cutting is not sustainable.

Table 24 Density of stumps by age class in Charawe mangrove ecosystem

Stump age	Inside JCBNP		Outside JCBNP	
	Stumps/ha	% of the total	Stumps/ha	% of the total
1 year	1,021	97	1,001	96.7
2-5 years	21	2.0	22	2.1
>5years	10	1.0	12	1.2
Total	1,052		1,035	

Source: Mangrove survey from this study

With the current rate of harvesting (reflected by the density of stumps of one year age) it is likely that the total number of mature plants will be completely removed in the next 3 years for mangrove inside and outside JCBNP respectively which clearly might threatens the resilience of both ecological and social component of the system. In this case the effectiveness of the conservation approach was questioned.

7.3 Current state of Charawe Social System

Charawe village and associated stakeholders form the major entity that make up the current state of the social component of the social system. The Charawe social component is described by a diversity of stakeholders with different levels of knowledge and interests to Charawe mangrove ecosystem services.

7.3.1 Stakeholder's diversity, interests and mangrove ecosystem services

This study found that Charawe social system is composed of stakeholders at local, district national and international scales. The stakeholders at international, national and district scale include international donors and national department staff implementing their programmes in Charawe to achieve their interests in Charawe mangrove. Mangrove stakeholders at international and national scales are the same as those indicated in section 4.8.2 and Pete case study. However, the national stakeholders in Charawe mangrove ecosystem were found to be more concerned with conservation of Mapopwe mangrove ecosystem that forms a part of JCBNP than Kinani mangrove. Other stakeholders at a national scale include transporters and traders of mangrove products, revenue collectors, and urban customers. The presence of a wide range of stakeholders at higher scales together with the stakeholders at village scales (as indicated below) shows the complexity of the society in relation to heterogeneity of interests of different stakeholder in Charawe mangrove ecosystem. Thus the stakeholders in Charawe were further divided based on the location, activities, interests or influence of stakeholders in the system (Table 25). It is important to note that although Charawe mangrove system is under two different management priorities (section 7.1), each stakeholder's interests in the ecosystem services generated by these two sub-systems are the same.

Primary stakeholders in Charawe involved those who have direct dependence on, obtain direct benefits from, or are involved in exploitation of the resources that may be found inside or outside the Shehia.

Table 25 Stakeholders' categories in Charawe social system

	Location		**Activities/interests/influence**	
Scales	Inside the Shehia	Outside the Shehia	Primary	Secondary
Shehia/village	Village residents, e.g. mangrove harvesters, traders, mangrove guards, members of NGOs and committees	Village outsiders from Chwaka, Ukongoroni	Village residents, e.g. mangrove harvesters, members of NGOs VCC, other committees, and village outsiders.	Village residents, e.g. members of local NGOs and VCC and other committees, the whole society
District		District Forest Officer		District Forest Officers
National	Employed JCBNP guards	National department staff and NGO (e.g. WEZA, mangrove traders and transporters	Revenue collectors, town wood traders and transporters	DFNRNR and other government departments
International		International Donors and projects		International Donors and projects

Primary stakeholders at the village scale were composed of household residents together with village outsiders who cut mangrove for provisioning ecosystem services especially firewood, charcoal, building poles and lime production. Beekeepers, local transport agents, traders of mangrove wood products, seaweed farmers, fishers, crab collectors, mangrove guards, and herbalists were primary local stakeholders in Charawe. Villagers also reported other primary stakeholders for Charawe mangroves were some members of committees that followed a standard Shehia formal administration arrangement including VCC, representative members of JECA and JOCDO (see section 4.2). Primary stakeholders above the village scales are provided in Table 25.

Charawe society also comprised of a wide range of secondary stakeholders who either benefited indirectly from the non-provisioning ecosystem services (e.g. coastal protection, climate regulation), were involved in management and conservation activities and/or their activities/decisions have influence on the supply of ecosystem services to primary stakeholders. These stakeholders were located at different spatial scales and may be living inside or outside the Shehia as indicated in Table 25. Field results indicated that Charawe society was composed of stakeholders which, according to their activities or competitive interests, form part of several stakeholders groups, increasing the heterogeneity of interests and complexity of the system. For example the community conservation groups such as VCC were established to address Shehia's interests and conservation on both terrestrial and mangrove forests and development activities in the village (section 4.2). However at the time of this study, the consensus from FGDs indicated that most Charawe VCC members, representative members of village NGOs and most of the villagers have become inactive and lost their incentive to participate in mangrove management and conservation activities in recent years. Instead most of them were found to participate in direct extraction of mangrove wood provisioning ecosystem services from mangrove inside and outside JCBNP despite their legal obligation to protect the mangroves.

7.3.2 Stakeholders' knowledge system in Charawe social system

This different group of stakeholders at local level were found to have different levels of education obtained from different knowledge subsystems. The type and level of formal education for Charawe stakeholders are similar to the level of education in Michamvi with little variations. Household interview results indicated that about 45% and 30% of the household heads have attained primary and secondary level of education, respectively, as their highest level of education attainment in Charawe. A further 20% of the interviewed heads have never attended school, while 5% have acquired college or university knowledge as their highest level of education attainment. Most of these respondents confirmed that they have not acquired forest conservation and management knowledge from their formal education, while only forest biological knowledge was provided on a very limited scale at secondary level of education. However, some Charawe residents have a wealth of scientific biological knowledge on planting of mangrove tree seedlings acquired through village to village study cross visits conducted by DFNRNR staff during 1996 (Finnie, 1997b). Charawe residents have also a wealth of ecological knowledge related to mangrove management and conservation which have been acquired not only from DFNRNR staff but also through oral discussions between elders and youth, experiences and local traditions in the village. For example, the majority of villagers during FGD with elders and village youth claimed that the apparent cutting techniques that involve complete removal of mangrove trees and root extraction have caused significant impact on the reduction of mangrove fish species that were commonly available in the pasts. Most of the mangrove harvesters reported that harvesting of mangrove wood products for charcoal and lime making at the current rate (compared to poles harvesting in the past) is not sustainable practice and might lead to complete degradation of the ecosystem in the near future.

In addition, the residents involved in mangrove harvesting were found to have local knowledge on market chains of different mangrove wood provisioning ecosystem services acquired through observation and participation of people in these activities. For example, the dominant harvesting of mangroves for charcoal and firewood gives indication that mangrove harvesters have clear knowledge on which mangrove wood products acquire good market prices.

7.3.3 Ecosystem services generated from Charawe mangrove ecosystem

Mangroves of Charawe were found to provide a range of ecosystem services to different stakeholders. Consensus from all respondents in Charawe indicated that mangrove harvesting for provisioning ecosystem services for firewood, charcoal, lime and poles were the most important ecosystem services to Charawe local stakeholders. Other mangrove ecosystem services include regulating and supporting functions, while no cultural mangrove ecosystem services were reported as supplied to Charawe stakeholders from Charawe mangrove ecosystem.

7.3.3.1 Provisioning services of mangrove ecosystem

Mangrove forest in Charawe was found to be greatly harvested by local communities for provision of wood material for a variety of uses. Table 26 provides a list of provisioning mangrove ecosystem services used for subsistence and sales by Charawe residents. The results from field observation indicated that mangrove extraction of these provisioning ecosystem services is widely practiced in both mangrove areas inside and outside JCBNP (Plate 7) regardless of the high management status of Mapopwe mangrove ecosystem

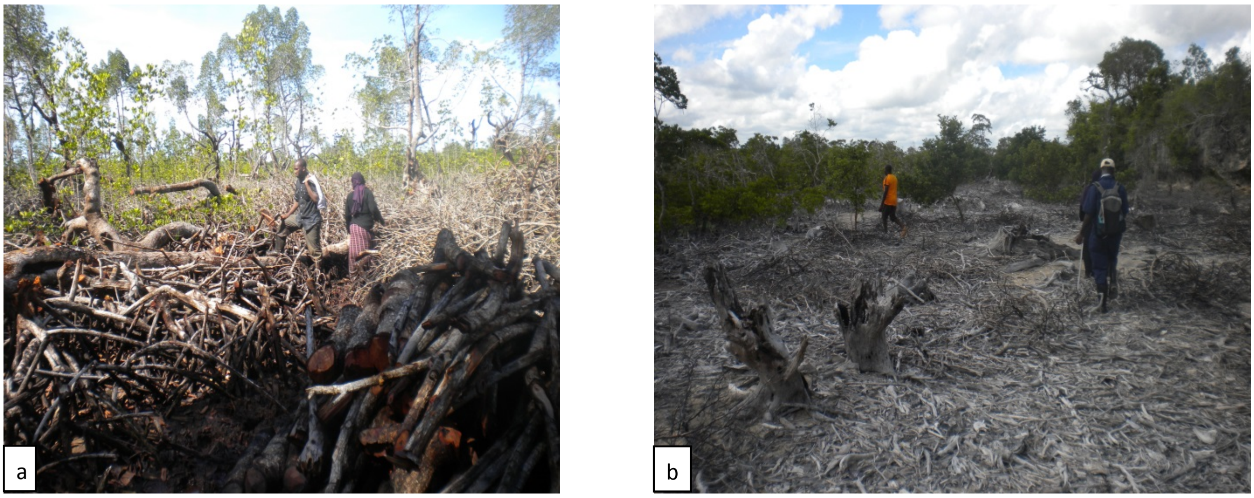


Plate 7 Tree harvesting in Charawe mangrove (a) Inside JCBNP and (b) Outside JCBNP

Source: Field survey 2013.

Villagers claimed that the level of dependence on mangrove ecosystem services have increased for the past four years and considered that mangrove is the only accessible resource that can support people's livelihoods in the village. During a FGD with young mangrove harvesters in the village, one of the Charawe VCC members narrated that:

"Koko ndio maisha yetu na hatuwezi kuishi bila kukata koko kwa sababu hiyo ndio rasilimali pekee tuliyonayo kwa kujikimu maisha yetu" That is "mangrove is our life and we cannot survive without cutting mangrove because this is our only natural resource that we are currently accessing to meet our daily livelihood"

Out of the total identified provisioning ecosystem services firewood, building poles and wood processed for charcoal and lime production were the most exploited mangrove ecosystem services in Charawe for both household uses and selling purposes.

a. Provision of firewood

Mangrove cutting for firewood is the dominant provisioning ecosystem service performed by both men and women in Charawe for commercial and subsistence needs. Results from household interviews indicated that about 77.5% and 85% of Charawe households were found to be involved in firewood production for commercial and subsistence exploitation respectively (Table 26). Villagers reported that harvesting of firewood is the most preferred income earning activity especially for men because firewood selling ensures more immediate availability of funds at any time than other mangrove products. One women narrated during FGD that

"Mume wangu anajishughulisha zaidi na kukata koko kwa kuni kwa sababu unauza hata zikiwa mbichi ili kupata pesa za haraka na huhitaji kusubiri kama unavyosubiri kupiga mkaa". That is

“my husband is engaged more on cutting mangrove wood for firewood because there is always the possibility of selling green mangrove firewood to get quick money and you don’t need to wait for processing like the way charcoal needs to be processed”.

Most of Charawe respondents (29% of the households) admitted that mangrove of any species is suitable for firewood. However in case of wider species availability *C. tagal* considered as the most suitable species (25.8% of respondents) followed by *X. granatum* (agreed by 19.35% of household respondents), and *R. mucronata* (12.9% of the respondents)

Mangrove harvesters reported that harvesting of mangrove trees for firewood involves cutting and splitting of roots, branches and the main stem of either the green or dried wood into pieces and tied together into small or big firewood bundles depending on customers’ needs (Plate 8).

Plate 8 Firewood harvesting inCharawe mangrove forest. *Source: this study, 2013*

Average monthly household harvesting of firewood bundles with their corresponding income and income saving equivalent for both commercial and subsistence is provided on Table 26. Note a small sized bundle of mangrove firewood was sold for 500 TSHS (£0.2) while the larger one worth 1200TSHS (£0.48) at the time of this study giving an average price of 850TSHS (£0.34) per bundle.

b. Charcoal production

Cutting of mangrove for charcoal making is a common activity in Charawe for income earning for both male and female residents (Plate 9). Results from household interviews indicated that 30% and 67.5% of the Charawe households were found to be involved in mangrove charcoal production for subsistence and commercial uses respectively. During FGD, mangrove harvesters estimated that about 70% of the charcoal makers were men and the remaining proportion were females. Villagers considered that charcoal production is a tedious job with their productivity differing between women and men charcoal makers. Men were reported to prepare large sized charcoal kilns producing an average of 17 charcoal sacks while women's charcoal kilns are of smaller size producing an average of 11 charcoal sacks.

Plate 9 Charcoal making from mangrove wood in Charawe. ***Source: this study, 2013***

Charcoal producers reported that production of charcoal from mangrove is species specific. 51.6% of the respondents agreed that *R. mucronata* was the most preferred species for charcoal production followed by *X. granatum* (29% of the respondents). These species perceived to be of high quality as reported by few charcoal makers and village charcoal users because it can be burned for long time while producing minimum ash in the kiln. However charcoal makers reported any species can be used if the preferred species are not available because there is no price difference between charcoal made by different mangrove species. Average monthly household charcoal production with their corresponding income for both subsistence and selling is indicated in Table 26. One charcoal sack was sold in the village between 9000TSHS (£3.6) and 10,000TSHS (£4.0) giving an average of 9500 TSHS (£3.8) per sack at the time of this study. An average weight per charcoal sack was 33kgs.

c. Provision of building poles and lime production

Charawe villagers described that mangrove forest is important to them as it provides house construction materials in the form of building poles and other wood used for burning stones for limestone production. Villagers reported significant reduction of mangrove harvesting for poles and limestone production in recent years. Results from household interview indicated that about 40% of Charawe households engaged in mangrove poles harvesting and production of lime in the village (Table 26). The harvested poles were found to be of different sizes that qualified for different uses in house construction and reflecting different market prices for each poles size (Plate 10). For example pole harvesters categorised harvested mangrove poles based on their diameter at breast height (dbh) into *boriti* referring to the largest pole size (8-10cm) followed by *nguzo* (6-8cm), *mapau* (6-3), and withies (1-3cm) as the smallest poles sizes (Table 26).

Plate 10 Mangrove poles in Charawe. *Source: this study, 2013*

These two ecosystem services were reported by villagers as male activities accessed in a small-scale in Charawe and mostly for subsistence consumption and sale of small sized building poles. Selling of limestone is only done when a limestone maker receives special order from the local or external customers. Consensus from FGDs and interviews indicated that banning of issuing of licenses for harvesting of mangrove products by the Government contributed to the reduction of cutting of mangrove poles because the poles are conspicuous enough and are easily recognised by the forest control managers in the course of transportation to market places. In addition, villagers have a feeling that the available small sized mangrove poles of low quality (Plate 10) will not be able to fetch good market price to compete with the poles from the mainland in Zanzibar town.

Provision of medicinal items and beekeeping were also among the mangrove provisioning services provided to Charawe residents. Beekeeping is not a very common practice in Charawe mangroves as it reported by only a few male residents who mainly produce honey for selling. Some Charawe elders perceived that fruits and barks of *X. granatum* have medicinal value and were thus being used by villagers to cure stomach disorders.

Other provisioning services which were exploited at low-irregular rate from Charawe mangrove ecosystem includes provision of wood for making canoes (dug-outs and masts) beehives, fish traps, door and window frames and provision of sticks for seaweed farming. Although the importance of bark tannins as a valuable source of dye has declined in Zanzibar, bark stripping is still performed by a few Charawe residents who sell the extracted mangrove barks in Zanzibar town for leather curing (field observation). Apart from the benefit obtained by direct extraction of wood products by individuals, provisioning mangrove ecosystem services in Charawe also generated diverse other benefits. Such benefits reported by villagers include village revenue collected through licensing (of illegal trade) of village outside mangrove traders, employment opportunities through transportation, processing and trading of mangrove products in the village.

Table 26 Amount of mangrove wood harvested for common provisioning mangrove ecosystem services in Charawe

Ecosystem services	Subsistence					Selling				
	% of households	No of hhs	Monthly harves/hh	Monthly income equivalent /hh in TSHS*	Annual income equivalent/hh in TSHS*	% of households	No of hhs	Monthly harvest/hh	Monthly income/hh in TSHS*	Annual income/hh in TSHS*
firewood (bundles)	77.5	192	6	5,100	133,200	85	211	101	85,850	1,030,200
Charcoal (charcoal sack)	30	74	1.75	9,500	114,000	67.5	168	38.0	285,000	3,420,000
Lime (kiln)	2.5	6	1.0	70,000	840,000	2.5	6	1	70,000	840,000
Poles(*Mapau*) *korja*	7.5	18	12	98,004	1180800	7.5	18	2	16,334	196008
Poles (*Nguzo*) *Korja*	7.5	18	12	200,004	2,400,048	7.5	18	1	16,667	200,004
Poles (*boriti*) *korja*	7.5	18	5	250,000	3,000,000	15	37	**	.	-
Withies (*Fito*) korja	15	37	40	60,000	720,000	20	49	16	24,000	288,000
Beekeeping (bottles)	0	0				2.5	6	3.2	40,000	480,000
medicine (barks & fruits)	15	37	1.5			***				-
Crab (kgs)	10	24	1.5	5,250	63,000	10	24	16	56,000	672,000
Seaweed (kgs)				-	-	12.5	31	54.3	19,000	228,000

*£1 = 2,500TSHS at the study time, ** = no regular harvests, *** = no commercial uses. *Source: Charawe household interview, 2013.*

7.3.3.2 Non-extractive mangrove ecosystem services

Although the majority of Charawe residents were engaged in direct harvesting of mangrove wood products, a significant number of respondents were found to have clear understanding and recognise a wide range of supporting services (see below), with less knowledge on the regulating function provided by their mangrove. Results from field survey indicated that Charawe mangrove regulating services observed in the field is the presence of diverse insects (including bees) and marine organism reflecting pollination and biodiversity values of the system. However, most of the village respondents were not able to recognise these ecosystem services. Only about 7.5% of the respondents reported on the importance of their mangrove for climate regulation, reflecting the role of mangrove in carbon dioxide sequestration (*hewa ukaa*) and regulation of the microclimatic condition of the village.

Charawe residents reported that their mangrove are important for the supply of diverse protective and supportive mangrove ecosystem services especially provision of breeding sites for juvenile fish and prawns (supported by 32% of the respondents) and provision of homes for other organism such as fishes, insects, monkeys, migratory birds, and other marine organism in the mangrove (agreed by 25.9% of the respondents). Other respondents (17.3%) reported that their mangroves are important as they protect their village from strong waves and winds, control beach erosion (14.6% of the respondents) and protect coral reefs (2.2% of respondents).

There are no ecotourism services being provided in Charawe mangrove ecosystem. However Charawe residents through VCC receives revenue share from JCBNP after every 6 months through revenue sharing mechanism established by the Park Authority (KII with VCC secretary).

7.3.4 Stakeholders' interests in mangrove ecosystem services

Diversity of stakeholders in Charawe social system has different interests and values to ecosystem services generated by the Charawe mangrove ecosystem. This study found that stakeholders at international and most stakeholders at national scales have strong interests in the supporting and regulating services provided by Kinani mangrove but with more management priority of achieving their interests through Mapopwe mangrove system. Key informant results with stakeholders at a higher scale indicated that they were particularly interested in Mapopwe mangrove for biodiversity conservation, protection of the coastal environment, fish breeding sites, providing the opportunity to diversify tourist attraction within the National Park and maintain the ecological integrity of the system. They were also interested in achieving full conservation of these fragile/sensitive mangrove areas like the bays and estuaries to provide potential research areas and other environmental services unique to mangrove ecosystem (Abdalla and Kitwana, 1997; key informant interviews with DFRNR staff).

Although stakeholders at higher scales were found to have little interest in provisioning mangrove ecosystem services from Charawe they are indirectly benefited through these services especially through collection of revenues in form of fines from illegal transportation of forest mangrove products. Low interest in provisioning ecosystem services by these stakeholders did not necessarily mean that they were not in need of the provisioning ecosystem services but suggests that they have alternative means of meeting these needs (e.g. buying of mangrove poles, firewood and charcoal and availability of employment in town). In this context although these stakeholders are not involved in direct extraction of mangrove wood products, some of them serve as important drivers that accelerate the rate of mangrove cutting through the creation of market incentives to local communities.

The interests of local communities were very different to those of other stakeholders at higher level. However, there was no variation in interests in ecosystem services generated between Kinani and Mapopwe mangrove blocks by Charawe residents. Results from household interviews and consensus from FGDs indicated that Charawe local stakeholders, especially local communities, traders of mangrove products including the village outsiders have greater interests in more visible mangrove ecosystem services that have direct use value or generate direct economic returns. Harvesting of mangrove wood products for charcoal making and lime making, firewood and building poles were the most valued mangrove ecosystem services desired by local communities (see section 7.3.3.1). Young mangrove harvesters from the village reported that they highly valued the mangrove wood provisioning ecosystem services because they can be easily transformed into cash required by them for their survival.

This is the major type of ecosystem services that cause significant changes to the mangrove ecosystem and are in conflict with the interests of government. For example it was found that cutting of mangrove wood for charcoal, firewood, building poles and lime are of greater importance and valued ecosystem services by Charawe people, which conflict with the interest of the Government for biodiversity conservation and maintainance of ecological integrity. In contrast, mangrove conservation for provision of regulating and supporting services are of greater importance to the stakeholders at higher scales, while receiving little interest or importance at village scale.

7.4 Interactions

Charawe mangrove SES identity is characterised by several ecological and social relationships. Interaction in ecological system is related to animal- plant interactions that influence productivity of mangrove ecosystem services. One of the most important observed animal-plant interactions in Charawe was between mangrove plants and honey bees which have influence on the production of honey in Charawe mangrove system. Another plant-animal interaction observed in Charawe was between crabs and mangrove seedling propergules which can have a significant impact on the establishment of mangrove species, by destroying seedlings and preventing regeneration (Dahdouh-Guebas *et al*., 1998). However there were insufficient data in this study to indicate the influence of these animals on ecosystem productivity.

7.4.1Mangrove management in Charawe

Socially, Charawe mangrove social-ecological interaction is characterised by relatively limited diverse kind of property rights practiced under different management priorities by the stakeholders at higher level between mangrove inside and outside JCBNP.

Charawe mangrove is governed by laws and regulations operating at higher national scales with little involvement of local communities. Results from all respondents from FGDs and KIIs in Charawe reported that their mangroves have been managed mainly under a State property regime whereby Government is the sole owner and decision maker on the access and use of the resources (section 4.8.2). In this management arrangement the Government considers the management of Charawe mangrove outside JCBNP to be like any other forest reserve in Zanzibar (section 4.8.2), while the management of Mapopwe mangrove has been raised to the status of National Park. Declaration of Mapopwe as part of JCBNP was deliberately done as a management strategy with the intention of providing full protection of the area under high conservation status to realise the Government objectives. Consequently the approach declared a total ban of the former management system of 'opening and closing' of harvesting of mangrove wood by the surrounding communities (Interview with Director of DFNRNR). However, the implementation of management institutions was found to be the same between the mangrove inside and outside JCBNP by central government. Local community reported that the government's management approach was being implemented through irregular patrols done by a few employed forest guards and or a patrol team from DFNRNR supported by donor resources (see Kinani case of Michamvi case, section 6.4.1.1**).**

Although the management of these mangroves is under the central government, local communities have been slightly encouraged by DFNRNR to participate in management of the ecosystem as per the standard Co-management approach to conserve the forest resources in Zanzibar (section 4.8.2 and Kinani case of Michamvi). In this partnership villagers reported that they are only encouraged to participate on supporting parks conservation activities such as joint patrols and giving information on illegal cutting activities to the park authority but without legal recognition of ownership, access, management and uses of the mangrove wood products. Charawe communities claimed that although they were required to conserve the mangrove, they were left behind during decision making process on the issues that have direct influence on their life. For example, declaration of Mapopwe mangrove into National Park and recently government decision on complete ban of extraction of any wood provisioning ecosystem services in Chwaka bay was made without involving local stakeholders who have a big stake in the bay's mangrove (VCC FGD consensus). This situation resulted in poor relationships and linkages between Charawe communities' stakeholders and national stakeholders. This study found that despite this management arrangement Charawe community with formalised VCC members have been very much discouraged with the overall management approach and they were not actively participating in management of mangrove ecosystems.

Apart from the formalised institutions governing Charawe mangroves, local communities were found to have informal institutions of slowly evolving social rules that express the behavioural norms of families, community and society and determine how they interact with the ecosystem around them. As most of Charawe residents are Muslim, one set of these informal institutions were based on their religious beliefs influenced by Islamic laws (see section 4.7), although with little influence on the current management system. On the other hand, Charawe communities have other informal rules of the game that governed their access and uses of mangrove resources. These institutions have been influenced by local setting and the cultural behaviour of Charawe communities and they were indicated by what was accepted and not permitted in relation to the uses of mangrove ecosystem services in the village. Although these informal institutions were not written down and no defined enforcement mechanism is in place, the commitment to these informal institutions were found to be quite strong and override the influence of formal management institutions (my field observation). For example, using their informal rules the majority of Charawe residents have been united in their acceptance to extract mangrove provisioning ecosystem services that meet their interests irrespective of the presence of formal governing institutions and organisations. This was evidenced by the number of charcoal kilns and bundles of fire wood scattered in the village (See plates 8 and 9). Despite the presence of these multiple institutions in Charawe, implementation of formal institutions has been very weak and ineffective to conserve the mangrove.

7.5 Innovation

Innovation is crucial to mangrove SES identity which according to some resilience scholars was explained by diversity of ecological and social systems (section 3.2.1). Innovation in ecological systems is the introduction of novel competitive species and increased performance of previously suppressed species in the ecosystem.

Ecological innovation in Charawe is considered in the same way as Pete and Michamvi case studies. The persistent nature of mangrove is known to have lower trees species diversity (Tomlinson, 1986) because of high morphological and biological adaptation of the species which provide competitive ability to grow in a specialised harsh environment. However, mangrove survey results indicated that Charawe mangrove has a relatively large number of high abundant mangrove species reflecting the high diversity of the system. Relatively high abundance of mangrove species in Charawe forest enhances greater chance of achieving a high level of diversity which is potential for increase of ecosystem functional diversity and redundancy and capacity to cope with disturbances in future.

Innovation in the social system is explained by diversity of functional actor groups, institutions and diversity livelihood activities. Despite the diversity of actors and institutions there is low level of coordination between Government and local communities (section 7.4.1) which provide low potential for creating alternative/new and effective institutional arrangement for mangrove management.

7.5.1 Charawe Livelihood activities

In contrast to Pete and Michamvi Shehia, Charawe communities have less diverse non mangrove livelihood activities in response to the decline of resource access in the village. Limited availability of diverse and reliable alternative livelihood opportunities independent of forests limit the capacity of Charawe communities to innovate and develop new income earning means that will remove them from harvesting mangroves. The results from household interviews indicated that harvesting of mangrove wood for various purposes is the most important income earning livelihood activity for the majority of people. Villagers

reported experiencing increased dependence of Charawe residents on mangrove wood harvesting performed both in mangroves inside and outside National Park (see on 7.3.3.1 and 7.8). Table 27 indicates the diversity of economic activities by gender (based on consensus from FGDs) with their corresponding monthly income in the Charawe social system. The variation of level of participation on different livelihood activities by different gender is grouped as F = female activity, M = male activity, B = both gender in relatively equal proportion, BM = both gender with more male participants, BF = both gender with more female participants.Table 27 Livelihood activities in Charawe Shehia

Livelihood activities	Gender	Number of respondents (Sample size)	Percentage of respondents	Monthly average income from selling and income equivalent for subsistence (TSHS)
Mangrove cutting for firewood	BM	34 (40)	85.0	90,950
Mangrove cutting for charcoal	BM	27 (40)	67.5	295,740
Agriculture	BM	26 (40)	65.0	67,961
Mangrove cutting for other products	M	16 (40)	40.0	127,187**
Fishing	BM	11 (40)	27.5	64,545
Small-scale enterprises	BF	10 (40)	25.0	34,500
Terrestrial wood cutting	BM	8 (40)	20.0	145,000
Employment	BM	5 (40)	12.5	266,000
Seaweed farming	BF	5 (40)	12.5	19,000
Crab collector	BM	4 (40)	10.0	61,250
Beekeeping	M	2 (40)	5.0	40,000
Drivers	M	1 (40)	2.5	100,000

*£1 = 2,500TSHS at the study time. *Source: Charawe household interview, 2013*

**Does not include income equivalent for subsistence uses of lime, and all types of poles indicated on Table 26.

All the wood provisioning services provided by mangrove and most of terrestrial forests together with fishing by the local communities were in conflict with government interests and posed a serious challenge to Charawe communities whose livelihoods were highly dependent on these resources (Table 27). This situation left the communities in a dilemma, wondering why government tried to achieve their interests at the expense of people's livelihood.

Agriculture is another important activity in Charawe for about 65% of the interviewed households, mainly for subsistence uses. However, with decline of access and increased difficulties on uses of marine resources, this has encouraged a few Charawe residents to diversify agricultural production by farming not only food crops but also planting permanent tree crops that have potential for acquiring good market prices such as lime, mango, pawpaw and others.

Small-scale enterprises have been introduced in Charawe under the support of stakeholders at higher scales (especially, CARE through HIMA) to promote innovation capacity of community on the development of alternative income generating activities that would provide community incentives to reduce dependence on terrestrial forests. For example, Charawe VCC secretary confirmed the receipt of small-scale village grants for supporting community development and individual projects (only 20 individuals), and provision of tree seedlings for establishment of tree woodlots after their village entered into the piloting phase of the carbon credit project run by HIMA. Likewise a saving and credit programme was introduced by CARE in collaboration with JOCDO to enable local communities to create alternative income livelihood which was not related to wood cutting (section 4.8.2). Results from wealth ranking indicated that about 216 Charawe residents have been engaged in eight saving and credits groups and out of them 66.7% of the members are women. However, it was found that most of the resultant projects have further accelerated the rate of harvesting of mangrove in the protected areas. Discussion with members of these groups reported that there is limited opportunity for economic diversification in their village which has resulted in the majority of women members using the saved money as capital for running wood related projects in the village. Such projects includes establishment of small-scale wood trading shops for charcoal and firewood or the money was used by women to employ young energetic men to harvest and transport mangrove wood products for the women's businesses.

Other livelihood activities performed by Charawe residents on a very small-scale include beekeeping, seaweed farming, hunting and crab collection. Despite these activities local communities viewed that the available non mangrove alternatives have not been effective to curb the rate of mangrove cutting in the village.

7.5.2 Economic values from mangrove harvesting in Charawe

Results from FGD and household interviews indicated that Charawe community has high dependence on the mangrove ecosystem and cutting of mangrove wood is the first and major income earning activity in the village. Although about 77.5% of interviewed Charawe households depended upon three to five sources of income, 85% of these households have 2 to 3 mangrove wood cutting activities as their income sources. About 10% of the households were completely dependent on harvesting of mangrove wood products as their main source of income. These activities have been found to give an average monthly income of 469,150TSHS per household engaged in these activities in Charawe. Among the common livelihood activities mangrove cutting for provisioning wood ecosystem service contributes 67% of the average monthly household income, while no ecotourism-related income was reported in Charawe (Figure 28). Although agriculture (which forms part of other non-mangrove income) was found to provide relatively small economic earnings of 14.4% of the average monthly household income, villagers engaged in agriculture perceived that farming is the intervention of less conflicts and restrictions which ensures food security especially to the majority poor in the village. Other non-wood mangrove income includes beekeeping and crab collection.

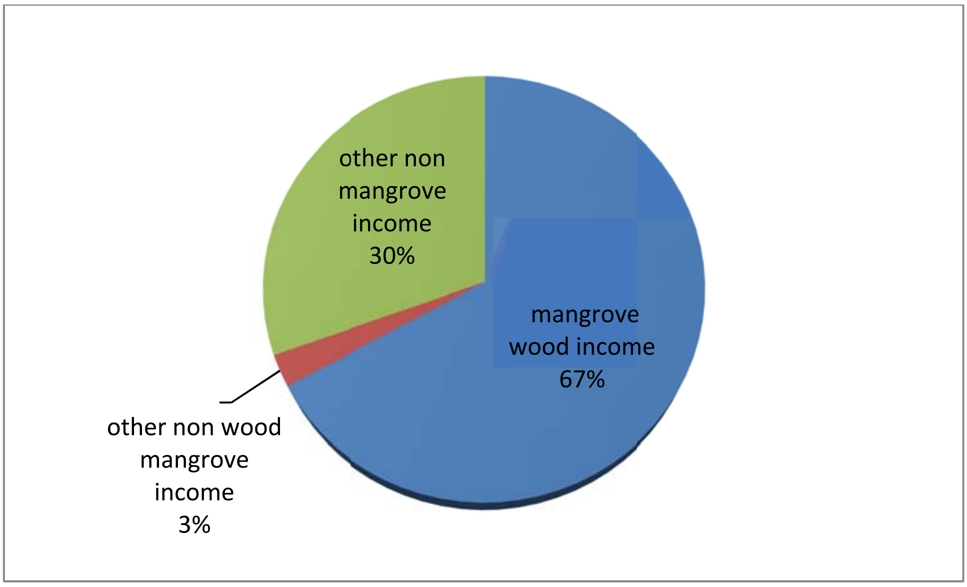


Figure 28 Average monthly mangrove household contribution in Charawe

Analysis of the importance of mangrove income to the Charawe households by wealth groups revealed that mangrove wood provisioning ecosystem services for charcoal, firewood, poles and lime production serves as an important source of household income across all wealth categories in Charawe (Table 28).

Table 28 Mean monthly household income from mangrove wood products by wealth groups in Charawe

Wealth groups	Sample size	Average monthly household income (TSHS)	Average monthly household income from mangrove wood harvesting (TSHS)				Average income contribution from mangrove wood harvesting (%)
			Firewood	Charcoal	Poles and lime	Total income from mangrove wood harvesting (TSHS)	
Richest	1	905,000	90,000	300,000	0	390,000	43.1
Rich	2	900,000	147,500	430,000	152,500	730,000	81.1
Poor	30	444,769	76,166	224,133	48,980	349,279	72.3
Poorest	7	343,333	46,428	2857	9308	60,593	27.4
Total	40						

Charcoal is the most profitable ecosystem service generating higher income to all wealth group categories in the society. Wealthier people received higher income with higher contribution to their total income than the poor households due to the economic ability of wealthier people to invest in wood harvesting and selling projects. Income from mangrove wood provisioning received by Charawe residents is higher than residents from Pete and Michamvi earnings per month implying that more efforts is required in Charawe to develop alternative income sources for the majority of the population.

Whilst average monthly earnings from household activities are more than three times the National minimum wage of 100,000TSHS, in Zanzibar (RGoZ, 2010). Charawe residents claimed that income generated from these activities is inadequate to meet the needs of their households.

7.6 Continuity

The continuity of ecological system depends on the presence of small changing variables (ecosystem memory) that enhances ecosystem organisation after disturbances. Ecological continuity of Charawe mangroves is considered in the same way as Pete and Michamvi case study. Thus the availability of propagules of mangrove species is considered as an important mangrove ecosystem memory that facilitates mangrove ecosystem recovery and continuity after disturbances (Sherman, *et al.*, 2001; Harun-or-Rashid *et al.,* 2008). In this case the observed high number of mature viviparous mangrove plants in Charawe ensures availability of a viable number of propagules that will facilitate continuity of the mangrove ecosystem after disturbances. Continuity of Charawe mangrove system is also ensured by the observed sufficient numbers of seedlings to re-vegetate the system after disturbances.

Social continuity depends on the availability of social memory that remains after disturbance. In Charawe villagers viewed that the social continuity will be enhanced by the presence of knowledgeable elderly people, Islamic leaders and conservation groups that provide mechanisms for mangrove management and conservation knowledge transfer and sharing in the society. However, in the current situation mechanisms of knowledge transfer by elderly people in Charawe have been weakened and influenced by the formal knowledge system whereby the majority of young people spend little time listening to stories from their elders. Results from KII with deputy village Sheha and consensus from FGD with mangrove cutters reported that, the presence of formal management institutions have discouraged most of the elders and Islamic leaders to take part on the transfer of environmental knowledge in the village which will threatens the continuity of the system. Deputy village Sheha stressed that the use of a gong (*upatu*- metallic plate which when struck produces sound) for conveying conservation knowledge, or making village announcement on the time, user condition or management requirement during open and closed mangrove harvesting system has been left behind.

Environmental knowledge transfer and sharing in Charawe is mainly done through formal school education, irregular village meetings conducted by the VCC in collaboration with stakeholders from higher scales or through conversations among the peers groups in the society. Charawe residents also reported that continuity of their social system will also be enhanced by the presence of institutional support for development of economical viable alternative livelihood activities that will reduce dependence on mangrove provisioning services to majority of Charawe residents. Either the continuity will be enhanced if new ways of exploiting mangrove ecosystem services that caused minimum disruption of mangrove ecosystem while generating more income to the communities are put in place (FGD with VCC). However, local communities argued that the introduced alternative activities and innovation in Charawe has not been effective in reducing dependence on mangrove resources and therefore threatens its continuity.

7.7 Charawe community's views on indicators for resilience mangrove SES

Charawe communities viewed that resilience mangrove social ecological system should attain certain characteristics as indicators for the desired resilience system. In this case, the consensus from FGDs and key informant results provided simple and practical indicators as villager's views on how the resilience mangrove social ecological system would like to be. These indicators were developed using the same approach as described in section 3.8. Thus in Charawe the developed indicators were based on the consensus of the majority of the contacted VCC, village elders and mangrove harvesters on the defined and presented mangrove social ecological variables potential for indicators for resilience mangrove SES. Table 29 provides simple and practical resilience indicators as suggested by Charawe villagers with corresponding interpretations of each variable that define the identity of the system. Note that categories (variables) in the first two columns and last column in Table 29 were presented by researchers and interpreted according to the most frequently cited literature, while variables in column three were the results of a participatory process.

Table 29 Villagers' perspectives on resilience indicators for Charawe mangrove SES

Mangrove SES attributes	resilience variables	Villagers' views on indicators for desired resilient system	interpretations on the desired mangrove SES
Mangrove structure	Mangrove area/cover	-Village elders and VCC members required that mangrove forests should be the same but increase in mangrove trees especially areas close to the village that have been heavily cut in the past	Mangrove should cover the same area but increase in intensity of vegetation cover especially in degraded areas
	Mangrove tree species diversity	-Mangrove tree cutters and village elders felt that their mangrove may have few dominant species but they are plenty available to provide the benefits required by local people -Few VCC members and village Sheha required that the forest should have many mangrove tree species for nice environmental attraction.	Mangrove ecosystem will be resilient if it would have a good proportion of keystone species that provide desirable ecosystem services by the communities while other respondents required that resilient mangrove should have diverse mangrove tree species to provide natural attraction of the ecosystem.
	Average tree density/ha	-All of the respondents required that their mangrove should have enough number of tall mature plants that would be able to provide the sustainable supply of all types of poles, and other benefits such as diverse mangrove fish species, crabs and *chaza.*	Resilient mangrove has sufficient enough number of mature trees to provide desirable provisioning mangrove wood ecosystem system of poles and other ecosystem services.
	Dominant tree sizes	-Mangrove harvesters, VCC members viewed that forest should have sufficient number of mangrove trees of different sizes that will be able to provide all mangrove benefits to the communities and other users.	Resilient mangrove should have good proportion of mangrove trees of different sizes that will be able to balance the supply of diverse ecosystem services to the stakeholders.
Mangrove function	Appropriate mangrove ecosystem services / amount of wood to be removed	-Resilient mangrove should be able to provide different types of poles as this is the most safe method of extracting wood as considered by most of the respondents -Islamic leaders and village elders stressed that the poles harvesting will lead into sustainable forest if the amount removed is small to meet the subsistence needs only.	Resilient mangrove should be capable of providing desirable wood provisioning ecosystem services of poles. The rate of rate of cutting of mangrove wood should be very low to meet the subsistence village needs.
Interaction	Plant-animal interaction	Not clearly understood by the respondents.	Diverse plant-animal interactions are found in the ecosystem. However local communities were not able to recognise them.

Innovation	Planting/natural colonisation	-Most of the village elders and Islamic leaders agreed that mangrove does not need to be planted, but need a resting time after cutting for new plants to establish. -Few VCC members reported that mangrove planting can assist the forest to re-establish *(kujihuisha*) especially in heavy degraded areas -Villagers views on diversity of species is the same as indicated above	-Villagers had a feeling that planting of mangrove (as innovation) is not necessary for re- establishment of the system. Either they felt that mangrove is resilient enough and is capable to re-organise itself under minimum disturbances. -In high level of disturbance re-organisation can be enhanced through planting in degraded areas.
Continuity	Seedlings/ha	-Village elders and Islamic leaders felt the mangrove will be able sustainable if mature plants produce enough seedlings to re-establish themselves	Resilient mangrove has large number of seedlings and saplings to re-generate the system after disturbances.
Social structure	Diversity of stakeholders, relationship and their interests	-VCC and village leaders required that diverse people to engage in mangrove conservation because they will assist each other on performing mangrove management works. -Village elders viewed that Government should promote good relationships between governed staff and community members to exchange their ideas and experiences.	Resilient system should encourage linkages and active participation of different stakeholders from different scales. This will enhance effective implementation of mangrove management and provide mechanism of learning through exchange of experiences and ideas.
	Knowledge systems	-VCC and village elders and Islamic leaders reported that resilient society should have enough and appropriate knowledge on the value of mangrove forest resources.	Stakeholders should have diverse mangrove knowledge systems and incorporated in the management system.
	Knowledge sources	-VCC felt that Government and other partners should conduct regular training to increase people understanding and awareness on the value and , management of mangrove forests. -Village elders and Islamic leaders reported that knowledge from the local people should also be mostly considered in the management of the forest and improving their life standard.	Resilience system should consider the importance of mangrove knowledge from multiple sources.

Social interactions	Management institutions	-All of the respondents considered that traditional mangrove management approach of open and closed of poles harvesting between is the appropriate and effective if will also actively involve the outsiders (Chwaka and Ukongoroni) in decision making and management. -VCC reported that Community based mangrove management will be successfully achieved if the concerned communities have very little dependence on mangroves provisioning services. -Village Sheha and VCC required that management should promote trusts and transparency among the peoples involved. -Mangrove cutters suggested that the government stuff should carry out close monitoring and provide incentives local communities to manage the forest. -Deputy village Sheha Resilient management will be achieved if Government become committed put mangrove within high government agenda. This will ensure resource availability for effective implementation of their plans.	-Villagers suggested that efficient management system allow some uses of wood materials required by communities or community should get direct benefits from the resources they are managing. -Efficient CBNRM will be achieved if the communities have low dependence on mangrove wood cuttings. -Here the question is not just formulation of laws and program but engaged continuously with local communities on actual implementation. -This will promote trusts and transparency among stakeholders.
Innovations	Economic options	-All of the respondents felt that resilience will be achieved if the society has reliable alternative livelihood options that will generate funds needed to meet daily basic needs for majority of young mangrove cutters, village mangrove traders and majority of Charawe residents. -Some VCC members reported that Government and other partners will promote social resilience if they will help society to get reliable markets for the goods produced from the village especially lime and crabs.	Resilient community will have diversified income sources that would give direct benefits to individuals and capable of removing majority of local people from depending on direct cutting of mangrove plants. This will be achieved if the society has the capacity to switch and adapt into new economic activities in the face of decline the availability of wood provisioning ecosystem services.
Continuity	Mechanism for knowledge storage and sharing	-Village elders and Islamic leaders stressed the need of government to prioritise and make use of them to share their experiences and knowledge so as to encourage young people to conserve the mangrove forests in the village. -VCC felt that Government should give regular training in the society	Resilient system will be enhanced by the presence of knowledgeable elderly people, Islamic leaders and conservation groups that provide mechanisms for mangrove management and conservation knowledge transfer and sharing in the society.

7.8 Change trajectories of Charawe mangrove social-ecological system

Charawe mangrove SES has undergone different phases of change both in ecological and social systems .This section describes major anthropogenic changes that have occurred in Charawe mangrove SES using the combination of historical profile approach and Adaptive Cycle concept. Periods of major events that changed and shaped Charawe SES were identified using the historical profiles which were grouped into defined phases of changes as described by Adaptive Cycle approach postulated by Gunderson and Holling (2002). Using different data sources a historical descriptions that depicts changes that Charawe SES has undergone emerges signifying two different time periods as indicated below.

Resource access era - 1920s to early 1990s

In early 1920s Charawe was a very remote village with vast forested village land area stretched to Mapopwe mangroves and Wangwani to the west and to the Jozani village boundary in the South (Williams and Basha, 1997). During the colonial time between 1920s up to early 1940s villagers reported that their village was without a road and lacked most of the important social services such as school, hospital and others. Discussion with Shehia leader reported that in this period Charawe village had a population of about 100 residents who had limited social cultural interaction with outsiders. Thus the society was strongly united and strictly bonded with their cultural habits, norms and values governed by traditions and Islamic beliefs.

FGD with village elders reported that during colonial period between 1920s and 1930s Charawe had a variety of natural resources especially coral rag forests, mangrove forests (both Kinani and Mapopwe) and fish resources accessible to Charawe residents for meeting their household needs. Most of the villagers were farmers and fishermen while only few residents were engaged on wood cutting mainly for subsistence needs (ibid).

This vast village land with their forest resources was under customary village laws of ownership and user rights as reported by the village Sheha. In the 1940s Charawe villagers realised that wood products in the form of firewood and poles fetched a good market value in Zanzibar town, which attracted Charawe residents to gradually shift from farming to wood cutting. In this period terrestrial wood harvesting, fishing and agriculture became the major livelihood activities in the village where by only few people were engaged in commercial harvesting of mangrove forest products (Village elders' FGD).

Sea crossing using small canoes from Charawe to Chwaka village was the main means of transport for Charawe residents. Villagers reported that they transported the harvested wood products over the Chwaka bay to Chwaka village for selling or transit before transported to Zanzibar town (also Williams and Basha, 1997). Since the early 1920s Chwaka was one of the most developed villages connected with the main road to Zanzibar town with effective administrative organs and social services available in the village (Pakenham, 1947). Thus Chwaka village has been used as a central market for selling mangrove products from all villages in the Chwaka bay where wood-related businessmen from different villages and towns would come to buy products. In late 1945 a first stretch of earth road/footpath from Jozani toward Mapandani (the junction between Charawe and its neighbouring village in the east) was initiated by two old men who were seriously engaged in terrestrial wood cutting and selling to Zanzibar towns (KII with Deputy Sheha). This stretch of road was upgraded to the level of gravel in 1957 and this is believed by Charawe villagers to have intensified wood cutting business for meeting the needs of building poles for house construction in Zanzibar town from mid-1990s.

In this period of 1920s to 1945 some of the Charawe village forest resources especially mangroves were used by colonial administration for commercial bark extraction and poles harvesting for export (section 4.8.2). In Charawe 45% (288 ha) of the mangrove area was selected and used for bark stripping while other areas were used for provision of other ecosystem services (Griffith, 1950). Although, all mangrove areas under commercial bark exploitation were reported to suffer from severe degradation such that they were not capable to sustainably supply desired bark quality (Griffith, 1949) required by the colonial government, but considered desirable state by Charawe residents. This was because the mangrove ecosystem was able to provide the poles of good quality needed by local communities (FGD with village elders). For example the smallest size of pole (*Fito* –used for roofing) was 5 to 10 cm dbh, *Mapau* (reapers) 5-7.5cm dbh, *Makongamoya*, 7.5 cm dbh, while *Boriti* (for supporting the roof) and Nguzo (pillars supporting the roofs) were 10-15cm (Griffith, 1949).

Despite wide use of forest resources there were no formal institutions for mangrove management in Charawe and all forests close to the village including mangroves (currently considered inside and outside JCBNP) were perceived as village/community forests. Consensus from elders' respondents in Charawe confirmed results from other (Mohammed, 2004,) that between 1920s and 1940s mangrove and other marine resources in Chwaka bay was managed through a system of well-defined property rights and a council of elders from eight villages around the bay including Charawe and Michamvi, which was considered wise and highly respected by the community. Property rights over marine resources were clearly demarcated and consisted to cover the area adjacent to the different village (De la Torre-Castro and Lyimo, 2012). In this period Charawe villagers reported to have use rights over the mangrove forest where the norms and regulation for management were developed by committee of four highly respected elders called *Wazee wa Miji* (also De la Torre-Castro and Lyimo, 2012). Village affairs were managed by the mosque committee, the members of which also belonged to village elders committees (Williams and Basha, 1997; interview with deputy village Sheha). The elders' committee who worked with the head village leader (Sheha) prepared rules which were passed through the council members from other village around the bay. These elders were also responsible for making decisions on the major village issues which was respected by majority of the population (KII with Sheha). The management institutions were influenced by peoples' traditions and beliefs and expressed by their daily activities.

One village elder during FGD described the way their elders achieved the management of mangrove that:

'Our village elders ruled that it is not allowed for young people to cut the mangrove close to the village, and it should be left for the elders' uses. In this way, the young people were only allowed to harvest the mangrove located very far from the village which contributed to the existence of the mangrove close to the village'.

Other FGD respondents stressed that Islamic leaders /*sheikhs* applied Islamic laws/ethics that advocate wise use of any available resources. These laws stressed the need to avoid overconsumption of resources which is considered a great sin in Islam. Therefore community educated/learned to cut the amount that was sufficient to meet their basic needs and to cut only the type and size of the tree they needed.

In 1947 the beginning of formal management arrangement to Charawe village resources which perceived by Charawe residents denied them full ownership of the resources but provided legal access and user rights on the ecosystem services desired by local communities. For example in this period the colonial government declared all mangroves as government land (see section 4.8.2) but local communities were given legal rights to cut wood on government land for subsistence uses for firewood and poles (Griffith, 1950). Extraction of mangrove products by Charawe communities were achieved through alternative harvesting of mangrove wood products between Mapopwe and Kinani mangrove block which controlled by the local communities and also supported by the colonial government (section 4.9.2). One of the Charawe old men narrated during FGD that

"We were the managers, controllers and decision makers while the Government was the supervisors and advisors who assisted communities on how better to manage and use the mangroves".

The council stopped working immediately after independence in 1964.

Similarly in 1965 Charawe mangrove and all mangroves of Zanzibar were declared as forest reserve (section 4.8.2) The gazetted Jozani Chwaka bay mangrove area (Kinani and Mapopwe mangrove blocks) in this time covered an area of 2,392 ha (JCBCP, 1995) which significantly reduced Charawe village land by including all of its mangrove area under the reserve. Although the management of this mangrove of opening and closing harvesting between Kinani and Mapopwe mangrove continued, but was achieved without community participation (section 4.8.2), Charawe communities were given user rights to harvest mangrove poles under permit control. Apart from the allowable uses, Charawe elders reported to using mangroves for diverse domestic uses including firewood, making lime and timber for building purposes. Sap from *R. mucronata* were used for water proofing fishing lines, stilt roots for fish traps, sawn timber for cart construction, posts, bed steeds, drums, chairs, spoons and spade handles.

In the mid-1980s, the influence of the World Bank and International Monetary Fund paved the way for further changes, opening the economy to external investors and speeding up structural reforms (Saunders *et al*, 2010). In this reform Zanzibar Government through donor support, provided credit and loan facilities and modern fishing gears (mainly stationary nets for fishing in the channel) and outboard engines to fishermen while damaging beach seine nets were banned (DFMR, 1994). Charawe was one of the villages that benefited from this programme which served as an important incentive attracting the majority of Charawe residents to fishing using nets, including destructive fishing gears (FGD with VCC). The reform also coincided with the intervention of external donor projects that resulted in a number of changes in the forestry sector during the1980s. For example, Finnish International Development Agency (FINNIDA) project in collaboration with the Forest Department supported village afforestation programme in the island (section 4.8.2). Discussion with village elders confirmed that a significant number of Charawe residents participated in this project whereby about 25ha of *Casuarina* wood lots were established in the village. In the late 1980s seaweed farming was introduced in Charawe which provided important economic opportunities especially for women earning money to support their household needs. Charawe villagers viewed that these international interventions served as an important innovation that increased resource availability to support their livelihood needs.

From the colonial period up to late 1980s Charawe residents considered that their mangroves (both shared Kinani and Mapopwe) flourished. The mangrove SES moved toward conservation phase (K) of the Adaptive Cycle. Respondents from focus group discussions confirmed that in this period Charawe mangrove was characterised by closely covered mangrove forest dominated by thicker diameter mangrove trees desired by Charawe communities for poles production. In this period Chwaka bay mangrove has had 9 mangrove species except *P. acidula* with *R. mucronata* as the most abundant mangrove tree species (Shunula, 1990). The forest retained some relatively pristine areas with high density of mature plants with good number of trees exceeding 12-15 m. (Shunula, 1990).

The society was united with relatively slow growing population (section 4.6) who had access and limited restrictions on diverse of village resources (like fish, terrestrial and mangrove forests) and few alternative livelihood that reduced pressures on their mangrove. Village elders reported that although wood cutting was the main source of income, selling of mangrove poles was mainly done by a few elders' not exceeding 40 people in the village up to early 1990s. Selective harvesting of a range of different building poles (e.g. *Boriti, Nguzo, Mapau,* and withies) was the main wood provisioning ecosystem services (Madeweya *et al.,* 2002) while no mangroves were used for charcoal production in Charawe. However, other mangrove trees species such as *X. granatum* preferred by communities for specific use especially for furniture making, firewood and medicinal uses (KII with old mangrove harvester). Although the mangrove management was under central government, most of the interviewed Charawe village elders reported having a positive perception of the management because it allows some uses of resources by local communities. In this context Charawe communities considered the open and closed harvesting system of mangrove forest between Kinani and Mapopwe blocks to be the most successful/fair management approach in village since the permit were released to local communities that provided them legal rights to extract poles of the desired quality.

Resources restriction and degradation era – 1990s to 2013

Charawe social system experienced a slight population increase from 531 in 1988 to 708 in 2002 (section 4.5). Charawe village reported that the increased population in the village correlated with the increase of number of people engaged in wood cutting in the village. These people were harvesting building poles of different categories from terrestrial forests and sold them to Zanzibar town. High demand of wood products in Zanzibar town (Rashid, 1991) created incentives for more Charawe residents to harvest wood products for selling (also FGD with mangrove cutters). Inefficient implementation of State management regime to control degradation of forest resources were experienced between 1980s to 1990s (Madeweya *et al.,* 2002, section 4.8.2) which also served as important driver promoted Charawe residents to cut more forest products.

In mid-1990's - global recognition of the importance of forest natural resources conservation attracted the intention of various donor supported projects to support Zanzibar government in achieving its conservation objectives of their natural resources (section 4.8.2). Jozani Chwaka Bay Project (funded by CARE and Ford Foundation) worked with DFNRNR between 1995 and 2003 to support the establishment of JCBNP (JCBCP, 1996) by firstly increasing Jozani Forest reserve from 2,512ha to 5,000ha (JCBCP, 1995). These policy changes marked a period where Charawe residents noticed a remarkable disturbance that was perceived by villagers to cause serious decline in access to village forest land. Consequently in 1996, Charawe village lost significant forest land both terrestrial and Mapopwe mangroves which converted to form part of Jozani Chwaka Bay Nature Conservation Area (JCBCA) which was declared to national park in 2004 (RGoZ, 2004; Village elders FDG and KIIs).

At the same time the project influenced changes of forest management regime from the State to CBNRM in 1996 (section 4.8.2). CBNRM was introduced in Charawe where the villagers were persuaded by the Government to establish a VCC in 1996 and formulate RUMA in order to control wood trading activities in Charawe and ultimately reduce excessive wood cutting from the village (Ely *et al.,* 2000). Charawe mangroves were not involved in this management system but continued to be governed on the same alternating of 'opening and closing' harvesting system between the two mangrove blocks. Whilst this regime shift intended to provide community more access to their forest resources (Zanzibar Forest Policy, 1996) the formulated village by-laws put more restrictions on the uses and access of village coral rag forests by putting more than half of this forest under full conservation zone including a complete ban on selling any wood products (Finnie, 1997b). The communities were provided with small-scale alternative income livelihoods designed to have a smaller impact on the environment. However, the introduced alternatives perceived by Charawe communities were not effective to support their livelihoods.

On the other hand in late 1996 villagers reported experiencing restrictions on fishery resources when government, through the department of fishery, put restrictions on harvesting of marine resources in Chwaka bay by imposing fishing ban following the conflicts between Chwaka and Marumbi fishers over fishing grounds and fishing gear. This conflict let to a series of fights with gear destruction, injured fishers and death of one fisherman from Marumbi Village (De la Torre-Castro and Lyimo 2012, also FGD with VCC and KII with deputy Sheha). Consequently Charawe villagers suffered from the clamp-down on illegal fishing in Chwaka bay which prohibited the use of nets of mesh sizes below 1.5 inches which many of the fishermen were accustomed to using (Ely *et al.*, 2000). This situation resulted in serious economic hardship to Charawe communities who were also depending on fishing for their sustenance (Jiddawi, 1997).

Focus group discussion with village leaders and the Sheha reported that in this period the majority of Charawe residents realised that the government interventions were not realistic and the formulated village by-laws cannot be effectively implemented. This is because the implementation of such laws would have direct negative effects on the accessibility of resources on which majority of the people depend. Therefore Charawe residents had no options but turned directly to the forests, and wood cutting and trading became major sources of income in the village during 1998 with smaller number of villagers involved in fishing and farming. In this period the level of terrestrial wood cutting was found to exceed the amount that the forest would produce and estimated that Charawe forest would have been exhausted within only 5 years (Ely *et al.*, 2000).

At the same time an indication of slight increase on the rate of mangrove harvesting and its impacts were reported between 1992 and 2001. For example Shunula (1996) reported a 25% increase in the amount of poles extracted from Chwaka bay mangroves. Due to increased cutting rates, Mapopwe mangrove (which is now under the National Park) was said to have been exhausted of all of its building poles one year before the area was due for closing and that Charawe villagers were forced to move to cutting building poles from Kinani mangrove (Ely *et al.,* 2000). In 1998 Charawe had a total mangrove area of 1,027 hectares with the total standing wood volume of 37,882m^3 (ibid). In early 2000 a detailed Chwaka bay mangrove inventory was carried out to examine the condition of the system and provide management directives. Chwaka bay mangroves were reported to have all 10 mangrove species found in Zanzibar following the identification of *P. acidula* in the bay (Jumah *et al.,* 2001). However there was a change on species dominance from *R. mucronata* dominated mangrove stands (Shunula and Whittick 1999) to *C. tagal* dominated mangrove stand (Jumah *et al.,* 2001). Consensus from FGD with mangrove harvesters showed that there was also a shift in provision of ecosystem services from building poles towards cutting mangrove wood for commercial firewood while mangrove charcoal was still prohibited in the village. Villagers also reported although CBNRM approach operated between1996 and 2003, was not effective in halting the rate of forest cutting but greater commitment and implementation of project activities by project raised conservation awareness in the village and created harmony and linkage to stakeholders at higher level. In this situation Charawe VCC members were actively participating in supporting JCBCP activities especially patrolling and planting of mangroves.

The reported change in rate of wood cutting was equivalent to the rate of population growth in the village. High increase in human population was reported to be the main factor in this radical change in Chwaka bay (Madeweya *et al.*, 2002) which lead to a decline in resource abundance, damage to mangrove forests (Masoud and Wild, 2000) and an increased pressure on fish stocks (Nasser, 1994). Other drivers of changes as reported by villagers include policy changes and lack of reliable alternative income in the village.

Consequently Government took some measures to control mangrove harvesting by collapsing of the 'closed and opening' management system of mangrove harvesting seasons between Kinani and Mapopwe mangrove blocks in 2000 (Ely *et al.*, 2000). In this period Mapopwe mangrove block were closed while Kinani opened without any further notice up to the time of this study. However Charawe mangrove harvesters claimed that this government decision was made with no enforcement such that Government through DFNRNR staff continued to issue user permits to communities around the bay for harvesting mangrove wood poles in both mangrove blocks until 2006. A General Mangroves Management Plan for Chwaka bay was prepared in 2001 but has never been put into practice. In 2004, the Mapopwe mangrove blocks were raised to conservation status following the declaration of JCBCA as a National Park (Jozani Chwaka Bay National Park Order, 2004) leaving Kinani under the former management status as a forest reserve. People from Charawe did not participate in the decision making process; they were discouraged from containing to participate in mangrove conservation activities around the Park. Charawe villagers were not happy with the government decision and this exclusion has created a feeling that they have been ignored as they are not responsible for protection or management.

Villagers reported that these interventions coincided with the period between 2004 and 2006 when donor support was not available and government (from both fisheries and forestry department) has no sufficient resources to continue with the activities introduced by the projects and enforce the laws. Poor enforcement of National Park laws and regulations and no obligation to protect the forest served as an incentive for the local communities to continue cutting mangroves and extract other village marine resources. Therefore, livelihood activities in Charawe were achieved through illegal harvesting of village resources as perceived by the Government (KII with Jozani park warden); focused on harvesting of terrestrial and mangrove wood products and fishing while few people engaged in farming.

Between 2007 – 2013 a period of active enforcement of government laws (Fisheries and Forest conservation laws) following the availability of donor funded projects represents a time of serious resources restrictions that as perceived by villagers intensified degradation of Charawe mangrove system. In 2007 to 2010, MACEMP strictly enforced fishery laws to prohibit the use of nets of mesh sizes below 1.5 inches to which many of the Charawe fishermen were accustomed. In this period villagers reported experiencing difficulties on accessing fisheries resources which perceived by villager to significantly reduced number of Charawe residents engaged on fishing who were adversely suffered from economic crisis in the village. Village resource restrictions was worsened when DFNRNR put a complete ban on harvesting any mangrove products mainly by stopping permits being issued throughout the islands in 2007.

CARE Tanzania worked in Zanzibar Islands in 2010 to pilot methods for reducing emissions from deforestation and degradation ($REDD^{+}$) through HIMA aimed at helping the forest dependent communities around JCBNP to gain access to carbon market funding through the conservation of village/community terrestrial forests (section 4.8.2). Charawe was selected to be one among the four villages piloting $REDD^{+}$ where by about 70% of its terrestrial forests has been allocated and conserved for this project (Draft revised COFMA, 2012). FGD discussion with VCC members confirmed that most of the village land entered under HIMA project was formally used by Charawe residents to meet their wood related needs and cleared for shifting cultivation in the village. In this case this project has further reduced access to forest resources and increased scarcity of livelihood options that most of the residents relied on. The project has also suggested that Charawe mangrove located outside JCBNP should be included under HIMA (Draft revised COFMA, 2012). This idea was rejected by most villagers who believed that the initiative will further reduce their access to village resources and achieving full control of the forests will be difficult because the mangrove outside JCBNP is accessed by several outsiders (Interview with Deputy Sheha, 2013).

HIMA project in collaboration with other NGOs such as JECA and WEZA has been providing small-scale income generating projects to Charawe residents. Such projects included the introduction of saving and credits groups, (see section 7.5.1), provision of seed funds for entrepreneurs, and the establishment of tree wood lots. In 2013 Charawe villagers received small carbon grant of 10,500,000TSHS (£4200) to support conservation activities, diversify income sources for the special need groups such as widows, elders, orphans and other people with a high dependence on the forest resources. Other economic innovations introduced into the village to diversify peoples' livelihood activities have met with limited value. Notably crab fattening (abandoned after one year), improving farming system by planting commercial crops (lime, mango, coconuts – but no market access), beekeeping in mangroves (few people engaged), seaweed farming (extremely low price and affected by diseases). However villagers reported that most of these projects were not economically productive to generate sufficient income to support people's livelihoods and in most cases cover a small fraction of the society. With increasing restrictions on the uses of resources which villagers have mostly relied on in the past and without reliable alternative income sources, Charawe residents realised that mangrove is the most accessible resource currently available thus, continue to be extracted under high cutting pressure for mangrove wood for charcoal, building poles, firewood and lime.

7.8.1 Assessment of Current Phase of Change of Charawe Mangrove SES

Although mangrove in the Charawe Shehia is managed under two different management priorities, there is no difference in the phase of change that the system currently resides in between Mangrove inside and outside the National Park. According to the Adaptive Cycle concept, Charawe mangrove SES has gradually changed and currently moved toward the back-loop of the Adaptive cycle under the release phase (Ω – omega) which is defined as the current state of social ecological system. In this phase the ecosystem has experienced significant changes signifying gradual regime shift towards an undesired ecological state.

There were clear changes in the mangrove ecosystem. Importantly there is an increased rate of mangrove harvesting indicated by high number of stumps of 1,052 stumps/ha which is almost equal to its standing density. This is a relatively high rate of degradation compared to the rate of mangrove cutting indicated by 522 stumps/ha observed in Charawe 12 years ago (Jumah *et al.*, 2001). Other observed changes is the reduction in vegetation cover (accepted by 82.5% of the respondents) and relative increase of average number of seedlings from 43,821 seedlings/ha (Jumah *et al.,* 2001) to the current seedling density of 43,932 seedlings/ha.

The observed changes were reported by villagers to have caused significant impact to the ecosystem. Household interview results indicated the excessive cutting in mangrove have resulted in increased difficulties in the availability of mangrove products (67.5% of the respondents) such that it became necessary to use automotive boats to travel very long distances to acquire the desired mangrove products. Other related impacts are the decline in the availability of some fish species, lobsters and crabs in the mangrove (50% of the respondents), high proportion of small size dominant trees with scattered mature old mangrove trees (55% of the respondents) that provide building poles of low quality while few respondents (30% of the respondents) experienced beach erosion along the costs. FGD with mangrove harvesters reported the decline in the availability of some of less dominant mangrove tree species especially *P. acidula, A. marina* and *X. granatum* in the ecosystem.

Local residents noted clear changes in the society. About 92% of the interviewed respondents agreed that there is significant increase number of mangrove harvesters which have increased the amount of mangrove wood provisioning ecosystem services harvested for meeting livelihood needs. Ely et al. (2000) estimated that about 64% (140 people) of the working men in Charawe were depending on wood cutting as primary income generating activity in 1998. This level of dependence is lower than the current rate of mangrove dependence alone on which about 85% and 67.5% of Charawe residents of both gender engaged directly in mangrove harvesting for firewood and charcoal respectively as their income sources. Mangrove harvesting contributed 24% of the average household income in early 1990s (Nasser, 1994) which is lower than the current level of 70% of average household income contribution. There has also been a clear shift in the uses of ecosystem services from mangrove selective harvesting for poles and firewood production alone (Ely *et al.*, 2000, Madeweya *et al.,* 2002) to increased clear cutting for charcoal production including stumps and roots extraction as supported by 82% of the respondents. A change of harvesting technology was evident whereby the use of chainsaw in place of axes for mangrove harvesting has become a common technique in Charawe (personal observation) thereby increasing the vulnerability of the forests to be degraded more rapidly. FGD with mangrove users and 50% of household interview noted significant changes on the mangrove management from the desired opening and closing that allowed some use of the resources to more restrictive management approach that denied them access and uses of mangrove products and other village resources. The current management of mangrove in Charawe involves combination of State–weak ad hoc implemented approach and informal/traditional management institutions which are performed and expressed by people's daily activities. For example, Charawe residents reported to experience fishery restriction in the last 3 years following the government effort to control illegal fishing gears practiced by majority of the fishermen around Chwaka bay. Likewise significant portions of terrestrial forests of Charawe Shehia have been conserved for piloting REDD$^+$ projects in the village.

These changes are reported to have caused significant impacts to Charawe social system. Importantly villagers noted that the current management system has caused shift on peoples livelihood from terrestrial wood cutting, fishing and agriculture to domination on mangrove cutting as a main livelihood options. This situation has further narrowed the livelihood options independent of forests, most of them with low economic returns while others have actually encouraged mangrove cutting (FDG with VCC). Local stakeholders have been discouraged from participating in conservation activities except a few VCC members who are obtaining short-term benefits when they are attending seminars or meetings. Consequently, villagers have strongly united to exploit the mangroves in a way that they can secure their livelihoods, even if only in the short term (section 7.4.1). Despite these short term benefits villagers reported a number of negative effects as a result of cutting of mangrove. Charawe villagers claimed that mangrove cutting is not an easy option and is done at considerable cost of their health and future development of their children. They particularly agreed (85 % of the respondents) that there is increasing incidence of cutting wounds and health effects for the people engaged on cutting mangrove. The availability of money through mangrove cutting has also attracted young village members including school children which have promoted school age truancy/dropout (60% of the respondents) and increased anti-social behaviour in the youth as they have access to cash at very young age (40% of the respondents).

Poverty, population expansion with high demand for mangrove provisioning ecosystem services and inefficient management system that put excessive restrictions on previous common livelihood activities without reliable alternative income sources were reported by Charawe communities was the main current underlying drivers that have accelerated high rate of mangrove cutting in their village. Other current underlying drivers reported by villagers to cause social ecological changes include market availability of wood products, lack of reliable alternative energy sources and lack of employment opportunities to majority of young village residents. Consensus from all respondents indicated that high rate of mangrove harvesting was the main direct driver caused changes in the ecological system.

The potential future drivers reported most of the respondents include availability of tourism and carbon market, availability of alternative energy sources and changes in mangrove management approach/policy.

Chapters 5, 6 and 7 provided case study descriptions on the current state that define the mangrove SES identity based on the components-interaction-innovation and continuity framework. The chapters also described the changes and their impacts on each mangrove SES case study. As the future is always uncertain, it is necessary to be prepared in order to minimise the risk that future shocks and uncertainties might affect the future. This can be achieved by developing multiple potential feasible futures that provide dynamic views of the future by exploring various trajectories of change that lead to a broadening range of plausible alternative futures. Chapter 8 does this by firstly presenting sets of assumptions on interacting drivers of change used for scenario development and finally ends with descriptions of each of the three sets of plausible alternative futures for mangrove SESs in the next 25 years as generated from socio-economic and mangrove biophysical data generated during FGD, stakeholder meeting and mangrove surveys as well as data from from secondary sources (see sections 3.5.3.2, 3.5.3.5 and 3.5.4.1).

Chapter 8

PLAUSIBLE FUTURE SCENARIOS FOR MANGROVE SES

One of the useful planning tools for building resilience in SES is structured scenarios building (Folke *at al*., 2002) especially in complex and highly uncertain situations related to ecosystem resource management dilemmas (Alcamo *et al.,* 2005). As suggested by Cumming *et al.,* (2005) the development of a few or a set of plausible alternative future systems is necessary in order to assess whether the system will maintain or lose its identity over the defined time horizon of interest under specific conditions and perturbations**.** Scenarios are not predictions but are storylines of the futures (Cork, *et al.,* 2005; McKenzie *et al*., 2012) that can be used as tools to allow stakeholders to envision multiple alternative futures and actions that might attain or avoid particular outcomes leading to more effective conservation policies (Peterson *et al*., 2003) that meet the needs of all stakeholders.

Scenarios are of different types and are developed using different approaches, including intervention, exploratory, projection (Mietzner and Reger, 2005; McKenzie *et al*., 2012) and vision or participatory back-casting scenario (Robinson, 2003). This study used an 'exploratory' or 'possible futures' scenario approach which drew on socio-economic and mangrove biophyical data generated during FGD, stakeholder meeting and mangrove survey as well as data from secondary sources (see section 3.5.3.2, 3.5.3.5 and 3.5.4.1). This approach offers a systematic structured way to investigate highly uncertain, unknowable and complex futures (Alcamo *et al.,* 2005; McKenzie *et al*., 2012) based on interactions of drivers of change which is a common feature of mangrove SES.

Using this approach allows exploration of how factors beyond direct human influence might shape the future (McKenzie *et al.,* 2012). The use of a scenario technique provides a flexible and appropriate way of describing multiple plausible future states (and associated major drivers) (Mietzner and Reger, 2005; Varum and Melo, 2010) and thus helps to generate strategies to reduce risks, to take advantage of opportunities and avoid potential threats (Miller and Waller, 2003). A Scenario approach open up the mind to unimaginable possibilities and to recognise 'weak signals', technological discontinuities or disruptive events and include them in long-range planning (Mietzner and Reger, 2005). Consequently a scenario approach may persuade managers to radically rethink the hypotheses on which they have grounded their strategy. This can help make organisations to be better prepared; avoiding the risk of being surprised and better able to handle new situations as they arise (Miller and Waller, 2003; Mietzner and Reger, 2005). Another benefit of using a scenario approach is that it helps improve the learning and decision-making processes and in the identification of new issues and problems which an organization may have to face in the future (Varum and Melo, 2010). In addition, scenario development processes can improve communication and coordination whereby aims, drivers of change and strategies of the interventions are shared between the participants which is important for supporting implementation of actions (Mietzner and Reger, 2005; Bishop *et al*, 2007).

Although the scenario approach has been used in various fields. particularly for planning and decision making in the face of uncertainty, a number of limitations have constrained its wider applicability. It has been claimed that the scenario building approach puts a strong emphasis on the involvement of participants/researchers with deep understanding and knowledge of the field under investigation, which in practice this could not be an easy task to fulfil (Mietzner and Reger, 2005). At the same time, the nature of the scenario development approach requires collection and interpretation of data from various sources. This has necessitated the integration of a more qualitative approach for contextual scenario development which makes scenario building even more time-consuming (ibid, 2005; McKenzie *et al.*, 2012). Whilst the technique offers participants a deeper understanding of how events and drivers can interact to create different futures (Varum and Melo 2010), the judgement on the impacts of defined drivers requires very experienced experts to train others how to do it, whichis not always easy to achieve (Bishop et al 2007). Similarly it has been argued that application of a scenario approach to fully characterize the uncertainties of the future using just a few dimensions andlimited data may give invalid estimates of the influence of all alternatives against all other alternatives (Bishop, et al. 2007). In addition, despite extensive application of scenario techniques in diverse fields, the relationship between scenario planning and firm performance or trying to evaluate the accuracy of the outcomes of a scenario has not yet being clearly studied (Mietzner and Reger, 2005).

A number of drivers were identified from FGD, participatory stakeholders' meeting as well as secondary sources (section 3.5.3.5) for the development of these scenarios (Table 31). Among several drivers, villagers and other stakeholders reported that poverty (income earning of households) (section 8.2; Hussein, 1995, Mohammed, 2004; McLeod and Salm *et al.*, 2006) and markets for trading different mangrove ecosystem services were the most important. Other associated underlying drivers were population growth, government political will and priority on conservation (Semesi 1992, 1998, Kairo 2001), inefficient policy and management institutions (Rajarshi and Rajib, 2013), national economic growth reflected by GDP (RGoZ, 2010), and access to alternative energy sources cheaper than biomass fuel (including relatively expensive energy technologies but heavily subsidised by the Government) (Rashid, 1991; MEA, 2005). Although climate change, especially the impact of rising sea level, is generally considered as an important driver that has already affected mangrove systems in many parts of the world (Alongi, 2002; McLeod and Salm, 2006; Gilman *et al*., 2008) these scenarios did not consider expected future impacts of climate change. This is because most of the respondents during FGDs perceived that climate change had caused no significant impacts to mangrove ecosystem of Zanzibar to date (also Sheikh, 2011) and the period under consideration is the next 25 years.

Both quantitative and qualitative data generated from household interviews, mangrove surveys, stakeholders' meeting and literature surveys were combined and used for the development of these scenarios (as suggested by Cork *et al.,* 2005). Based on extrapolation of past and current trends using data on current states and changes of mangrove SES presented in chapter section 5, 6 and 7) and by a combination of various interactions among the drivers of change and under specific assumptions about their potential outcomes generated during the stakeholder meeting (section 3.5.3.5), three sets of scenarios were developed representing three plausible alternate futures for the next 25 years. This timeframe was selected because it is the approximate period required for one tree generation (period required to achieve optimum production from mangrove trees as suggested by stakeholder' meeting participants – section 3.5.3.5). Common qualitative assumptions on the current and potential drivers for the development of these scenarios is presented and summarised in Table 30. The direction of change of each driver is qualitatively presented using three levels of responses of indicators. That is (0) = if there is no or slight change in driver (s) between 2013 and 2038, ↑ = if the driver (s) increased or available between 2013 and 2038, and ↓ = if the driver (s) declined or is not available between 2013 and 2038.

Table 30 Potential responses and assumptions on drivers for development of mangrove SES plausable future scenario based on seconadary data, stakeholder meeting outcomes and further interpretation by researcher.

Drivers	**Coastal Boom scenario**	**Techno-green scenario**	**Non-inclusive State Control scenario**
Population growth	↑	↑	(0)
Dependence on mangrove harvesting and biomass fuel	↑	↑	↓
National economy	↑	↑	(0)

Poverty of local people	↑	↓	↑
Alternative income sources	↑	↑	↓
Political will and priority on conservation	(0)	↑	↑
Reliable and affordable alternative energy sources	↓	↑	↓
Effectiveness of management institutions	↓	↑	(0)
Market for biomass fuel	↑	↓	↑
Ecotourism	↓	↑	↓
Conventional tourism	↑	↓	↓

8.1 Coastal Boom scenario 2013 - 2038

The Coastal Boom scenario represents a future that assumes many of the current drivers persist. Under this scenario, as in most other least developed countries, Zanzibar experiences high population growth (section 4.5) and high levels of poverty (section 4.6) with corresponding high dependence on the use of bio-fuel as the major source of energy. For example, in 1985 Zanzibar had a population of 620,000 people with a total wood fuel consumption of about 600,000m^3 (Jaakko and Oy, 1987). The wood fuel consumption increased to 1,000,000m^3 in 2002 to meet the domestic energy needs of 984,625 people (Magessa, 2008) whereby in 2011 about 94% of domestic energy was derived from biomass energy (Owen, 2011) from both terrestrial and mangrove forests. High biomass energy demand accelerated the rate of mangrove/terrestrial forest harvesting at the village scales such as in the Charawe, Pete and Kinani mangrove forests. Results from household interviews indicate that Charawe is currently composed of about 67.5% and 85% of the households engaged in direct commercial exploitation of mangrove wood provisioning ecosystem services for charcoal and firewood, respectively (section 7.3.3). As a result, analysis of household interview data indicate that an average annual amount of 76,608 charcoal sacks and 255,732 firewood bundles are being harvested for commercial charcoal and firewood, respectively, from mangrove inside and outside JCBNP (Table 26 section 7.3.3.1). Considering an average weight of 33kg/charcoal sack and 16kg/firewood bundle (measured in this study), the harvested amounts give an average annual total of 2,528,064kgs (2,528tonnes) of charcoal and 4,901,712kgs (4,901.7tonnes) of firewood (Household interview data in Table 26 section 7.3.3.1). This corresponds to an annual mangrove wood harvest of 20,072m^3 for charcoal and 3,437m^3 for firewood based on Owen's (2011) wood conversion factor of 7.94m^3 and 0.84m^3 per tonne of charcoal and firewood, respectively. The relationship between the current rate of tree removal and standing density of mature plants in these sites suggests a high rate of harvesting (section 5.2.3, and 7.2.3 in Chapter 5 and 7, respectively). In mangrove SES like Pete the current average rate of mangrove tree removal is 218 stumps/ha and 314 stumps/ha of one year age in boardwalk and Muungwi mangroves, respectively (Mangrove ecological survey data, section 3.5.4.1 and 5.2.3). Similarly the rate of tree cutting in mangrove ecosystems like Charawe and Kinani is nearly approaching its standing density (section 7.2.1) indicating high demand of wood products by the surrounding communities.

Given the existing economic hardship of the islands which are characterised by low per capita income of USD 557 (section, 3.5, RGoZ, 2010a), it is assumed that government efforts will focus on improving the economy and by 2020 Zanzibar will attain high economic growth of 12% annual increase in GDP (RGoZ, 2013a) through effective exploitation of the presumed existing petroleum resources (Zanzinews, 2014a). Initial preparation process is under way whereby a joint implementation committee has been established and a Memorandum of Understanding (MoU) between the Revolutionary Government of Zanzibar and Shell International signed for oil and gas exploration and production (Guardian news, 26 Jan, 2014). Zanzibar Government has directed its training institutions to offer short and long term training programmes and improvement of government sectors and policies are taking place to build capacity of communities and Government to effectively engage and benefit from the sector. Zanzibar economic development policy will also focus on dramatic expansion and investment in the tourism industry along the coasts (RGoZ, 2010) in the next 25 years. This government decision is based on its recognition that tourism is the most important sector for the economy of Zanzibar, contributing 47% of the GDP and 80% of foreign exchange earnings (RGoZa, 2013) following the fall of the clove world market price (Gossling, 2003). The presence of attractive sandy beaches, coral reefs and other natural attractions in mangrove SES like Michamvi will attract significant levels of tourist investment over the next 25 years. High level of tourism development along the Michamvi coast will need more land and beaches to meet the increasing demands of tourism investors to construct luxurious hotels along the beaches (Stakeholder meeting, section 3.5.3.5).

This scenario assumes that current trends continue in which mangrove conservation has received low government priority despite its understanding that the rate of mangrove harvesting and extraction of other coastal resources such as terrestrial forests and fish resources is currently unsustainable (Madeweya, 2002; Owen, 2011; Jiddawi, 1997). As in most African countries (Blaikie, 2006; Idemudia, 2009) it is assumed that the wealth generated though these sectors will improve national economic growth without benefiting the majority of Zanzibaris. Likewise it is expected that the Government, private sector and other development partners will not invest in the development of reliable and affordable renewable sources of energy or provide subsidies to help urban dwellers to adopt novel energy technologies. Community members will be forced to opt for the cheapest cooking fuel such as firewood and charcoal. The consumption of the available alternatives such as electricity, kerosene and LPG will lag behind the needs of a growing population (Owen, 2011).

Assuming the Mainland Government imposes a complete ban on exportation of any wood products to Zanzibar, this will further increase biomass energy demand on Unguja Island (Owen, 2011) and raise market prices for the harvested mangroves/forests for firewood and charcoal, together with building poles, from coastal villages. At the same time due to its low priority, it is likely that the Government will not allocate sufficient financial and technical resources to DFNRNR and other related sectors to effectively conserve the island forest resources (Stakeholder meeting results, section 3.5.3.5). Consequently DFNRNR and other government ministries related to natural resources management and community development will independently implement their plans. Implementation of DFNRNR activities and other departments will rely on donor support to enforce the unrealistic CBNRM policy desires of increased restriction and a complete ban on extraction of any wood provisioning services and fish resources from the coastal ecosystem.

This arrangement has put significant terrestrial forested areas under carbon trading ($REDD^+$) projects (Draft revised COFMAs, 2012) and introduced some alternative income activities that are not sufficiently profitable to significantly contribute to household income needs for the majority of poor households.

This arrangement slightly encouraged communities to participate in management as a means to achieve the government aim to attain its conservation objectives. For example, the introduced carbon selling project has attracted the interest of most residents to conserve terrestrial forests under the $REDD^+$ project expecting high financial returns in the future. This situation has resulted in a shift in their cutting demand to the nearby forest resources to meet household needs of the villagers (section 8.2.2.1 and TAF, 2013). At the end of donor support it is assumed that DFNRNR will suffer from a shortage of funds and other resources resulting in the collapse of all donor initiated activities and with no enforcement to implement its plans (section 5.4.1, 7.4.1). Absence of alternatives and inefficient management will automatically create a negative reaction and lose the trust of local communities to conserve mangroves which will serve as an incentive to increase the rate of cutting in the next 25 years by local communities.

Assuming Charawe's population growth rate of 2.0% will be maintained, the village population will nearly double and reach 2,097 individuals in the next 25 years (Table 8). The addition of 1,047 people will double the total number of current households by 2038. This will certainly increase the number of poor unemployed young villagers who lack capital to engage in other projects that will generate funds to sustain their lives. Consequently, with no alternative income sources, the number of commercial mangrove harvesters will increase as mangrove cutting is the most probable livelihood activity that can be initiated with no or minimum capital in the village. If the mangrove cutting activity will increase in proportion with population, an average annual amount of commercial mangrove wood harvested for charcoal and firewood alone will be twice the current level to reach 40,145.7m^3 and 6,874.1m^3, respectively, by 2038.

Charawe's current mangrove stock has an average of 38.09m^3/ha for mangrove of 755.25ha inside JCBNP and 32.54m^3/ha for mangrove area of 111.47ha outside JCBNP which provides the total standing stock of 33,063.54m^3 in both mangrove locations. Considering mangroves' wood biomass increases by a mean annual increment of 2m^3/ha/year (Magessa, 2008), Charawe mangrove can sustainably provide a total of 1,733 m^3/year (threshold) an amount which is 13 times lower than the current rate of harvesting (section 7.3.3.1). Similarly in Pete-Jozani current mangrove stock has an average standing density of mature plants of 4,210 and 3,035 trees/ha in boardwalk and Muungwi mangroves, respectively (section 5.2.1). With this harvesting level it is suggested that most of the mature mangrove plants will be cut by 2016 while Pete mangrove trees will be completely removed in the next 19 and 9 years in boardwalk and Muungwi mangroves, respectively, several years before 2038 (Table 9, section 5.2.3). At the same time it is assumed that DFNRNR will use limited resources to control illegal cutting inside JCBNP for firewood and charcoal which together with wood harvesting from COFMs' areas will contribute 40.2% of the average household income for about 57.5% of Pete-Jozani households (section 5.5.1 and 5.52). This will increase economic hardship of Pete residents.

On the other hand with low priority given to mangrove conservation compared to tourism investment it is assumed that in Michamvi the Government will sell significant land along the beach including mangrove areas to tourism investors for hotel construction without any community consultation as reported in other parts of the world (Ellison and Farnsworth, 1996; Wang *et al.,* 2003). Unplanned mass conventional tourism will also result in a high population of immigrants who will increase the pressure on the available village resources and tourism related income opportunities on which local people will depend. Significant number of immigrants who have high level of education and knowledge of other language will benefit more from tourism development than natives in Zanzibar (Gosling, 2005). At the same time, if the expected oil will be extracted in mangrove areas, this will cause serious environmental impacts in mangrove areas as reported elsewhere (Idemudia, 2009).

The excessive harvesting and/ or conversion of mangrove forests for hotel construction and oil exploration will result in Coastal boom mangrove degradation. It will not be possible to maintain most of the mangrove ecological indicators and this will move the ecosystem toward the collapse phase (Ω) of the Adaptive Cycle. In this phase the ecosystem will be marked by reductions in mature mangrove trees and seedlings below thresholds, impacting regeneration capacity and ecological resilience.

This scenario will result in loss of the supply of ecosystem services (Table 31) to village stakeholders especially wood provisioning ecosystem services, honey from beekeeping and a decline in the availability of mangrove fish and crabs due to destruction of their breeding sites and mangrove ecotourism sites. It will also reduce ecotourism opportunities and biodiversity value and lead to a decline in carbon sequestration, but will maintain the limited supply of other ecosystem services (Table, 31) that might not be desired by locals.

The decline of wood products in Pete and Charawe will also reduce the financial returns from wood harvesting and beekeeping benefits below the minimum income required by mangrove harvesters to cover their basic needs (thresholds). Likewise the decline and or disappearance of mangrove ecosystem and associated ecosystem services in Michamvi will also decrease the financial returns that are currently obtained by local communities through ecotourism (13% of the average household income) and thus threaten the diversity of the available income activities in future. This, together with high pressure on the available livelihoods, will reduce social resilience unless sustainable alternatives are developed.

8.2 Techno-green scenario 2013-2038

This scenario represents a future whereby the Zanzibar Government will have sufficient resources and political will to implement their development plans. According to plans by 2020 Zanzibar will eradicate abject poverty and attain sustainable economic growth which will raise the Isles per capita income to that of middle income countries (RGoZ, 2010). This scenario is based on the assumption that although Zanzibar will experience high population growth to 2038, it will attain high economic growth, social and environmental welfare in the island. This is expected to be achieved if Zanzibar will effectively manage to exploit the petroleum resources that are presumed to exist (Zanzinews, 2014a) in the next five years.

The optimistic assumption of local people is that successful development of the petroleum industry will create some employment opportunities for the growing population to reduce household poverty and improve general country development (Stakeholder meeting results, section 3.5.3.5). Empirical evidence indicates that most oil-exporting countries illustrate few of these benefits, which consequently suffer from 'resource curse' resulting in negative socio-economic and environmental outcomes (Robinson *et al.,* 2006; Blaikie, 2006). However, some success has occurred in Norway which, through the presence of institutions that promote accountability and State competence, has used the benefits of North Sea petroleum to achieve a strong social development performance (Robinson *et al,* 2006). High economic growth will also arise through large-scale expansion in tourism sectors along the coasts which will create tourism related employment opportunities to locals. It is suggested that small-scale locally- owned tourism business in some developing countries created a form of pro-poor tourism that provided reliable household income as a useful component of local economic strategies for the poor to protect the environment (Lepp, 2007; Mbaiwa and Stronza, 2010). This government aim fits well with the long-term Forest Department goal which intends to put at least 40 % of mangrove forests to be managed as tourist attractions by 2015 (RGoZ, 2010b) and control the level of harvesting.

This scenario assumes that Government will improve the limited access to modern and affordable energy services on the Island as an important contributor to the poverty levels and low economic development. To resolve this problem it is expected that Government and other development partners will put significant efforts to invest, develop and increase access to adequate, clean and affordable energy sources to the majority of residents who are currently depending on biomass energy (Stakeholders meeting section 3.5.3.5). In this case energy investment will create new sources of domestic energy such as LPG and potential renewable sources of energy such as solar, wind and tidal energy from the ocean that can significantly minimize bio-fuel energy demand. Subsidies will be provided to help rural and urban dwellers to adopt the novel energy technologies reducing demand for firewood and charcoal (Energy Policy, 2008).

Under the scenario of high economic growth and strong political will on mangrove conservation it is expected majority of stakeholders' meeting participants that the Government will allocate sufficient financial and technical resources to effectively implement mangrove plans and allow realistic participation and empowerment of local people and their institutions in mangrove management before the collapse. DFNRNR will achieve its plan by controlling illegal cutting activities in the park and by effectively extending the application of flexible co-management approach at the village level. In mangrove SES like Michamvi and other mangrove SESs, Government will strengthen and recognise the importance of participation of locally oriented institutions through the influence of local leaders and delegate ownership and use-rights to forest users. This management approach will re-build community trust, synergies and commitment of the elders and that this will provide a learning platform for the young generation to actively conserve the forests. Byers *et al*. (2001) reported that local institutions have been successful in conserving forest patches in northern Zimbabwe on which the influence of village leaders and religious beliefs has played a significant role in controlling forest degradation.

The government focus on this arrangement is not only to use people as a means to achieve conservation goals but also to improve the income and well-being of mangrove/terrestrial forest dependants. It is assumed that successful development of reliable alternative income generating activities will be achieved if there will be inter-sectoral coordination of ministries responsible for natural resources and those responsible for community empowerment (Stakeholders meeting, section 3.5.3.5). The coordinated sectors will work together to manage all coastal resources on which communities depend. A joint effort will also support mangrove/forest dependants such as in Pete and Charawe to support and improve productivity of diverse, reliable and economically feasible alternative economic activities that will generate the amount of funds to compensate for the benefits which were obtained from commercial harvesting for fire wood and charcoal production. For these innovations to be reliable they should cover a large proportion of people and generate at least 67% and 40.2% of an average monthly average income, which is the amount that is currently obtained through selling of firewood and charcoal by Charawe and Pete residents, respectively (section 6.5.2 and 5.5.2).

It is assumed by most of respondents that the availability of a global tourism market in mangrove SES like Michamvi and other areas will be well planned and controlled such that it will support a large proportion of young people to maintain and improve availability of reliable and diverse employment opportunities in the village. For example current tourism including mangrove ecotourism contributes 22% of the household income (section 6.3.4.2). It is likely that further availability of ecotourism and tourism markets for trading fish and cockles, and local products will create more diverse and reliable income sources to cover the needs of the future growing population (Stakeholders meeting, section 3.5.3.5).

The realisation of direct economic benefits from conservation and general improvement of communities' well-being will be likely to reduce conflicts and create positive views on conservation. This together with the control of the market for biomass fuel will reduce the number of commercial mangrove/forest harvesters who have direct dependence on mangroves as their main livelihood option in the villages (Stakeholders meeting, section 3.5.3.5). Assuming that the number of mangrove dependants will increase in proportion to the Charawe population growth of 2% annually (section 4.1), the community empowerment program at Charawe will be effective if it will develop reliable income sources that will completely remove at least 4% of the households engaged in mangrove harvesting from dependence on commercial firewood and charcoal activities annually. This will ensure there will be no commercial harvesters in Charawe by 2038. In this way in mangrove SES like Pete and Charawe villagers will change their perception from seeing the forest as the only source of quick money and engage in the exploitation of non-provisioning ecosystem services and other introduced and available livelihood activities in the next 25 years (Stakeholders meeting, section 3.5.3.5). Similarly the Government will resolve some of the resource scarcity conflicts to ensure fair boardwalk income distribution between Pete and Jozani village and allow a low rate of subsistence emergency mangrove harvesting in all mangrove ecosystems (ibid, section 3.5.3.5).

By doing this, it is probable that by 2038 cutting pressure will be reduced and will limit the possibility of the villagers to shift their cutting pressure to mangrove in the future. For example, Vijichuni mangrove currently has an average rate of mangrove tree removal of 99 stumps/ha of one year age. With its current standing density of mature plants of 4,110 trees/ha, and without replanting, Vijichuni mangrove can maintain this rate of harvesting sustainably for the next 41 years (section 6.2.2 and 6.2.3). This will allow the level of harvesting to be maintained below the threshold level and thus provide sufficient time for the mangrove to recover.

A low harvesting rate in all mangroves will allow them to grow and move toward conservation phase (K) of Adaptive Cycle characterised by high accumulation of natural mangrove vegetation cover, with sufficient number of mature plants to produce seedlings and enhance the ecological resilience. The presence of mature, less disturbed mangrove forest will provide green scenery along the coasts, increase the attractiveness of mangroves and balance the supply of desirable ecosystem services to all stakeholders (Table 31). Such ecosystem services include selective irregular harvesting of poles in specific areas, accessing the available ecotourism market, non-timber mangrove ecosystem services (e.g. beekeeping, carbon trading) which increase the available livelihood activities and therefore strengthen the social resilience.

8.3 Non-inclusive State Control scenario

Non-inclusive State Control scenario represents a future that assumes that Zanzibar will experience low economic growth in the next 25 years through the growth of tourism industry resulting from massive tourism expansion along the beaches to attract more investors (Stakeholders meeting, section 3.5.3.5). The tourism expansion will result in a continuous influx of coastal immigrants who are searching for the available tourism job opportunities (Zanzibar Tourism Policy, 2006). Under little increase of economic growth, it is presumed by most of stakeholders meeting participants that, the wealth generated will not boost the economy of the majority of the poor, and will not be able to control the market of mangrove wood provisioning ecosystem service because the government's capacity to develop reliable and affordable alternative energy sources for the majority of biomass users will be limited.

However, it is assumed by all government officials, representatives of local NGOs and some village representatives during stakeholders meeting that, the increase of global recognition on the importance of coastal resources will promote conservation awareness to national scale stakeholders, create positive political will on conservation and that government will consider the conservation of coastal recourses as one of the high priority activities in future. This government decision will result from the notion that proper conservation of forest resources will create attractive scenery that will serve as an additional tourist attraction on the Island (FRMCA, 1996).

As a result government will focus on the allocation of sufficient financial, technical and manpower resources to enforce laws to protect the mangroves and other forest resources.

This scenario is based on the assumption that under adequate resources availability in the DFNRNR, the Government becomes optimistic and feels that it is capable of controlling and maintaining an ecologically sustainable level of forest harvesting with limited community support. In this case, in mangrove SES like Pete and Charawe the Government will not put any efforts to develop alternative income sources for the local communities (Stakeholders meeting section 3.5.3.5). The migrants in tourism zone like Michamvi may create the pressure on the available resources, increase competition and reduce the available income options to local majority (Gossling and Schulz, 2005) and will create imbalance on the ecological knowledge sharing mechanism which will destroy the social memory of the system.

Instead Government departments responsible for forest resources management become coordinated to control extraction of any wood and put restriction on fish resources on which coastal residents depend (Stakeholders meeting, section 3.5.3.5). In mangrove SES like Michamvi, the management arrangement will not recognise the power of local institutions in the management of mangroves. Consequently the government measure to control the resources in all areas will be achieved through intensive and regular forest patrols by employed forest guards, District forest officers and patrol team from the Department. The strict law enforcement will be not only for the village residents but also focused on giving strong punishment to outsiders who are violating the laws including the traders of wood products. This will result in a significant reduction in the rate of extraction below the thresholds (ibid, section 3.5.3.5). In mangrove SES like Pete and Charawe the current amount of harvesting of wood provisioning services will not be accessible to them. At the same time the non-wood mangrove provisioning activities such as ecotourism and beekeeping and other limited alternative livelihood activities will not be available to a majority of residents. This situation will discourage local communities to manage the resources, forcing the majority of them to engage in low income activities such as agriculture which it is assumed will not be productive to support the basic household needs of the growing population. This will result in a significant reduction in the average income per house hold below the minimum (thresholds) (ibid, section 3.5.3.5).

In this situation economic hardship in the villages will consequently cause some of the village community to migrate from their village to look for other livelihood opportunities (Gossling, 2005). The remaining communities will enter into conflict with the Government through low rate of illegal extraction of village resources and sell mangrove wood products in the available biomass and tourist market to support their lives. Decline of population indicates the declining capacity of the ecosystem to sustain the components of the system and thus create undesirable social state suggesting significant loss of the social resilience (stakeholders meeting, section 3.5.3.5).

Low level of mangrove cutting will allow the ecosystems to remain under the forward loop of the Adaptive Cycle [exploitation (r) to conservation (K) phase). In this phase the ecosystem will be able to provide limited wood ecosystem services, supporting and some of the regulating services. However, the high conflicts between stakeholders will create unfavourable conditions for the market of non-wood provisioning ecosystem services such as ecotourism, honey and carbon trading (Table 31) which may not be desirable by the residents.

Differences in the expected ecosystem services between the three scenarios

Although with variations between sites, the general interpretation of past trends and current drivers indicates a declining trend in the quality of mangrove ecosystem with corresponding overall decreasing supply of ecosystem services of Unguja mangrove (section 8.1.1). The impact of different drivers on each scenario results on variations in the expected mangrove ecosystem services in the next 25 years is given in Table 31. The assessment and presentation of future ecosystem services can be done using software tools such as InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) whereby expected outcomes are depicted in the form of maps of land use changes (McKenzie *et al.*, 2012). Due to lack of quantitative data to put numerical values of these services and or model development, the supply of these possible expected future mangrove ecosystem services is presented qualitatively using three levels of indicators to show future responses to the trends of availability of ecosystem services. That is (0) = if the ecosystem services are slightly available in the ecosystem and used between 2013 and 2038, ↓ = if it is in greater decline or not available for use in 2038, and ↑ = if it is in better condition or available for use in 2038 (modified from Alcamo *et al.,* 2005). These expected ecosystem services are consistent with those indicated in each respective scenario.

Table 31 Expected outcomes on mangrove ecosystem services across the scenarios in 2038 – generated from stakeholder meeting, section 3.5.3.5

Ecosystem services	Coastal Boom		Techno-green		Non-inclusive State Control	
	Available in the ecosystem	Uses by stakeholders	Available in the ecosystem	Uses by stakeholders	Available in the ecosystem	Uses by stakeholders
Provisioning						
Firewood	↓	↓	↑	↓	↑	↓
Charcoal	↓	↓	↑	↓	↑	↓
Lime	↓	↓	↑	↓	↑	↓
Poles	↓	↓	↑	↓	↑	(0)
Withies	↓	↓	↑	(0)	↑	(0)
Beekeeping	↓	↓	↑	↑	↑	↓
Medicines	↓	↓	↑	↑	↑	↑
Timber	↓	↓	↑	↓	↑	(0)
Regulating						
Biodiversity	↓	↓	↑	↑	(0)	(0)
Carbon storage	(0)	↓	↑	↑	↑	↓
Supporting						
Erosion control	(0)	(0)	↑	↑	↑	↑
Protection of strong waves and winds	(0)	(0)	↑	↑	↑	↑
Fish habitats & others	↓	↓	↑	↑	↑	(0)
Cultural						
Ecotourism	↓	↓	↑	↑	↓	↓
Training	↑	↑	↑	↑	↑	↑

Source: stakeholders meeting and researcher interpretation in this study

This chapter described three plausible mangrove SES futures scenarios using a scenario building approach. Common identity of mangrove SES of Unguja needs to be defined along with its resilience to the increased rate of cutting and other drivers of changes need to be assessed. In achieving these further stages for resilience evaluation, as suggested by the resilience framework (Cumming, *et al.*, 2005), need to be completed and is discussed in chapter 9.

Chapter 9

GENERAL DISCUSSION

Mangrove is an important ecosystem that provides diverse ecosystem services to a wide range of stakeholders. Despite the benefits offered to the environment and societies, mangrove ecosystems have been threatened and undergone dramatic changes (Spalding *et al.,* 2010) caused by internal and external drivers of change. Resilience has been proposed as the central concept that provides a highly reliable and systematic way of analysing social-ecological changes and for assessing the capacity of mangrove ecosystems to maintain the supply of desirable ecosystem services in the face of human use and a fluctuating environment (Carpenter *et al.,* 2001). The aim of this study was to analyse the resilience of the Unguja mangrove SES to the current rate of harvesting and other drivers and perturbations. Resilience, as the term has been used in this study, is the ability of mangrove SES to absorb these various kinds of disturbances without changing the components, or relationships, source of innovations and continuity that define the social-ecological identity (Berkes *et al.,* 2003; Cumming *et al.,* 2005).

This chapter draws together the findings generated in this thesis to produce an assessment and discussion of the resilience of mangrove SES to the impacts of different drivers in the three case studies (Chapter, 5, 6 and 7). Gunderson and Holling's (2002) Adaptive Cycle provides a useful theoretical model for explaining how complex adaptive systems change over time. A hybrid (mixed) approach that combines the Adaptive Cycle approach and Cumming et al. (2005) framework is used here to discuss the changes in mangrove SES identities through three case studies. The approach has further been used later in this chapter for resilience assessment. Some resilience scholars argue that the Adaptive Cycle is not universally applied across SES as it fails to provide a direct relationship between connectivity and resilience (Holling *et al.,* 2002). However, both theories are relevant and useful to describe the dynamic nature of complex systems (Cumming *et al.,* 2005; Abel *et al.,* 2006) such as mangrove SES and allow a comprehensive resilience analysis. Whilst the Adaptive Cycle will be used to describe the trends and the phase each mangrove SES is currently residing in, the Cumming et al. (2005) framework describes system identity variables along with the resilience of mangrove SES as they were assessed at various defined phases. This is because mangrove stands can follow a natural series of phases over time like other forests, from the initial pioneering stage though rapid early growth and development to later maturity and death (Jimenez *et al.,* 1985). However, in interrupted ecosystems most of these phases are in transition showing a trend rather than a particular well-defined phase.

9.1 Past trends, current state and drivers for mangrove SES dynamic

Between the 1920s and 1970s mangrove SES from all case study sites were under the forward loop (r-k) of the Adaptive Cycle which was considered desirable by the local communities. A mangrove structure that defines the identity of a system in this phase of the Adaptive Cycle is represented by a closely covered canopy and is in a relatively pristine state. Typically the mangrove ecosystem is characterised by a high density of large-sized, tall mature plants with common mangrove tree species and diverse fish and other marine species. The ecosystem is dominated by species tolerant of environmental variation and adapted to modulate such variation as has been shown in other studies (Gunderson and Holling, 2002). The social components were characterised by relatively low populations with relatively a low level of dependence on wood provisioning services, socially cohesive with traditional knowledge on the value and management of the mangrove resources. Mangroves were managed traditionally by village elders whose knowledge, some associated with magic and/or influenced by Islamic values, was important for controlling exploitation of the resources. This traditional management approach was combined with or subsequently replaced by State management regimes such as the opening and closing harvesting system introduced in Chwaka bay. This provided communities with legal rights to extract poles of the desired quality which created positive interactions and linkages between social and ecological components of the system. Traditional management approaches provided a mechanism allowing the community to share their knowledge and experiences which served as a store of knowledge that was important for social and ecosystem continuity. The society had access to diverse village resources as alternative income sources (e.g. productive agricultural land and sufficient fish resources) and a base for innovation that reduced dependence on commercial harvesting of mangroves.

These mangrove SESs from each of the case study sites have changed in temporal and spatial scales and have entered into various phases in the past, as indicated in Table 32. Mangrove SESs have changed with people's access to diverse livelihood activities; and in particular, management institutions which have impacted on the level of dependence each of the study villages had on mangrove ecosystem services (Table 32).

Table 32 Comparative temporal and spatial difference on changes of mangrove SES generated from sections on changes of mangrove SES (sections 5.8, 6.8 and 7.8)

Time-line	Pete-Jozani	Michamvi	Charawe
1920s -1970s	- Closely covered mangrove forest at conservation K phase.	- Intensively covered at K phase for Kinani mangrove. - Community planted Vijichuni mangrove which reached maturity (K) in 1970s.	- Closely covered mangrove forest at K phase.
1920s-1947	- Mangroves and other village resources managed informally by respected village elders committees. - Influenced by people's traditional beliefs and/ or Islamic leaders.	- Joint opening and closing traditional management in Chwaka Bay for management of Kinani mangrove up to 1947 - Vijichuni was governed by strong informal Michamvi village elders committee, cultural beliefs and Islamic leaders.	- Joint opening and closing traditional management in Chwaka bay for management of both Kinani and Mapopwe mangrove blocks. - Influenced by traditional beliefs and Islamic leaders up to 1947.
1920s-1970s	- Local people were the main users of mangrove ecosystem services - Fishing and extracting good quality wood for poles and sawn timber for home uses were the main ecosystem services	- Mangrove used by Colonial companies for commercial bark and pole extraction, while community harvested poles for home uses in Kinani. - Vijichuni mangrove selectively harvested for poles by Michamvi Kae for home use.	- Commercial bark extraction and poles harvesting by Colonial companies - Selective harvesting for poles by villagers.
	-Agriculture, brick making, beekeeping and harvesting of terrestrial forest were the main livelihood activities. -Low dependence on mangrove products for home use.	-Farming, fishing, stone extraction and lime making were main activities. -Low dependence on mangroves for subsistence needs.	-Agriculture, followed by fishing were the main livelihood activities. -High access to village resources such as terrestrial forest resulted in low dependence on mangroves.
1965	- Declaration of forest reserve after Zanzibar independence in 1965 reduced villagers' access to village agriculture and forest resources.	- Declaration of forest reserve weakened community ownership but provided access to mangroves for home use for Kinani. - Vijichuni was not affected by this government decision.	- Declaration of forest reserve weakened community ownership but provided access to mangroves for home use.
1965-1980s	- Locals harvested poles for subsistence.	- End of commercial bark and pole extraction by colonial companies in Chwaka bay in 1963. - Locals harvested poles for	- Collapse of commercial bark and pole extraction in Chwaka bay in 1963. - Locals harvested poles for subsistence and few

		subsistence. - Vijichuni was cut intensively in 1977 and moved toward collapse in late 1970s.	residents engaged in selling of mangrove poles.
1995	- Declaration of JCBCA in 1995 influenced conversion of more village land into conservation areas - Farmer's crops affected by monkeys weakened informal institutions.	- Application of forest reserve laws weakened community participation for the management of Kinani but still active for Vijichuni mangrove management due to perceived resource ownership by locals.	- Significant portion of terrestrial and mangroves were declared a conservation area in 1995. - Weakened informal institutions
1996	- Introduction of restrictive CBNRM to control uses of terrestrial forests and pilot the approach on managing mangroves but with no enforcement.	- Introduction of CBNRM that restrict the use of terrestrial forests in 1996 but not applied to mangroves. - Collapse of opening and closing management approach for mangrove harvesting by communities in Chwaka bay in 2000 but with weak law enforcement. - Vijichuni was not affected by this government decision.	- Introduction of CBNRM that restricts the use of terrestrial forests in 1996 but not applicable in mangroves. - Collapse of opening and closing management approach for mangroves in Chwaka bay in 2000. - Mapopwe become part of JCBCA which was declared as part of NP in 2004, but with weak law enforcement.
1980s -1990s	- Livelihoods changed to commercial wood cutting from terrestrial forests between 1980s and 1990s	- Livelihoods changed to fishing followed by agriculture, seaweed farming and introduction of tourism (not engaged in by villages). - Use of destructive fishing gear in 1990s and serious economic hardship.	- Livelihoods changed to fishing followed by terrestrial wood harvesting.
Late 1990s-2005	- High population. - Community-Forest reserve conflicts on crop raiding and forest access. - Livelihood changed to commercial mangrove harvesting between late 1990s to 2005. - High dependence on mangroves for charcoal, firewood and poles.	- Rapid population growth, - Conflicts over fish resources and fishing ban in 1990s. - Increased rate of harvesting in Kinani mangrove for commercial firewood and poles, furniture by locals – moved towards collapse phase.	- Rapid population growth. - Community-government conflict over fish resources and fishing ban in 1990s. - High dependence on terrestrial forest harvesting for livelihoods.
2006-2009	- Community and government planted mangrove to	- Villagers planted Vijichuni mangroves moved towards conservation (K) phase.	- Low dependence on mangrove for meeting villagers livelihoods up to

	rehabilitate the degraded forest.		2006, but increase from 2007 to the current situation.

Currently mangrove from each of the study sites reside at different phases of change across the Adaptive Cycle (Figure 2). Pete is in the back loop of the re-organisation phase (**α**), Charawe (both inside and outside JCBNP) and Kinani have moved towards the collapse phase (Ω), whilst Vijichuni has moved towards the maturity phase (K) of the Adaptive Cycle. The variables that describe the current system components, relationship, innovation and continuity of each case are discussed here to indicate changes that have been taken place over the previous state. Table 33 indicates similarities and differences in the Mangrove SES identity for Pete, Michamvi and Charawe in the current situation.

Table 33 Similarities and differences between case study attributes that define mangrove SES identity

		Similarities	Differences with the Current status					
System attributes	Attribute variables		Charawe inside JCBCP	Charawe Outside JCBCP	Pete board-walk	Pete Muungwi	Michamvi Kinani	Michamvi Vijichuni
Mangrove structure	Mangrove tree diversity	9 species	9 species with 3 abundant	8 species with 4 abundant	7 species with 2 abundant	9 species with 3 abundant	6 species with 4 abundant	9 species with 4 abundant
	Average tree density/ha		2462	1084	4210	3035	2064	4110
	Dominant tree sizes/ha		76.5% small sized (2-5cm)	65.8% small sized (2-5cm)	86.2% small sized (2-5cm	91.5% small sized (2-5cm)	70% small sized (2-5cm)	51.9% large sized (>5cm)
	Average volume in m^3/ha		38.09	32.54	23.27	8.67	37.07	173.51
	Average stumps/ha		1052	1035	287	410	953	197
	Seedlings/ha		43,932	34,841	46,188	18,049	31,076	33,117
Social component	Diversity of stakeholders	Some higher scale stakeholders and local scale ecosystem users and formalised conservation groups & NGOs.	-Mangrove traders and transporters but village elders and religious leaders not actively involved. -No strong linkage to higher national stakeholders.		-Village elders and religious leaders not actively involved. -Higher stakeholders are working closely with local stakeholders. -No strong linkages between VCC and village youth members.		Village outsiders are the most important stakeholders.	-Strong local organis-ation (not named) at Vijichuni. -Tourists and tour investors are among the stakeholders.
	Knowledge systems	Formal and informal knowledge and sources on management and	Market chain, cutting tools and processing of wood products.		Local knowledge on beekeeping		Not known	Planting techniques, planting time, species selection, recovery time, ecotourism, forest rights and ownerships.

		conservation				
	Knowledge integration	Active implementation of knowledge from national scale stakeholders.	Traditional knowledge weakened and not integrated in the current system	Traditional knowledge weakened and not integrated in the current system	Higher scale stakeholders knowledge	All knowledge systems are integrated in the mangrove management
Ecosystem function	Dominant mangrove ecosystem services and stakeholder interests	Higher scale stakeholders have more interests on non-wood ecosystem services. -Local stakeholders are more interested on ecosystem services that have direct market value	- Mangrove wood extraction for firewood, charcoal and poles are the most important ecosystem services used by the locals (men and women) -This ecosystem service is in conflict with the interest of higher scale stakeholders	- Beekeeping and ecotourism are the most dominant ecosystem services. -Local community have strong interest in wood provisioning services but cannot be supplied by the ecosystem.	Kinani: wood provisioning ecosystem services are the most exploited services.	Ecotourism and crab harvesting are the most important ecosystem services to the respondents. -Local communities have low dependence on mangrove wood harvesting.
Ecological interactions	Plant-animal interactions	Not studied (plant- animal interaction) in this thesis. -Only few interactions observed during field observations.	-Very few beehives (2) were observed in the forests. -Some species of marine organisations (crabs, gastropods) were observed in the ecosystem.	-Observed insect pest, of larva of Lasiocampidae spp. in young planted *R. mucronata.* -Observed species of insects (e.g. bees) and marine organisms but not reported by villagers.	Not known	-Beehives were observed in the forests. - Some species of marine species (crabs, gastropods) were observed in the ecosystem.
Social interaction	Official management institutions (in theory).	-Mangroves are state property that need complete protection. -Locals are required to provide support	National Park. | Forest reserve.	Restrictive laws (COFMA) and Forest reserves with no ownership or use rights for wood products by the communities.	Forest reserve.	Forest reserve.

		through (CBNRM) to manage without any extracting wood products from the ecosystems.					
	Apparent management institutions (management institution in practice.		-No enforcement of formal institutions. - Informal institutions override the influence of formal institutions evidenced by the extraction of mangrove wood resources.		-Formal CBNRM in practice. -Communities agreed to carry out small-scale seasonal harvesting to meet emergency needs for poles controlled by VCC.	-Formal forest reserve institutions. -The system is not effective, locals harvest the forests to meet their needs.	Managed traditionally by local residents using local institutions with little influence of formal institution arrangements.
Innovation	Ecological innovation	-Planting has been reported to be done in different times at different scales in the past. -Mangrove from all study areas dominated by few abundant mangrove plant species. -Mangrove ecosystem does not allow for ecological innovation.	Reported decline on the availability of some mangrove tree and fish species gives indication on the decline of species diversity.		Reported decline in the availability of some mangrove tree and fish species gives indication of the decline of species diversity.	Not applicable.	No reported decline of availability of mangrove tree species.

Social innovation	Diversity and coordination of stakeholders, management institutions, and livelihood activities.	Low level of stakeholder coordination in all cases.	No good coordination between stakeholders and formal and informal institutions.	-No regular stakeholders coordination. -Slight recognition on the application of traditional knowledge.	No regular coordination of stakeholders and institutions.	-Local institutions allow coordination with formal ones. -Formal institutions have little influence on the management of the forests.
	Diversity of livelihoods	Respondents claimed that the available economic options are not economical powerful to meet basic livelihoods/or remove from forts harvesting.	Have limited reliable alternative income generating activities independent of mangrove wood cuttings.	Relatively diverse livelihood activities independent of mangrove wood harvesting.	Kinani village outsiders livelihood diversity are not known.	Relatively diverse and reliable livelihoods not dependent on direct mangrove cutting.
Ecological continuity	Seed bank (mature tree and seedlings).	All mangrove ecosystems have sufficient number of mature viviparous plants and seedlings per ha.	-High number of mature plants and seedlings/ha. -Intensive cutting might affect continuity of the system.	High number of mature plants and seedlings/ha.	High number of mature plants and seedlings/ha.	-High number of mature plants and seedlings/ha -Mangrove planting and selective cutting may contribute to continuity of the system.
Social continuity	Elder people, customs, traditional laws, taboos and their influence on knowledge transfer and sharing.	Formal management system (school, higher scale stakeholders) has some level of influence on formal knowledge sharing and transfer.	No recognition of the knowledgeable elders and religious leaders in knowledge transfer and sharing in the society.	Very low recognition of Islamic leaders and elders on knowledge sharing and transfers.	Not applicable.	Village elders and Islamic leaders have greater influence on knowledge sharing and transfers.

9.1.1 Changes in mangrove structure

Mangrove structure in all study sites displayed various changes in relation to mangrove species composition and diversity, tree density, basal area, volume of mangrove trees and stumps in the ecosystem. All ten mangrove species reported to be found in Zanzibar were found in this study showing the common species composition of Zanzibar mangroves, which is dominated by three species from *Rhizophoraceae* family with limited representation and distribution of other mangrove species. Variations in mangrove species diversity and abundance between sites were found (Table 33 and sections 5.2.1, 6.2.1 and 7.2.1 in chapters 5, 6 and 7 respectively). The presence of a few abundant species is a common characteristic in most mangrove ecosystems which have relatively few tree species compared with terrestrial forests (Duke, 1998; Field *et al.,* 1998; Alongi, 2002). Changes in the proportion of each mangrove tree species in the study villages were not clearly defined because there is no baseline data available for these villages. However, mangrove harvesters in Pete and Charawe experienced a decline in the availability of less dominant mangrove tree species. There was a general increase in the total number of mangrove tree species (species richness) identified in Pete compared to five mangrove species reported in this forest twelve years ago (Akil and Jiddawi, 2001). The variation in the number of mangrove species in Pete might have been partly due to a less intensive survey done in the previous studies or to recent planting activities. Even with an increase, the relationship between changes in biodiversity and ecosystem function is not easily assessed in mangrove ecosystems (Twilley *et al.,* 1996). This is because there are some highly managed, relatively stable, less diverse 'natural' mangrove ecosystems that support the needs of human populations (Field, 1999). A growing body of empirical evidence, theory, and models suggests that ecological resilience is generated by increasing species diversity providing functional diversity and redundancy which enables regeneration and renewal to occur following ecological disruption (e.g. insect outbreak, fire) (Elmqvist *et al.,* 2003; Walker *at al.*, 2006). In this way the ecosystems experiencing species loss produce ecosystems that are more vulnerable to ecological collapse, with a reduced variety of possible alternative ecological organizations and thus decreased ecological resilience to future disturbances (Peterson *et al*, 1998). For example, Brown (2007) argues that although the management of Matang mangrove forest in Malaysia that promotes the re-growth of single *Rhizophora species (*by spraying herbicide to kill less important mangroves) has been able to supply charcoal and high quality timber for a century, this ecosystem is not resilient because a single shock such as a change in tidal inundation or a pest outbreak could completely destroy the entire system.

The studied mangroves showed a decline in quality of mangrove tree species indicated by a relatively high density of small-sized mature trees (2-5cm dbh class) over the larger ones (>5 cm dbh class) with corresponding smaller basal areas, volumes and many stumps in the ecosystem. However, variations exist between sites (section 5.2.2, 6.2.2, and 7.2.2 in chapter 5, 6 and 7, respectively, and Table 33). Among the study sites, Pete mangrove system has the most pronounced domination by a relatively high density of smaller-sized mature mangrove trees, lower basal area and volumes per hectare. In Pete, the current density of mangrove trees has increased more than six times compared to the standing density observed nine years ago (Othman, 2005). More than 87% of its mature plants are within the 2-5cm dbh class which is a higher percentage ratio than the average proportion of 50% of small dbh tree in Menai Bay (SONARECOD, 2009). These mangrove structural attributes indicate that Pete mangrove has declined in terms of quality of mature plants representing a highly disturbed mangrove stand which is currently under the re-organisation phase.

Mangrove of Charawe and Kinani had a relatively low standing density of mature plants with a correspondingly high basal area and volume per ha compared to Pete mangrove forest. However, the mean standing volumes from all these forests was lower (ranging from 8.67 to 38.09m^3/ha) than the average standing volume of 41 m^3/ha for Unguja mangroves reported twenty years ago (Leskinen and Silima, 1993), indicating a decline in the quality of these forests. Decline in quality from these sites was also indicated by the presence of substantial numbers of stumps with old scattered mature mangroves trees, moving the ecosystem into the collapse phase in the Adaptive Cycle. Villagers reported a decline of common fish species, and desired wood provisioning ecosystem services.

The exception was found in Vijichuni which had a relatively good combination of high density mature trees giving a high basal area and volume which is statistically different at $P < 0.0001$ compared to other sites. The number of tree removals was lower compared to other sites (statistically different at $P < 0.0001$). This mangrove has recovered from 1977 when excessive cutting was reported by villagers. These structural attributes indicated that the ecosystem has increased in quality and quantity of mangrove trees, representing a less disturbed mangrove ecosystem which can be described as being under the conservation phase of the Adaptive Cycle. Whilst the total species diversity in other forested ecosystems tends to decline at conservation phase and reduce the ecosystem resilience (Gunderson and Holling, 2002) there are no observed patterns in the decline of mangrove tree species towards the conservation phase in Unguja mangrove ecosystems. This is because of the frequent human disturbances in the ecosystem interrupting normal succession sequences and making the ecosystem appear to be more in the pioneer-phase, with numerous and continuous production of propagules, than in the mature-phase (Smith, 1992). Although there is no reported diversity index threshold below which the resilience of mangrove will be threatened, mangrove ecosystems which have experienced significant loss of mangrove species will have potentially devastating economic and environmental consequences for coastal communities, especially in those areas with low mangrove diversity and high mangrove area or species loss (Polidoro *et al.,* 2010).

The mangrove ecological systems studied were also found to have changed in area. Whilst villagers from Pete and Charawe perceived that the mangrove area had declined, in the Vijichuni mangrove new areas had been colonised where no mangroves had grown before in living memory (section 6.8, chapter 6). Although there was no reliable data to validate such changes, understanding of ecosystem dynamics by local communities proved valuable as a background to reconstruct historical use and impact on mangroves as has been shown in other studies (Dahdouh-Guebas *et al.,* 2004).

Total vegetation cover of Zanzibar mangroves has declined dramatically whereby about 17.6% of the area has been lost between 1964 and 2012 (RGoZ, 2013). Globally mangrove forest areas are disappearing at an alarming rate accounting for a 35% decline since the 1980s with a pronounced loss in countries with large mangrove forest areas (Valiela *et al*., 2001; Alongi, 2002). Little is known about the effects of mangrove area loss on resilience of the ecosystem but the current loss of Unguja mangroves follows similar global trends that may greatly reduce the overall ecosystem diversity and limit the supply of ecosystem services (Alongi, 2002). Loss of more than half of the Mahakam mangrove forests in Indonesia between 1990 and 2002 affected fisheries productivity and the livelihoods of communities living in Mahakam delta (Sidik, 2008). This may be compounded with the degradation of habitats for other forms of life in the ecosystem if the current rate of decline continues.

9.1.2 Stakeholder knowledge systems and interest in mangrove ecosystem services

The mangrove social system at all study sites was found to be composed of a wide range of stakeholders at different scales with diverse knowledge systems relating to mangrove management and conservation. Many stakeholders at global, national and district levels had modern scientific ecological knowledge mostly acquired through formal educational systems via colleges and universities. On the other hand, local stakeholders had mangrove management and conservation knowledge influenced by the formal education system and/or modern scientific ecological knowledge transferred to the local stakeholders from the national level stakeholders. In addition, they had a wealth of traditional knowledge on mangrove biology and management and local knowledge on economic uses of the mangrove system (sections 5.3.2, 6.3.5 and 7.3.2 in Chapters, 5, 6 and 7 respectively). Some of this knowledge varied between study sites and among different stakeholders in the communities.

In Michamvi, where most people were directly involved in mangrove management, village elders and some youth groups had traditional ecological knowledge on mangrove planting techniques, planting times, species selection, recovery time, forest rights and ownership. On the other hand in Charawe, where local communities were more engaged in harvesting of mangrove wood, mangrove harvesters had local knowledge of market chains for different mangrove wood provisioning ecosystem services, use of more efficient cutting tools and processing of wood products. Most Charawe mangrove harvesters have clear understanding of wise uses of the ecosystem perceiving that their current harvesting of mangrove wood products for charcoal and lime making at the current rate (compared to poles harvesting in the past) is not a sustainable practice and might lead to complete degradation of the ecosystem in the near future. In Pete, users of mangrove provisioning services such as honey had a broad local knowledge on beekeeping.

These variations reflected local people's different experiences and dependence on the use of particular resources and might have influenced the management of the resources (Walters *et al.,* 2008). The diverse local and traditional knowledge can serve as a powerful tool to guide resources utilization, monitoring, understanding the changes and increase the capacity of the society to learn and adapt to the changes. Apart from such variations, Islamic leaders and village elders, together with other stakeholders involved in mangrove conservation in all study sites, had common traditional knowledge on local names of mangrove species, their suitability for different ecosystem services, mangrove management and conservation and a limited understanding of the values of other services provided by mangroves, especially supporting and regulating services.

Mechanisms for protection of these forests in the past were associated with evil spirits (*Majini*) in all study sites. Currently, people's cultural practices and or the influence of Islamic and village elders' knowledge are used to manage mangroves in some of the case study villages.

In Michamvi, people engaged in active use of traditional knowledge through the influence of village elders and Islamic leaders. This is because Michamvi people have excluded the forest from the Government (official management system) perceiving that they own the forests since it was planted by their elders. However, in Pete and Charawe people perceived that this knowledge was not recognised or included in the current official management system despite its application in the past.

In general the influence of traditional ecological knowledge, including traditional and religious beliefs, was found to have a significant effect in the successful conservation of forest resources (Berkes et *al.,* 2000; Colding and Folke, 2001). This is because traditional local ecological knowledge can be used to interpret and respond to feedback from the environment, provide capacity to learn about qualitative changes in complex ecosystems, and directing an ecosystem into a resilient trajectory (Berkes *et al.,* 2000). However, the availability of knowledge alone by ecosystem users does not guarantee the adoption of sustainable ecological practices. For example, despite the majority of Charawe residents having a clear knowledge on the importance of mangrove conservation and that their current rate of harvesting will not lead to a sustainable supply of desired ecosystem services, there has been little application of this knowledge. Instead local communities continued to harvest mangrove wood to meet their economic needs which was apparently inconsistent with their knowledge. Several authors have argued that the knowledge of local people who use the resources and scientific knowledge must be integrated in a complementary way to increase the capacity to learn and develop ecologically resilient and sustainable community-based management programmes (Berkes and Folke 1998; Ericksen, 2005). Management approaches that incorporate traditional knowledge systems (beliefs, values) and formal knowledge and institutions are likely to be more effective in conserving forests than a strategy that ignores the links between culture and nature (Berkes *et al.*, 2000).

The diversity of stakeholders with different and often competing interests in mangrove ecosystem services is an important variable that defines the social component of a system. District, national and international stakeholders (sections 5.3.5, 6.3.5 and 7.3.4) are typically more interested in ecosystem services that have little or no direct economic value attached to them but contribute to the maintenance of mangrove ecological integrity and achieve conservation of natural resources. Such services include ecotourism in Pete, and supporting and regulating services from all study sites. On the other hand, the majority of stakeholders at the village level have greater interest in mangrove ecosystem services that either provide direct use values and or generate economic returns that contribute directly to their household incomes. The types and rates of exploitation of these services varied between sites. Mangrove harvesting for provisioning ecosystem services was practiced in all study sites and had also been practiced in various other part of Zanzibar (Madeweya *et al.,* 2002). Among the study sites mangrove harvesting for charcoal and firewood had increased and was the dominant ecosystem service exploited in Charawe because of its high economic returns for the majority of residents. Supply of these services had declined in Pete and Vijichuni indicating a significant reduction in the availability of the desired ecosystem services in Pete and in the case of Michamvi the availability of alternatives that provided a higher return than wood cutting. Consequently, non-wood mangrove ecosystem services especially ecotourism in Vijichuni and beekeeping in Pete have become the most valuable ecosystem services available to 44% and 40% of the villagers, respectively. In addition, some members of local conservation groups and other village residents had interests to conserve the ecosystem for the supply of non-wood provisioning services.

The different interests of stakeholders across spatial scales were found to be the major source of conflict over mangrove ecosystem services. Conflicts are common in the field of natural resource management particularly where there is a resource scarcity (Grimble and Wellard, 1997) and this was found to be the case where the mangrove ecosystem provided multiple and competing ecosystem services. For example, excessive cutting of mangrove wood by Charawe residents and outsiders caused conflict with the government stakeholders who wanted to conserve the trees in order to maintain the supply ecosystem services of their interest. Likewise in Pete, villagers interested in non-wood provisioning services such as beekeepers, medicine collectors, fishermen and others were in conflict with mangrove cutters who wanted to harvest the mangrove wood in order to meet their needs. These conflicts resulted in weak linkages and coordination between the stakeholders and weakened the management system.

9.1.3 Interactions and linkages in mangrove ecological system

Mangrove SES identity was found to be characterised by several ecological and social relationships which explained the interactions in the system. Interaction in ecological systems can be between species of plants, animals or between plants and animals. However, the mangrove ecological interactions in this study are concerned with animal-plant species interactions that influenced the overall productivity of harvestable mangrove ecosystem services. Two important animal-plant interactions were observed in all study sites (sections 5.4, 6.4, 7.4 and Table 33). Firstly, there was the relationship between mangrove plants and honey bees which influences the level of production of honey in the system. Local communities preferred to do beekeeping in mangroves rather than non-mangrove areas because of safety against fire, and continuous flowering of mangroves which was perceived by local communities to yield more honey compared to terrestrial plants (Jiddawi and Lindstrom, 2012). Another animal-plant interaction is that between crabs and mangrove seedling propagules. This interaction can have a significant impact on the establishment of mangrove species, by destroying seedlings and preventing regeneration (Dahdouh-Guebas *et al*., 1998). Bosire *et al.* (2005) observed that mangroves provide a suitable habitat for the crabs, and the crabs reduce competition between mangrove plant species through selective predation on seedlings.

Herbivorous insect damage on highly nutritious mangrove propagules and seedlings is more common than in mature forests and is reported to significantly reduce the growth rate and cause mortality in the mangrove ecosystem. Larvae of an insect pest Lappet moth *Lasiocampidae* spp. were found infesting leaves of recently planted *Bruguiera gymnorrhiza* in Pete mangrove system in 2013. A small outbreak of this insect also occurred in several newly planted mangrove areas in Pemba Islands especially at Micheweni, Muambe and Michenzani villages between 2008 and 2011 (Field observation in 2011) resulting in the complete loss of young trees in open areas planted by villagers (Plate 11).

Plate 11 Insect pest damage at Michenzani village in May 2011. *Source: field visits 2011*

Such 'outbreaks' are a recent phenomenon and as such may be symptomatic of increasing fragility and vulnerability of the ecosystem to future insect outbreaks resulting from overexploitation and poor understanding of the ecosystem. These kinds of interactions have also been reported in other parts of the world. Caterpillar larvae of *Junonia evarete* caused substantial mortality (up to 100% at some sites) of *Avicennia germinans* (L.) propagules and seedlings in Colombia (Elster *et al.* 1999). Burrow (2003) found that at juvenile stage both *A. marina* and *R. stylosa* suffered significant insect damage and leaf loss and reduced average longevity of all leaves to maturity by 4-5% for *R. stylosa* and 12-13% for *A. marina*. Another study reported that the boring of the scolytid beetle, *Coccotrypes rhizophorae* (Hopkins), into *R. mangle* propagules killed 72–89% of planted mangrove seedlings (Sousa *et al.,* 2003). An increased understanding of how mangrove tree species interact with other system variables is important in order to support the efforts of local communities to manage them effectively to adapt with the unexpected changes in the ecosystem. In the absence of meaningful support from authorities, this outcome could severely reduce productivity, and completely undermine the confidence of villagers to continue restoration efforts and reduce the rate of ecosystem recovery.

9.1.3.1 Dynamics of institutions and management approach governing mangrove SES

Interaction in the social system is described by diverse laws and regulations that govern the uses and management of mangrove resources. Mangroves in the study sites have been formally managed as forest reserves under the State management regime since 1965 (RGoZ, 1996) whereby the Government is the sole owner and decision maker regarding access to and uses of the resources. This policy decision has undermined the traditional management system for common pool resources that existed in the past (research findings and Mohammed, 2004). Since then management arrangements have been changing including the system that allowed some uses through alternative opening and closing harvesting in Chwaka Bay to the current more restrictive approach that has put a complete ban on the use of any wood products by the surrounding communities. The National mangrove management approach has been developed through the formulation of legislative tools and management plans. This has raised some mangrove areas to National Park status (in Mapopwe) and introduced more restrictive pilot community-based management arrangements in some selected villages (for example Pete) and restrictive co-management extended to other villages around the mangrove forest.

In typical co- management arrangements local communities are involved in decision making, and management responsibility is shared between Government and user groups (Ostrom, 2000, Carlsson and Berkes, 2005). Successful co-management depends on the availability of conducive conditions for development of the system including an enhancement of community security and resource tenure, their right to organize, availability of appropriate financial resources and facilitation support (Ostrom, 1990).

However, what was often actually observed was an 'extractive knowledge capture approach' where local communities input was limited to providing information, while being subsequently informed of decisions already taken (Evans *et al.,* 2006) and participation restricted to activities that favoured conservation of the resources with no ownership rights, decisions or realistic benefits derived from the resources. This management arrangement has also been applied intensively to other traditional village resources resulting in increased restrictions on access to fish and terrestrial forest resources on which communities depend for their livelihoods. Management arrangements that focused on complete restrictions to resource extraction have been termed 'Command-and-control' which is a poor fit for management of ecosystems with high ecological uncertainty (Holling and Meffe, 1996; Carlsson and Berkes, 2005). This management approach affords a minimum level of resource conservation and provides legal protection of the resources and the ecosystem. However, its major setback is that it is based on equilibrium stability concepts and emphasizes the application of rigid rules and regulations made by technical experts who are not resource users from a central bureaucracy to maintain steady states and control the maximum yields (Berkes *et al.,* 2000) while compromising the basic right of participation of local communities. Such management arrangements reduce variability and opportunity of bringing different views and new thinking in the system to cope with unexpected outcomes which results in a gradual loss of resilience (Folke *et al.,* 2002). Successful mangrove management requires some level of harvesting (Kairo *et al.,* 2002) which promotes mangrove tree species diversity (Wah *et al.,* 2011), provides resource use flexibilities by local communities and promotes better stand stocking density (Feka *et al.,* 2011) which is adequate for sufficient production of propagules and enhances ecosystem continuity (Bosire *et al.,* 2008).

Lack of active and influential participation and access to realistic benefits has discouraged local people from participating in the current management system. Consequently villagers from each case study site have devised informal mangrove management institutions which are quite strong and have more influence on the uses of local resources. These local institutions have not been equally recognised in the current formal management approach which has created a range of contrasting systems for management of the mangroves at the study sites. For example, Pete mangrove system was managed under an ad hoc implementation of a mixture of formal rules and regulations (State control and pilot CBNRM with developed village by-laws), while in Charawe management was achieved through a State – National Park with co–management to assist Government in forest protection. With low government capacity to enforce these laws, neither the State nor the community-based management approaches have been effective at managing the resources. On the other hand, Vijichuni mangrove system was being managed traditionally by village elders in collaboration with village youth who were actively enforcing the existing village by-laws based on their traditional knowledge. This arrangement came into place after the villagers planted the mangrove in the past. Thus local people claimed ownership of their mangrove and through their rules they felt empowered to make decisions and play a realistic and influential role in balancing the supply of ecosystem services and use of the resources.

9.1.4 Role of diversity as innovation in Mangrove SES

Innovation is crucial to maintaining the integrity of mangrove SES identity, which, according to resilience scholars, is explained by diversity in both ecological and social systems. Diversity is a recognizable source of creativity that can lead to innovation providing a base and the potential for resilience building through absorbing disturbances, spreading risks, creating novelty and re-organising following changes (Low *et al.,* 2002; Adger *et al*., 2005). Diversity in SES is of two kinds: Firstly; 'functional diversity' which is the number of functionally different groups which influence system performance, and secondly 'response diversity' or 'functional redundancy' which is the diversity of types of responses to disturbances within a functional group which influences resilience (Hughes *et al.,* 2005; Walker *et al.*, 2006).

Innovation in the ecological component has focused on diversity of mangrove tree species which influences ecosystem function and identity. A total of ten mangrove tree species dominated by three species were identified with variations between sites, showing the common species composition that defined the identity of the Zanzibar mangrove ecosystem. No systematic studies have been done for Michamvi and Charawe mangroves to indicate changes of species over time apart from the general inventory data for the whole of Chwaka Bay, which provided non-comparable data. Villagers in Pete and Charawe reported the decline in the availability of less dominant mangrove tree species in the forest. However, it has been suggested that mangrove ecosystems which naturally support relatively low diversities of the dominant higher plants can remain well-functioning pristine mangroves (Duke, 1998; Alongi, 2002) growing within a broad range of structural and functional attributes that promote their survival in harsh competitive conditions (Duke, 1998) which is not conducive for ecological innovation. In this sense the increase of mangrove tree species does not necessarily enhance ecosystem performance or resilience (McLeod and Salm, 2006), but rather the ability of each species to cope with the wide range of environmental conditions in utilizing their individual specialised attributes (Duke *et al.,* 1998) and provide ecosystem functions. However for the ecosystem experiencing species loss there is general acceptance that loss of mangrove tree species diversity reduces its capacity to cope with disturbances and leads to lower resilience of the system through reduction of functional redundancy (Brown, 2007) as explained in section 9.1.1.

9.1.4.1 Social innovations and resilience

The potential for innovation in a social system is influenced by the diversity of functional actors, institutions and diversity of livelihood activities (Table 33). Management approach is one of the critical issues that can either undermine or enhance resilience and the sustainability of a SES and its ecosystem services depends on how the SES organises itself in response to management actions (Folke, *et al.,* 2002). Although the prevailing current mangrove SES management approach in Unguja consists of diverse stakeholders and institutions operating across spatial scales, active and realistic participation by local stakeholders and their institutions is weak and may limit innovations in the social system. This study argues that management systems that inhibit active and influential participation of other stakeholders and their institutions threaten the resilience of the mangrove management system through a reduction of functional diversity and redundancy of the management system. Functional redundancy would be achieved if the management system was decentralised with clear use and decision making powers distributed to other stakeholders (Ostrom, 2000) enabling them to respond and contribute to the same function in the face of social ecological changes (Hughes *et al,* 2005). For example, if the introduced CBNRM was realistically empowering, Charawe communities would have the incentive to actively perform management activities in the absence of donor support or under limited government resources. In this case multi-level social networks and sharing of management authorities allowing cross-scale interactions and cooperation are required for successful resource management (Adger *et al.,* 2005). This situation was evident in areas like Vijichuni where local people claimed the ownership of their mangrove; the informal institutions have become very strong and play a realistic and influential role in balancing the supply of ecosystem services and management of the resources at a time of limited government support.

Diversity of economic activities is an important aspect for building resilience of local communities whose livelihoods are dependent on coastal resources. Coastal communities are considered to be resilient because they depend on diverse resources which themselves are resilient and relatively stable (Adger, 2000). However, mangrove SESs managed for conservation require livelihood options that provide opportunities for diversification of income sources that are more profitable and independent of mangrove harvesting. Availability of alternative livelihood options and diverse income opportunities allow communities to be flexible to adapt to social, political and economic changes which is necessary to maintain social and ecological resilience (Adger *et al.,* 2005).

Villagers from all case study sites were found to depend on different combinations of livelihood options from different coastal resource systems (Table 33) as livelihood coping strategies in the areas. These activities varied between sites subject to the accessibility and or availability of activities or resources that provide higher economical returns to meet householder needs. This has resulted in differences in the level of dependence on mangrove wood provisioning ecosystem services which might have impacts on the dynamics of the ecosystems. In Charawe, communities have limited opportunities to access reliable alternative livelihood options independent of forest harvesting (section 7.6.1 in chapter 7). As a consequence this increased the level of mangrove harvesting, contributing about 70% of the average household income compared to a 24% contribution from all mangrove related activities reported twenty years ago (Nasser, 1994). Whilst Charawe residents across wealth groups received higher income from mangrove wood provisioning ecosystem services than Pete and Michamvi, few alternative strategies provide them limited options to survive in the face of collapse of mangroves (market shock) than their fellow villagers. Limited livelihood options prevented them from shifting to more productive activities and have narrowed their capacity to innovate new income earnings that will remove them from terrestrial forest and mangrove cuttings. At the same time, although relatively diverse income sources are available in Pete social system these are not sufficient to make them stop cutting terrestrial forest and mangrove. In this way terrestrial forest harvesting is the most profitable income earning activity providing local people with short-term benefits, but may have long term impact in the society and increase vulnerability of mangrove systems to a high rate of cutting when sufficient large size mature plants become available.

In contrast, the availability of diverse profitable tourism-related alternative income activities in Michamvi gave the local community the opportunity to adopt a new way of developing livelihood activities not related to harvesting forest ecosystem services. Similarly, tourism has promoted economic profitability of the previous/traditional livelihood strategies by providing good market opportunities for fish and other locally-sourced products. Whilst it has been widely claimed that tourism development is achieved at the expense of local people's livelihoods (Gossling 2003; Salum, 2009; SONARECOD, 2010) the results in Michamvi are consistent with the findings of Mbaiwa and Stronza (2010) who noted significant improvement of livelihoods of rural communities in Botswana as a result of tourism development. In Botswana, basic needs such as shelter, employment and income and social services like water supply systems, transportation, scholarships and payment of funeral expenses were provided to community members and funded with income obtained from tourism related benefits.

It is apparent that people's livelihood strategies depend on availability of diverse coastal resources which are in most cases governed under different sectors. Therefore management of one sector will not lead to successful outcomes. This requires inter-sectoral coordination to manage coastal resources and support communities' livelihoods which has not been implemented so far.

9.1.5 Continuity of mangrove SES

The continuity of mangrove SES depends on the presence of small changing variables in the form of seed-banks, knowledge of elderly people, social legacy, customs and taboos, laws, or formal archives and libraries that remain after disturbances and become repositories of knowledge and also of identity (Cumming *et al.*, 2005). Due to the lack of seed banks in mangroves (Fransworth, 2000; Harun-or-Rashid *et al.*, 2008) poor availability of propagules of mangrove species is considered to be an important element of mangrove ecosystem memory that can limit mangrove ecosystem recovery and continuity after disturbances (Sherman *et al.*, 2001; Harun-or-Rashid *et al.*, 2008). Mangroves from all the study sites had relatively high numbers of mature viviparous mangrove plants producing sufficient number of propagules to facilitate continuity of the mangrove ecosystem after disturbances (sections 5.6, 6.6, 7.6 and Table 33). However, the density of mature propagules producing mangrove plants was low in Charawe compared to other sites. High rates of mangrove harvesting might have contributed to the observed low density in that site which, if continued, would negatively impact on the availability of propagules and hence seedling establishment and continuity (Ellinson and Farnsworth, 1996; Feka *et al.*, 2011). Although there are limited data in this study on the influence of other slowly changing variables on the continuity of the mangrove ecosystem, it is well established that environmental variables such as temperature, salinity, wave energy, currents and tidal regime, substrate condition (pH, adequate amount of sediments, nutrients) (as affected by rainfall and extent of freshwater runoff) are the main slowly changing factors that account for the continuity and resilience of the ecosystem (Chapman, 1977; Tomlinson, 1986; McLeod and Salm, 2006; Harun-or-Rashid *et al.,* 2008).

Social continuity is dependent on the presence and influential participation of knowledgeable elderly people, Islamic leaders and conservation groups in providing mechanisms for mangrove management and conservation knowledge transfer and sharing in the society. Such methods include story telling between elders and their families and young, stories among peers, elders meetings, public Islamic talks, and use of a gong to convey conservation knowledge in societies (sections 6.6, and 7.6). However, the influence of these methods varies between sites. In Charawe and Pete where village elders and Islamic leaders have little recognition in the formal management system their influence in knowledge transfer and sharing has been weakened which might threaten the continuity of the system. In Michamvi, the presence of strong local institutions has allowed active participation of village elders and Islamic leaders in knowledge sharing and transfers among community members which strengthens the continuity of Vijichuni mangrove SES.

9.2 Drivers of changes of Mangrove SES

The observed changes in mangroves SES have been a result of major past and current direct and underlying drivers to the mangrove ecosystem. Several alternative approaches exist for categorising the drivers for change. This study adopted the Millennium Ecosystem Assessment approach which considers drivers as human or natural disturbances that directly cause changes in the system while pressures or indirect drivers operate more diffusely, by altering one or more direct drivers (Bennet *et al.,* 2005). This study found that human disturbances, mainly through excessive cutting of mangrove wood for commercial exploitation, and planting are the major direct drivers of changes in the mangrove ecological system. These drivers were fuelled by a number of underlying causes for change in the mangrove social-ecological system including poverty and limited livelihood diversification, inappropriate and counter-effective management regime, and access to market. The same drivers and underlying drivers were found in all study sites, although their impact varied depending on the context of each study site, the strength of the drivers and the capacity of mangroves and communities to respond to these drivers.

9.2.1 Direct current drivers of changes in mangrove system

9.2.1.1 Excessive cutting of mangrove wood by local communities

While Walker and Salt (2006) argued that mangrove cutting by small rural communities cannot lead to ecosystem degradation, this study found that unregulated exploitation of the mangroves by local communities was the main cause of ongoing ecosystem degradation (dynamics), with variations between sites (Table 33). Among the study sites, mangroves of Charawe and Kinani suffered from high rates of exploitation of wood materials for charcoal, poles, lime and firewood by the majority of residents, as well as outsiders. The current observed rate of harvesting in Charawe was double the observed harvesting rate twelve years ago (section 7.7.1). Although the rate of harvesting in Pete had declined dramatically, the observed rate of harvesting did not indicate a sustainable future (section 5.8). High rate of wood extraction was the major driver found to be causing significant changes to the mangrove structure as explained above, leaving the mangrove with tree stumps and clear-cut patches which has led to undesirable shifts in the ecosystem structure and availability of ecosystem services.

Overharvesting has previously been reported to be the cause of overexploitation of mangrove in Zanzibar (Ngoile and Shunula, 1992; Saunders *et al.*, 2010). Such unsustainable exploitation was known to shift the ecosystem into an undesirable state marked by reductions in mature mangrove trees, number of mangrove tree species and associated macro-fauna, and reduction in aesthetic value (Othman, 2005). Similar results have been reported in Tanzania mainland and other parts of the world where coastal communities use mangroves in a more or less unsustainable manner leading to overexploitation when they exploit them for local needs and commercial activities (Semesi, 1988; Hussein, 1995; Hong, 1996; Alongi, 2002; Mohammed, 2004; McLeod and Salm, 2006). This kind of extraction can potentially lead to decreases in mangrove area (Alongi, 2002; Wang *et al*., 2003, Dahdouh-Goubah *et al.*, 2004), reduced species, lowering the intrinsic value (Kairo *et al.,* 2002; Dahdouh-Goubah *et al*., 2004), limit seedling regeneration (Ong and Gong, 2013) and may lead to stand collapse (Mohamed *et al.*, 2008) of the mangrove system. Evidence reveals that the likelihood of regime shifts may increase when humans reduce resilience by actions such as removing whole functional groups of species or trophic level and altering the magnitude, frequency and duration of disturbances (Folke *et al.,* 2004). Excessive degradation has resulted in complete ecosystem shifts including woody inversion to semi-arid range lands (Walker, *et al.,* 2004), algal blooms in fresh water lakes (Grimm and Wissel, 1997) and mangrove forest that resembled a ‘pock-marked terrain’ full of *Acrostichum* fern or an abandoned shrimp pond complex in Indonesia (Brown, 2007).

9.2.1.2 Planting

Mangrove re-afforestation programmes can be carried out to restore the degraded mangrove vegetation for conservation, landscaping, sustainable production and coastal protection (Field, 1999; Bosire *et al.,* 2008). In Zanzibar, mangrove planting campaigns have been done by DFNRNR to encourage local communities to plant mangroves in mangrove ecosystems close to them in different villages of Unguja and Pemba to protect the coastal ecosystems without any ownership or substantial incentives. It is estimated that about 40 ha of open and degraded mangrove ecosystem has been planted annually (SONARECOD, 2010) in the past decade. In some situations individuals (e.g. in Kitogani village) or community groups took their own initiative to plant mangroves to meet their basic emergency needs of building poles or apiary development for honey production (ibid, 2010). In this way there is no specific afforestation programme planned by the DFNRNR, such that in some situations for example, mangrove planting can be done to achieve political aims like celebrating a National tree planting day in the Island. The planting was done using the species which were either common, easily available or perceived to have high economic value by stakeholders mostly from *Rhizophoraceae* family.

Pete and Michamvi residents have participated in planting of their mangroves in the past to facilitate the colonization of mangrove trees in the open or degraded mangrove areas in different time periods. The high rate of mangrove tree planting from mid-2000 in Pete has impacted the vegetation structure of the ecosystem characterised by a higher density of mature small-sized plants than in any of the other studied mangrove systems. This is a typical feature of restored mangroves having higher stem density with lower average basal areas than relatively undisturbed mangroves (Bosire *at al.*, 2008). Randomly planted mangrove seedlings without consideration of spacing between trees and high survival rate of trees planted is likely to have contributed to this stand structure. Unsupervised planting by school children reported by Macintosh et al. (2002) resulted in three times higher density of mature plants in rehabilitated mangrove shrimp ponds in Ranong mangroves compared to other sites where planting was done with moderate plant spacing. High rates of planting in Pete have contributed to the current status of an ecosystem in recovery state which is an important phase in re-building ecological resilience, although currently an undesirable state for villagers because of the lack of desirable ecosystem services.

Likewise in Michamvi, villagers who re-planted their mangroves in the past contributed to increased mangrove cover that can now provide the desired ecosystem services to the local stakeholders and others. Following environmental or anthropogenic mangrove degradation, massive mangrove rehabilitation programmes have been carried out in many parts of the world, especially in Asia, Latin America and some African counties for coastal protection and increased wood production using a functional restoration framework (Macintosh *et al.,*2002; Bosire *et al*., 2008; Rajarshi and Rajib, 2013). However, as in many restoration programmes, DFNRNR efforts to encourage local communities to engage in mangrove tree planting was done without first assessing the natural recovery opportunities, and how to facilitate such initiatives (Bosire *et al.,* 2008) and with limited silvicultural knowledge on different mangrove tree species (SONARECOD, 2010). Clear knowledge of the mangrove ecosystems and of the need for a re-forestation programme is required to avoid unnecessary costs and or failure especially in a situation where mangroves can naturally colonise themselves without human interventions.

9.2.2 Indirect drivers of change

Indirect drivers of change help to explain why people are doing what they are doing, and are likely to be among the most important factors to be addressed if the conservation of resources is an ultimate aim. However, in most cases they receive little attention by the policy and decision makers in management of natural resources.

9.2.2.1 Markets

Markets are generally crucial for the success of enterprises. The results from the respondents and field observations showed that markets can have both negative and positive effects on the system depending on the availability of the right market for a specific ecosystem service. Markets can have detrimental effects if they promote degradation of mangrove resources.

In Zanzibar 94% of domestic energy is derived from biomass (Owen, 2011). This demand has created an attractive market for selling biomass products both in the villages and in Zanzibar town. Consequently availability of the market has provided a strong incentive for Charawe residents and village outsiders to accelerate the rate of mangrove cutting for producing charcoal, fire wood and building poles and this will ultimately threaten the ecological resilience of the system.

In other parts of the world, conventional tourism markets have caused significant loss of mangroves due to clear-felling for hotel resort and golf course construction, notably in the

Caribbean and Sri Lanka (Ellison and Farnsworth 1996; Wang *et al.,* 2003). In Zanzibar the impact of a massive expansion in tourism has started to show signs of mangrove degradation especially in Chake-Chake mangroves (Pemba Island) where a hotel has been constructed and Michamvi where a significant portion of mangrove was once clear-cut for the same purpose. In addition, significant bank erosion was observed near the location where tourist camping sites were created in Michamvi resulting in the collapse of fringing trees which may further threaten the long term resilience of the mangrove system in the area.

On the other hand, a market can be the saviour of a mangrove system if it trades in mangrove ecosystem services that have low environmental impacts such as honey, ecotourism or carbon trading. For example, the availability of a market for honey has attracted a significant number of people to engage in beekeeping in Pete which was not only found to contribute significantly to household incomes but also acted to protect the mangrove forests where hives were located. The mangroves in Pete (through boardwalk construction) and Michamvi (through providing camping sites and good tree sceneries) have been promoted for ecotourism. The availability of a good market for these services contributed to the maintenance of the ecological integrity of Michamvi mangrove biophysical structure which could ensure the resilience of the ecological system and increase social resilience through improvement of people's welfare. These findings are consistent with others (Bookbinder *et al.,* 1998; Salum, 2009) who also noted significant improvements of biodiversity management in protected areas after the introduction of ecotourism with direct impact on provision of community social services. However, the availability of a market for one ecosystem service can lead to degradation of other resources especially in a society where people depend on exploitation of a mixture of ecosystem services from different ecosystems. This is typical of the introduced pilot carbon trading projects observed in the study sites that has put significant areas of community terrestrial forest under conservation status, but has squeezed the limited livelihood options of dependent people. Consequently Pete villagers shifted their cutting pressure into terrestrial harvesting in JCBNP (and TAF, 2013) while Charawe residents increased their harvesting of mangrove forests both inside and outside the JCBNP.

9.2.2.2 High rate of population increase with high demand for mangrove wood

Zanzibar, like other coastal areas, has experienced a rapid population expansion in recent years and there are now 1,303,569 inhabitants with an average population density of 530 individuals per square km (NBS, 2012). The rate of population growth in the study sites reflected the rate for the whole Islands (Table 7), although with variations in population size between sites (section 4.5). This study found that population was an important underlying driver that created pressure on mangrove ecosystem services when they had a high dependence on them. Charawe village has a comparatively low population, about 32% lower than that of Pete and Michamvi but with a high and growing demand whereby more than 85% and 67.5% of their population were engaged in direct commercial exploitation of mangrove wood for firewood and charcoal, respectively. As population and consumption levels grow, human disturbance through harvesting intensifies (Hussein, 1995, Valiela, *et al.,* 2001; Mohammed, 2004; McLeod and Salm, 2006) which might degrade the resilience of a mangrove system. On the other hand, Pete and Michamvi Shehias have a higher population than Charawe, but the majority of their residents are currently not engaged in heavy exploitation of wood resources and this therefore reduced the level of mangrove forest degradation observed. High urban population pressure close to mangroves with a low dependence on mangroves was found to cause no serious degradation in other mangrove areas in Unguja (Othman, 2005) and in other parts of the world.

9.2.2.3 Poverty and economic growth

With a low per capita income of USD 557 in 2009, compared to developed countries, it is clear that Zanzibar is poor and has a relatively small economy (section 4.6). The level of poverty in the study villages was very high where the majority of residents lacked employment or capital to engage in other projects to generate funds to sustain their livelihoods. Subsequently villagers relied on a combination of different village resources and activities as a livelihood strategy. However, villagers reported experiencing serious shortages of most of these resources due either to their depletion or reduced accessibility caused by the introduction of natural resource conservation programmes such as the establishment of JCBNP, control of illegal fishing practices in Chwaka bay and more recently the carbon trading project; all resulting in increasing restrictions on available village resources (section 4.8.2).

High poverty levels of many indigenous coastal communities have been reported to be the major cause of mangrove degradation (Semesi 1992; Kairo 2001; MEA, 2005). Likewise it has been argued that a general increase in economic growth in high income countries tends to be associated with conservation of mangrove areas if mangrove is not linked to a primary economic sector responsible for growth (Barbier and Cox, 2003). Alternatively high economic growth especially in medium and low income countries has caused an increase in mangrove degradation as in the case of massive tourism and shrimp farming (ibid, 2003). Another example is the impact of oil exploration, notably in the Caribbean and Nigeria where oil spillages have resulted in tree defoliation, stand death, loss of associated sessile and mobile animal species and has led to significant loss of mangrove area (Ellisson and Farnsworth, 1996; Adati, 2012). Barbier and Cox (2003) suggested mangrove areas have more potential to remain under the scenario of high economic growth in medium and low income countries if the respective countries attain high political stability, a number of protected areas and a large amount of protected coastline.

9.2.2.4 Lack of appropriate and realistic alternative livelihood options

Availability of reliable income sources independent of harvesting mangrove wood provisioning services are necessary if the conservation of mangroves is to be achieved. Various types of alternative income activities were found in each of the case study sites but with different capacities to control mangrove harvesting. In Charawe village there were limited economically productive alternative livelihood opportunities for the majority of villagers, while in Pete the available alternatives were not efficient enough to deter people from forest harvesting (sections 5.5.1and 7.5.1). A number of factors contributed to inefficiency and ineffectiveness of the available income sources to generate sufficient income to meet local communities' needs, including low capital injected to the projects which are short term in nature, lack of market for the products or some of the projects promoting degradation of the forests. As a result, the available options have not been sufficiently economically productive to compensate for the loss of income that villagers obtained from mangrove and terrestrial cutting or to meet their household needs.

Availability of diverse livelihood activities that contribute significantly to people's income is an important factor that determines the way local people view mangroves and ultimately affects the resilience of a mangrove SES. Diversity of livelihoods can provide a way for local communities to spread risks which significantly reduce vulnerability to sudden economic shock and community instability (Adger, 2000). This situation was observed in Michamvi where the availability of diverse reliable income sources, including tourism related activities, had allowed economic diversification in the village and therefore reduced dependence on Vijichuni mangrove. This study suggests that conservation of mangroves and other coastal resources will not be possible unless and until available alternative livelihood opportunities generate sufficient income to supports people's livelihoods.

9.2.2.5 Inefficient mangrove management institutions and lack of Political will

Mangroves from the study sites are formally managed under the State management regime whereby the Government is the sole owner and decision maker over access rights and use of the resources while communities are encouraged to participate in achieving government conservation objectives without realistic benefits from the resources. Legislative tools and management plans have been introduced which have raised some mangrove areas to National Park status and imposed more restrictive pilot community based management arrangements, including a complete ban on the uses of mangrove wood provisioning ecosystem services by the surrounding communities who were using these resources for generations. Despite the imposition of bundles of formal laws and regulations weak enforcements of these legal measures, poor monitoring (Rajarshi and Rajib, 2013) and lack of reliable alterative income activities for the communities have been identified by the communities as major drawbacks in mangrove conservation. Low government priority, lack of political will and awareness amongst decision makers about the true value of mangroves have also contributed to this failure (also Semesi 1992; Kairo 2001). This has necessarily discouraged local communities from actively participating in management resulting in the management system becoming very weak and ineffective in controlling the ongoing rate of harvesting.

Consequently villagers from each case study have devised informal mangrove management institutions which are quite strong and have more influence on the uses of mangrove ecosystem services than formal management institutions. However, the impacts of these institutions on sustainable harvesting of mangroves vary between sites. Informal institutions in Charawe and Kinani have allowed excessive exploitation of mangroves for firewood, charcoal and other products. These institutions have not been recognised in formal management arrangements. On the other hand, informal institutions developed and enforced by a strong informal village committee composed of village youth and elderly villagers of Michamvi Kae residents have resulted in a decline of mangrove harvesting.

9.3 Villagers' views on indicators for resilient mangrove SES

To clarify whether the extent of change caused by defined drivers will result in irreversible loss or maintain SES identity requires the establishment of indicators which can be used to monitor the trend of changes of SES variables that define the identity of the system (Cumming *et al.*, 2005; Cabell and Oelofse, 2012). Changes with respect to these indicators suggest change in the vulnerability and movement of the system away from or towards a state of resilience. This section summarises key mangrove SES resilience indicators based on villagers' consensus on qualitative analysis of key selected variables that define components, relationships, source of innovations and continuity as presented in the three case study locations (section 5.7, 6.7 and 7.7). These indicators were established using the methods suggested by others (De Bruin and Barron, 2012) as explained in section 3.7. Comparative resilience characteristics, some in quantitative form, from the most frequently cited resilience literature were used to discuss the identified indicators along with some of the important differences identified by respondents are indicated. These selected variables with their corresponding indicators are found to be relevant for Unguja mangrove SES because they have direct impact on the resilience of the ecosystem. Table 34 provides examples of the selected variables with their corresponding indicators for monitoring and evaluation of changes of mangrove social and ecological variables. These indicators serve as a key step towards the establishment of threshold levels.

Table 34 Potential mangrove resilience indicators based on selected variables presented to communities to define changes of the mangrove SES identity

Selected variables of the Mangrove SES identity	Examples of indicators
Components	
Mangrove tree species	Population of abundant common mangrove trees species show no consistent decline.
Average tree size and density	Number of large sized mature trees/ha – example at Mngazana suggests 5% removal leaving 3,000 trees/ha.
Mangrove stakeholders	Availability of mangrove ecosystem services to meet the needs of stakeholders directly depending the ecosystem.
Knowledge systems	Levels of cultural-religious knowledge incorporated in the formal management system.
Appropriate ecosystem services	Level of communities benefit from non-wood mangrove ecosystem services increased.
Harvesting rate (dependence)	Sustainable level of selective cutting of wood for home uses maintained.
Relationship	
Mangrove management institutions	Institutions capacity to maintain sustainable levels of harvesting is strengthened.
	Level of linkages and transparency increased and conflicts minimised.
	Regular implementation, and follow-up of the planned activities.
Innovations	
Diversity of species	Degree of protection or rate of planting in degraded areas.
	Dominance of common mangrove species that provide the ecosystem services.
Diversity of institutions	Traditional institutions recognised in the formal management system – communities have sense of ownership and influence in decision making.
Diversity of economic options	Diversity of economically profitable livelihood activities independent of harvesting of mangrove wood provisioning ecosystem services by majority of the stakeholders available.
Continuity	
Mangrove seed banks	Number of seedlings/propagules (*miche*) (2,500 -10,000 seedlings/ha) made available or planted after cutting.
Mechanism of traditional knowledge transfer and sharing	Level of involvement of Islamic leaders and other traditional. knowledge transfer mechanisms in the management system.

One of the indicators was based on the mangrove tree species. The majority of respondents especially village elders and mangrove harvesters felt that resilient mangroves would maintain the most abundant tree species that provide building poles and other wood provisioning ecosystem services. Mangrove ecosystems are naturally less diverse than terrestrial forests and support a relatively low diversity of dominant higher plants (Duke, 1998; Alongi, 2002). Resilient mangroves would be able to maintain common representative tree species and habitats that identify the system (McLeod and Salm, 2006). This is because even if only a few mangrove tree species are found in the ecosystem they have a broad range of structural and functional attributes which promote their survival and propagation in the relatively harsh conditions of the intertidal zone. In this sense the diversity of mangrove plants is not measured in terms of number of species but in terms of the ability of each species to cope with the wide range of environmental conditions in utilizing their individual specialised attributes (Duke *et al.,* 1998). However, respondents who were interested in conservation and/or non-wood provisioning ecosystem services such as ecotourism and beekeeping felt the mangrove with a more diverse range of tree species was the most important indicator for a resilient mangrove ecosystem. This may have been due to the fact that they felt that a decline of overall ecosystem species diversity provided a signal of ecosystem degradation (also Iftekhar and Islam, 2004) and may reduce the availability of ecosystem services. This finding is supported by Josoeph et al. (2012) who reported that mangrove ecosystems with a high diversity of vigorously growing mangrove trees species enhanced belowground biomass in young mangrove plantations more than mangrove ecosystems with fewer mangrove tree species.

Related to the number of mature plants, all respondents agreed that resilient mangrove should have sufficient number of mature mangrove trees to be able to provide the diverse ecosystem services they needed. They reported that if the number and size of mature trees declined below a certain level (threshold), the capacity of the ecosystem to provide desirable ecosystem services would be considered to be degraded. A high abundance of mature trees enhanced resilience of mangrove forests because mature trees produced a healthy supply of seeds and propagules for colonising new areas and repopulating areas damaged or destroyed by disturbances (Brown, 2007; Rajkaran and Adams, 2010). FAO (1994) suggested 12trees/ha of mature seed producing mangrove called ‘standards’ should be left after clear felling in plantation mangroves. Similarly, a harvesting intensity of 5 % per annum was thought by Rajkaran and Adams (2010) to maintain the number of mature individuals for *Rhizophora mucronata* at greater than 3,000 trees per ha in Mngazana mangrove forests. This level of harvesting may vary depending on site specific condition of the forests.

Respondents felt that a resilient ecosystem should support and maintain the needs of interested stakeholders. When mangrove ecosystem will not be able to supply the ecosystem services needed by stakeholders above certain levels then this would lead to a significant decline of the village population in the absence of other livelihood opportunities. On the other hand because these stakeholders have diverse knowledge of mangrove ecosystems, villagers agreed that a resilient mangrove SES should incorporate cultural and Islamic-religious knowledge in the management system. Involvement of a diversity of stakeholders and their knowledge was highly encouraged in building a resilient system (Ostrom, 2009) because an increase in the capacity to learn different appropriate skills and knowledge is one of the key aspects of resilience (Berkes 2007).

The type and amount of ecosystem services to be utilized is of particular importance for resilient mangrove SES. Respondents from Pete and Michamvi agreed that a resilient society had a low dependence on mangrove wood harvesting for subsistence needs while benefitting more from non-wood mangrove ecosystem services such as honey and ecotourism. This is because small-scale selective cutting would have little impact (Ellinson and Farnworth, 1996) and may stimulate regeneration (Kairo *et al.,* 2002), while meeting the direct subsistence needs of the local population. However, this resilience indicator was opposed by the majority of Charawe mangrove harvesters who viewed that resilient mangrove should have the capacity to continue to deliver wood materials essential to contribute to meet their livelihoods income needs. Thus mangrove harvesting should contribute about 67% of the average monthly household income. This is because of high dependence on mangrove and limited livelihood options in that village. Thus, loss of supply of desirable ecosystem services such as lack of provisioning wood ecosystem service, and lack of beekeeping or ecotourism opportunities were effective indicators of a significant loss of resilience of the ecosystem.

Regarding mangrove management, villagers suggested that one of the critical indicators for resilient management institutions was the capacity of the management system to maintain a sustainable level of harvesting. This will be achieved if the management institutions were committed to undertake regular law enforcement, monitoring and follow-up of their plans. Another important indicator for resilient management agreed by villagers involved the encouragement of linkages and social cohesion between scales, sectors and actors (Bahadur *et al.,* 2010).

The critical aspect of resilience in relation to innovation is diversity of species, economic opportunities and institutions (Folke *et al.*, 2002). Respondents viewed that the presence of abundant numbers of dominant mangrove tree species was an important indicator for a resilient mangrove ecosystem. High diversity of mangrove tree species might have less influence on the resilience of mangrove because of the unusual nature of well-functioning mangrove ecosystem to support a few species of dominant mangrove tree species (Duke, 1998; Ball and Ellison 1998). However, as previously discussed, general thinking is that higher species diversity in ecosystem has more potential for resilience building through absorbing disturbances, spreading risks, creating novelty and re-organising following changes (Low *et al.,* 2002; Hughes *et al.*, 2005).

The most important indicator for building social resilience with regards to social innovation required by all respondents was for a resilient society to have the majority of people deriving their livelihoods independent of mangrove cutting. This requires not just developing various income sources, but creating appropriate alternative income generating activities that would bring in substantial incomes that serve as substitutes for the income once obtained from the mangrove wood harvesting. For villagers with high dependence on mangrove, such as that in Charawe the introduced livelihood activities would be required to generate 67% of the monthly household income and cover not less than 70% of total households.

Villagers also agreed on resilience indicators reported by Ostrom (2009) that resilient management should promote a management approach that allowed active participation of village elders and their institutions with realistic ownership, decision making power and benefits to local stakeholders.

Maintenance of system memory was an important aspect for system continuity. Ecological system memory can be in the form of seed banks and other biophysical resources that are inherited from predecessors (Cumming *et al,* 2005; Cabell and Oelofse, 2012). Although mangroves have no seed banks (Farnsworth, 2000; Harun-or-Rashid *et al.,* 2008) villagers agreed with the views reported by others that resilient mangrove should have an abundance of established mangrove propagules which are important for mangrove to recover (*kujiotesha*) (McLeod and Salm, 2006). A density ranging between 2,500 -10,000 seedlings/ha has been suggested as an adequate number required for ecosystem recovery after disturbance (FAO, 1994; Bosire *et al.,* 2008). In addition, elders in Michamvi stressed that the presence of less disturbed and well protected mangrove forests was an important indicator for a resilient system. The existence of ecosystems that are locally respected and have restricted access, such as sacred forests, has been found to maintain a 'genetic memory' which is important for ecosystem continuity (Robinson and Berkes, 2010).

System memory in social systems can be maintained in culture and traditions, indigenous knowledge, and institutions that serve to store knowledge (Cumming *et al.,* 2005, Capell and Oelofse, 2012). Villagers viewed that resilient systems should encourage and make use of knowledgeable religious leaders and village elders to facilitate knowledge sharing and transfer. The knowledge of elders is a form of legacy (Cabell and Oelofse, 2012), and thus the existence of institutions that facilitate continuous learning and store knowledge and experience are important for resilience building (Scheffer *et al.,* 2000, Carpenter *et al,* 2001; Berkes *et al.,* 2003).

9.4 Resilience evaluation

This section makes a qualitative assessment of the resilience of mangrove SES through a comparative analysis of the three plausible alternative future scenarios discussed in Chapter 8. The aim is to evaluate which alternative future is likely to lead to a more resilient mangrove SES by maintaining its identity and thus ensuring a sustainable supply of ecosystem services under the future drivers of changes and perturbations.

The assessment involved assigning the level of likelihood to each alternative future moving towards a resilient state by making predictions about whether or not properties of interest are resilient (Cumming, *et al.,* 2005) when compared with the defined resilience indicators across different aspects of SES identity (Table 35). In this study therefore, if the overall system identity is projected to change beyond pre-defined indicators under the influence of specified drivers and perturbations over the next 25 years, the current system is not resilient to these future conditions (ibid, 2005). In other words, a system which is performing well against the indicators within the specified time period over which resilience is being assessed is more likely to be resilient to shocks of different kinds (Cabell and Oelofse, 2012).

The approach provides an opportunity for systematic comparison of each scenario variable to the established indicators across scales, allowing identification of trends according to the established indicators. This allows development of specific interventions that need to be addressed for building resilience of the system. However, identification and comparison of each variable according to each indicator in relatively complex mangrove SES has contributed to increased difficulties and a long time spent on data collection, including the development of scenarios with diverse stakeholders in the field. Using a scenario technique to envision various plausible futures provides an opportunity for stakeholders to discuss key drivers and key uncernatinities of changes that when avoided, may contribute to achiving a more desired pathway. The approach also serves as a tool to define a methodological framework to generate a wealth of knowledge from diverse stakeholders to envisage the future. However, the intensive empirical data requirement for successful development of different scenarios presents challenges and difficulties in a scenario development process.

Whilst all three scenarios represent the dynamics of alternative futures, it is important to understand which of the scenarios is currently prevailing and more likely to be representative of the future of Unguja mangrove SES. Five out of the six studied mangrove sites indicate high rates of cutting, together with associated social variables (e.g. high reliance on village natural resources). This reflects the Coastal Boom scenario which most closely represents the true image of the majority of Unguja mangroves SES, other than Vijichuni mangroves. This study suggests that the trends of the key drivers for Coastal Boom scenario represent the most likely future.

Table 35 Comparison of future mangrove SES variables for each plausible mangrove SES scenario according to resilience indicators

Selected variables of the Mangrove SES identity	Examples of indicators that may be potentially used to identify thresholds	Coastal Boom	Techno-green	Non-inclusive State Control
Components				
Mangrove tree species	Prevalence of common mangrove trees species	Likely to decline	Likely to increase	Likely to increase
Average tree size and density	Number of large sized mature trees/ha – e.g. Mngazana suggested 5% removal leaving 3,000 trees/ha.	Likely to decrease	Likely to increase	Likely to decrease slightly
Mangrove stakeholders	Mangrove ecosystem services to meet the needs of stakeholders directly depending on the ecosystem.	Not likely to be met	Likely to be met	Not accessible and likely to lose some village stakeholders
Knowledge systems	Levels of cultural-religious knowledge incorporated in the formal management system.	Not likely to be incorporated	Likely to be incorporated	Not incorporated
Appropriate ecosystem services	Level of communities benefit from non-wood mangrove ecosystem services increased.	Not likely to be available	Likely to be available	Likely to decline
Harvesting rate (dependence)	Sustainable level of selective cutting of wood for home uses.	Not likely be to maintained	Likely to be maintained	Likely to be maintained
Relationship				
Mangrove management institutions	Extent of institutional capacity to maintain sustainable levels of harvesting.	Highly likely to decline	Highly likely to increase	Likely to increase
	Level of linkages and transparency among the stakeholders.	Likely to decline	Likely to increase	Likely to decline slightly
	Type and level of conflicts	Highly likely to increase	Likely to decline	Likely to increase
	Regular implementation, and follow-up of the planned activities.	Likely not to be achieved	Most likely to be achieved	Likely to be done by higher scale stakeholders
Innovations				
Diversity of species	Mangrove protection or planting in degraded areas.	Not likely to be done	Likely to be done when needed by locals	Protection by higher scale stakeholders
	Dominance of common mangrove species.	Likely to decline	Most likely to be available	Most likely to be available
Diversity of institutions	Recognition of traditional institutions in the formal management system – sense of community ownership and decision making.	Not possible to be achieved	Most likely to be achieved	Not possible to be achieved
	Coordination with other coastal resources sectors.	Not likely to be possible	Mostly likely to be achieved	Not likely to be possible
Diversity of economic options	Diverse and economically profitable livelihood activities independent of harvesting provisioning mangrove wood ecosystem by majority of the	Highly likely to decline	Most likely to available	Likely to decline

	stakeholders.			
Continuity				
Mangrove seed banks	Number of seedlings/propagules/ha (2,500 - 10,000 seedlings/ha) after cuttings.	Not likely to be available	Likely to be available	Likely to be available
Mechanism of traditional knowledge transfer and sharing	Level of involvement of Islamic leaders and other traditional knowledge transfer mechanism in the management system.	Likely to decline	Likely to increase	Likely to decline

The Non-inclusive State Control scenario (section 8.3) represents a future where mangroves are strictly conserved by the Government to the disadvantage of local people, many of whose livelihoods will be undermined by the management system. Mangroves and other coastal resources that formed parts of village common resources and were used by people for generations will be entered into protected zones. This system can create resilience for the mangrove ecological system in the short term, but will not be socially desirable for local communities. The ecological resilience will be supported by strict government law enforcement that will put most of the forest under protection and significantly reduce the level of harvesting. Local communities will continue to do low levels of illegal cutting, allowing the mangrove ecosystem to maintain its identity characterised by the presence of common mangrove tree species and a sufficient number of mature trees that are capable of producing sufficient propagules to re-organise the ecosystem (Table 35). It has been argued that this is a conventional 'command-and-control approach' to managing ecosystems (Holling and Meffe, 1996) that assumes a static model of the environment which can make a system more vulnerable by masking critical system properties that may go unnoticed until it is too late to recover (Resilience Alliance, 2010).

At the same time, this alternative future state is socially undesirable because it excludes people from the management and use of ecosystem services and provides no alternative income options while suppressing the existing ones. This situation will result in undesirable outcomes as it will not be able to maintain most of the resilience indicators of the key mangrove social system variables in the next 25 years (Table 35). When resilience is lost or significantly decreased, a system is at high risk of shifting into a qualitatively different state which may not be considered desirable by the local communities (Adger, 2000). For example, in mangrove SES like Charawe and Pete an increase in restrictions on village resources, without alternative income generating activities, will increase economic hardship for the majority of people. Lack of community participation will promote community–National Park conflicts which will threaten the ecotourism market in Pete. This situation is likely to force people who were depending on the mangrove ecosystem services and other forest resources (e.g. mangrove and terrestrial forest harvesters, beekeepers, tourism workers) to migrate to the nearby villages, town or beyond, leading to a significant loss of population and social identity. Likewise, domination of the state management regime, which does not recognise the power of local institutions in mangrove management in mangrove SES like Michamvi, will clearly discourage villagers to conserve mangroves. At the same time, high population pressure with limited livelihood options will increase economic hardship in the village and degrade social resilience. This will result in some illegal cutting of mangroves that will increase conflicts between villagers higher scale stakeholders. Lack of community participation with their institutions will lower the villagers' trust within communities and in other stakeholders, and it is likely that cross-scale stakeholders linkage and knowledge sharing, transformation, and learning will not take place and this will degrade the continuity of the system.

This study suggests that the Non-inclusive State Control scenario is not capable of maintaining the positive trend of changes of most of the key social variables of the identified indicators resulting in loss of identity of mangrove social system and therefore it will not be resilient to cope with the future drivers of change (Table 35). Governance of coastal resources through a State management regime without community participation reflects a 'conventional prescription of resources management' which in many cases does not result in sustainability and ecosystem resilience (Holling *et al*., 1995; Berkes and Folke, 1998) and is likely to collapse as it has been observed in in many places (Faraco *et al.,* 2010; Mangora, 2011).

Coastal Boom scenario (section 8.1) represents a future that is not likely to lead to a resilient system identity. One of the major weaknesses is that Coastal Boom scenario applies an unrealistic conventional ecology approach where exclusion of human resource use is thought to protect changes of the ecosystem characteristics (Berkes and Folke, 1998). Management approach is achieved through approval of institutions that impose restrictions on the use of resources under protected areas by the surrounding villagers without realistic law enforcement.

Whilst the management of different resources on which communities depend falls under different sectors, the Coastal Boom scenario will focus on the management of a single resource, with little coordination with other sectors which leads to degradation of other resources. For example, in Charawe where the $REDD^+$ project focuses mainly on community terrestrial forests, people have shifted their cutting pressure to mangroves forests. Likewise in Pete where $REDD^+$ projects focus on limited village terrestrial forest and mangroves, the majority of people shifted their harvesting pressure to the National Park. This suggests that if $REDD^+$ fails to work and under uncoordinated management it is likely that communities will shift their cutting pressures and cause degradation to these $REDD^+$ protected areas once they fail to recognise true benefits in future. This is particularly true for carbon trading project that allows the global North to maintain high level of resources consumption by paying Southern communities engaged in conservation a pittance for offsetting carbon emission (Liverman, 2009).

Similarly, money saved by most of the women members engaged in saving and credit groups in Charawe and Pete SES has been used as capital to run a wood trading business, thereby accelerating forest degradation in the areas. Solutions that address individual problems as they arise may be successful in the short term, but they may also set into motion feedbacks and interactions among the different parts of a system that can come into play later and cause adverse impacts to the system (Resilience Alliance, 2010).

At the same time although mangroves will be protected by laws to the extent that there is no permission to cut a single mangrove tree and collect dry wood including leaves as indicated in all COFMAs, the absence of political will results in low government priority on conservation of mangrove ecosystem. In this way the Government will fail to allocate sufficient resources to conserve the mangroves and therefore these laws will not be enforced or will be characterised by ad hoc implementation subject to donor availability and interests whose support is short-term and has specific focus on their activities.

Paradoxically Government through CBNRM encourages local communities to protect the mangrove ecosystem but with no decision-making powers or ownership of the resources. If the communities would have realistic decision-making authority there will be no possibility for all villagers to develop similar COFMA that put complete restrictions on the harvesting of mangrove resources to comply exactly with the Forest Act (see revised COFMAs in all study sites). In mangrove SES like Pete, Charawe, and Kinani this will result in non-implementation of these local management plans and will be a cause of controversy between the Government and locals especially in this situation of high economic hardship and no reliable alternative income means to these communities. The issue of alternative income for local communities is explored in detail later in this section.

All of this makes both State and CBNRM rules not only inadequate but also inefficient and even unfair and has not been effective to control mangrove cutting. This finding is consistent with a study undertaken by Saunders *et al.* (2010) who assessed the changes in mangrove cover before and after a five-year (1996-2001) pilot formal CBNRM at Kisakasaka mangrove forest in Menai Bay Unguja. The result from satellite images indicated that the rate of mangrove clear cutting was dramatically increased during the project time from 14% clear-cut areas in 1984 to 28% in 2001 (Saunders *et al.,* 2010). The main cause of the failure was the lack of government support and limited donor funding as few non profitable alternative economic activities were developed for the local communities. The alternatives that were developed were beekeeping and forest plantation which generated lower income than the income communities' obtained from charcoal.

Inadequate Government and other stakeholders (e.g. private sectors and civil societies) support to develop reliable alternative income opportunities that have potential to reduce household income poverty for communities around the protected areas is another important limitation of the Coastal Boom scenario. Government efforts and other stakeholders through DFNRNR will emphasise the introduction of ecotourism, beekeeping, carbon selling, saving and credit and tree planting without knowing their potential economic benefits to reduce poverty for the intended beneficiaries. Whilst these are the kind of alternative income sources that are perceived by government and other supporting partners as appropriate in providing communities economic incentives to stop mangrove/forest degradation, villagers from Pete and Charawe viewed that the available alternatives have not generated sufficient household income to stop them carrying out commercial harvesting of village forest/mangrove resources.

The main reasons for poor performance have been identified including lack of political will and government commitment on mangrove conservation which results in low government priority to allocate sufficient resources to develop reliable alternative income activities for the local communities. As a result there is a tendency towards over-reliance on donors and external expertise for initiation of the projects, who in most cases introduce the project-based activities to address specific government/donor interests aimed to support community development activities with limited focus to meet specific household needs. This has been a typical experience in the mangrove boardwalk ecotourism introduced in Pete to resolve community and park conflict

(Masoud, 2001), whereby the generated revenue is shared by several stakeholders from national to local levels as compensation to UWEMAJO and support community development projects without direct household income to the individuals (section 5.3.4b in chapter 5). Similarly in Charawe where the majority of people are poor, the introduced community projects such as improvement of school and health centre buildings have not contributed directly to household income in the village. In the same way carbon incentive funds from HIMA were given to local communities surrounding the JCBNP to meet specific village expenditures defined by the projects (personal observation, 2013). This approach is potentially useful since it may result in general long-term community benefits, but is not desirable in terms of meeting immediate short-term household alternative income needs to support their livelihoods.

Other reasons for inefficiency of the projects are that most of the alternative income opportunities are introduced with insufficient initial consultation with local communities. Interventions have insufficient capital to support project productivity; cover a small fraction of the community's needs, and/ or lack a reliable market for trading the products. They tend to focus on the short-term only, which means they have limited spill over effects, and they are not sustainable while some of them collapse even before the donor funding stops. For example, MACEMP provided a modern fishing boat in all of the study villages which was reported by villagers to fail to give benefits to the people while the introduced poultry project in Charawe collapsed before it ended. Similarly the HIMA project supported a small-scale entrepreneurs' development programme in Charawe to reduce dependence on forest harvesting following the selection of this village to pilot REDD$^+$ climate change mitigation measures project in the Island. However out of more than 90% of Charawe people who were forest dependent, only 2.1% of them have been selected to pilot new small-scale alternative income generating projects in the village by the HIMA project (Personal communication with Deputy village Sheha, 2013). Other projects fail due to the tendency of Government or funding agents to ignore the complexity and heterogeneity of communities leading to resource disputes and capture of project benefits by community elites (Brown, 2004). Individual members are seen as united by culture into "`moral communities'" sharing common interests and mutual dependence (Leach *et al.,* 1999, Blaikie, 2006). This has been a common feature in REDD$^+$ projects whereby community simplification resulted in REDD$^+$ compensation benefits being captured by a few influential community groups without adequate compensation to non-elite community members (Blom et *al.,* 2010). The outcome is increased conflicts and continued degradation by non-elite groups which leads to inefficiency of the projects. Indeed, in general, most carbon trading projects are paying a very small amount of money to the communities involved in conservation of resources (Liverman, 2009). In some situations Government, special interest groups and individuals of countries receiving foreign aid do not have incentives to promote efficient use of the funds or some donor agencies prefer to set big, wide sweeping goals to satisfy the political imperatives of politicians and bureaucrats in the aid recipient countries which results in failure of the projects (Williamson, 2010). Lack of donors' accountability contributes to the poor performance because they have very little incentive to monitor how the interventions continue once they are in the hands of the target recipient government or after the project ends.

One possible outcome of Coastal Boom scenario is that lack of political will and low government priority on mangrove conservation will allow the mangrove in tourism zones like Michamvi mangrove SES to be cleared in favour of tourism expansion and development. In these areas, unplanned conventional tourism and city expansion under the Coastal Boom scenario will result in complete conversion of mangrove ecosystem for hotels, resorts or port construction leading to collapse of the mangroves and complete loss of key ecological variables that define ecosystem identity. Such a scenario was evident in some of terrestrial forest SES of Unguja where expansion of tourist infrastructure in Nungwi and Paje village results in significant conversion of local forests for hotel building (Suckall *et al.,* 2012). At the same time, unplanned tourism will result in excessive population growth in these areas due to immigrants from outside Zanzibar (Gossling and Schulz, 2005). This will exert pressure and competition on the available resources and tourism related businesses on which locals depend. This will clearly narrow the available livelihood opportunities and increase the economic hardship for the majority of natives in these areas.

High population growth with low household income earning, and no alternative income or energy sources, will promote high demand for wood products for energy and building needs. This will result in excessive cutting of mangrove resources beyond thresholds to meet short term income needs of the local people while destroying the future capacity to cope with the impacts of complete degradation of resources.

These drivers will push most of the key mangrove SES variables beyond their threshold level and lose most of the resilience indicators which suggests a significant loss of identity and resilience of Unguja mangroves SES as indicated on Table 35. For example in areas like

Charawe and Pete mangroves SES the increase in population will be associated with high demand for mangroves and other forest products resulting in high cutting pressure that will alter the structure of the ecosystem. The ecosystem will lose mature common mangrove tree species and this will result in the loss of identity within the next 25 years. This change will have different impacts on the supply of different ecosystem services and livelihoods to different stakeholders groups cross scales. Primary stakeholders who have direct dependence on harvesting wood products and other ecosystem service such as beekeeping, fish and cockle collection for their livelihood will be much affected. On the other hand, all village stakeholders will suffer from reduced efficiency in the supply of non provisioning mangrove ecosystem services such as control of strong winds and waves from the sea. Despite its high regeneration rate indicated by high number of seedlings and saplings, excessive removal of mature plants before the next generation strongly suggests that it will destroy the capacity of the ecosystem to maintain its regenerative ability and this will threaten the continuity of the system.

Likewise significant loss of mangroves in tourism zones will result in loss of current ecosystem services such as ecotourism and their associated income. Excessive loss of mangroves results in decline of the availability of other coastal resources especially total catch of mangrove associated fisheries (De Graaf and Xuan, 1998) on which communities depend although there is no precise data to correlate changes in fish yields with changes in mangrove cover in Zanzibar mangrove. Social unrest may not necessarily happen but there is a chance it will happen through the increase in conflicts and competition over scarce resources among the society members. Tourists will not visit a place where there is social unrest which further degrades the tourism related income for the communities. Lack of reliable alternative livelihood opportunities will not only cause mangroves to suffer enormous short-term degradation but whole populations will have to eventually move.

The Non-inclusive State Control scenario is less desirable and the Coastal Boom scenario (that is currently dominating) is clearly not fostering a resilient future. Policies and management systems that are conducive to any of these scenarios under the current situation without addressing their limitations toward resilient mangrove SES are not likely to result in successful outcomes. Instead it increases the vulnerability of mangroves SES to higher future cutting pressures that may result in collapse of the system.

To achieve desirable resilient mangrove SES, an alternative future trajectory is needed to provide diverse ecosystem services to satisfy the needs of all stakeholders. Among the three identified scenarios Techno-green (section 8.2) gives the best alternative future option that will be able to maintain most of the important mangrove SES indicators in the next 25 years (Table 35) and thus achieve conservation of mangroves, balance the supply of ecosystem services, and improve the livelihoods of the surrounding communities. The alternative scenario is not a completely new system but an approach that maintains the strength of both Non-inclusive Control and Coastal Boom scenarios while trying to overcome their limitations towards resilience building. This provides a way through active adaptive management (Folke *et al.,* 2002) which allows managers to learn from mistakes, embrace changes, avoid undesirable pathways and build resilience-based approaches (Anderies *et al.,* 2006).

This scenario represents the current feature of Michamvi/Vijichuni mangrove governing system whereby the presence of a strong informal mangrove management institution has shown significant success toward resilience building. The people in this village planted their mangroves since the ancient time to protect the village from strong waves and winds and meet the village wood demand, which provided them with a sense of ownership and decision making power on management and the use of resources and thus contributed to their success. This case provides lessons that can be learned, replicated and applied more widely in Zanzibar and elsewhere. However, despite its potential to bring out a resilient system the adaptation of this management approach requires addressing some of weaknesses of the system that might limit its wider application. Such drawbacks include the applicability of the system in the Michamvi local context which represents an exceptional tourism environment where communities have access to diverse tourism-related alternative income activities or market for selling other produce. The plausibility of such a scenario is more questionable in some of the areas where tourism has not yet developed or is not benefiting locals. Additionally the closeness of the village to the mangrove, and its small size, allowed local communities to watch over the resources more effectively than if the mangrove was distant from the village.

The results from this study show that for resilient future Techno-green scenario to be achieved government efforts and strategies in collaboration with other stakeholders (donors, private sectors, and civil societies) should focus on addressing the underlying drivers that accelerate the rate of mangrove harvesting in the Island. The most important drivers that will be addressed to bring about resilient future are the level of poverty, the market for trading wood provisioning ecosystem services and workable institutions for conservation of resources. These both require and are needed to bring about changes of behaviour of the stakeholders. It is obvious that none of these drivers can work in isolation or be implemented by one stakeholder group and be able to follow the pathway toward Techno-green scenario, but rather the likelihood of success to achieve expected outcomes depends on the improvement of a combination of these factors by different stakeholders. For example, poverty reduction alone does not necessarily result in improved mangrove conservation or vice versa. Even the better off among the local inhabitants in Charawe has high dependence on wood harvesting because the income received from non-mangrove sources is not sufficient to stop them from mangrove harvesting.

Potential responses that could be implemented towards a Techno-green future and more resilient mangrove SES

- **Poverty reduction**

Poverty is a major factor causing excessive mangrove cutting in Unguja rural villages and until it is tackled decisively by the Government, conservation of mangrove and associated coastal resources will remain in vain. Under the Techno-green scenario Government takes the needs of their populace seriously. This means both addressing their desire to increase national economic growth in the form of GDP and the local population's desire to improve household economic earnings through increasing access to reasonable economic opportunities. According to the government vision, Zanzibar will eradicate abject poverty and raise per capita income to that of middle income countries by the year 2020 by emphasizing broad-based equitable and pro-poor income growth of the Islands (RGoZ, 2010). Some of the measures that will be taken by the Government to improve national economic growth include mass investment in industry, agriculture and fishing, and service sectors.

To increase foreign income earning Government will focus on development of the service sector which includes tourism as this is a major income earner contributing about 47 % of the GDP and 80% of external revenue in the Island (RGoZa, 2010). It is suggested that successful exploitation of presumed existing petroleum resources which is expected to be realized in the next five years will also contribute to national foreign exchange revenues. With a significant contribution from the tourism sector, Zanzibar's annual macro-economic growth has increased from 6.7% in 2009 to 7.0% in 2013 which is also expected to reach 12% by 2020 (RGoZ, 2013a). However, it has been argued that this type of growth (tourism) has not generated sufficient employment opportunities and therefore has low potential to reduce income poverty (HBS, 2010) and achieve broad based equitable and pro-poor income growth of the Island (RGoZ, 2009). Gossling (2003) reported that the tourism sector in Zanzibar has not generated sufficient employment opportunities for the poor coastal communities. It has been seen that people from outside Zanzibar are benefiting more from employment opportunities generated in the tourism industry than the local communities who are bearing the full brunt of the environmental and cultural costs of tourism (Gossling and Schulz, 2005).

Despite Botswana being a middle income country with annual GDP per capita of $9,500 unemployment, rural poverty remains high at about 40% (Blaikie, 2006). Likewise the extraction of natural resource wealth in highly dependent resource-rich Sub-Saharan African States may seem to hold potential for contributing positively to Africa's economic development. In practice it has been difficult to convert resource wealth into broad-based improvements in economic growth and human development (Pegg, 2003). In fact, countries highly dependent on oil and mineral exports tend to grow more slowly, face lower living standards, and suffer higher levels of environmental degradation, corruption and violence than resource-poor countries (ibid 2003, Ebegbulem *et al*., 2003, Idemudia, 2009).

In responding to these challenges under the Techno-green scenario, Government will train more Zanzibaris in more useful fields in tourism such as hospitality so as to significantly expand the employability of the local people in the tourist industry (RGoZ, 2009).

Although it is less common to achieve a positive link between environmental protection and development particularly on oil exploration, Zanzibar will also improve economic growth through oil extraction if the Government will follow the pathway indicated by successful countries such as Norway which, through the presence of institutions that promote transparency, accountability and State competence, has used the benefits of petroleum extraction to achieve a strong social development performance (Robinson *et al,* 2006). According to Tanzania mainland strategic plan to avoid negative environmental impacts caused by oil extraction, there is a focus on using environmental friendly technologies that will minimize negative effects on communities and the environment (PWYP, 2011). If this strategy is successful, the Zanzibar government could adopt similar technologies to secure mangrove from the future impact of oil industry. It is also noted that the potential oil exploration areas are located in four blocks off Zanzibar’s coast (Zanzinews, 2014) which do not include areas with mangrove forests. At the same time decision makers will ensure thorough implementation of Environmental Impact Assessments (EIAs) and Strategic Environmental Assessments (SEAs) in order to mitigate likely future negative environmental and social impacts of oil before the approval of gas and oil extraction projects (RGoZ, 1996b); Zanzibar Tourism Policy, 2006). Successful implementation of these measures require greater commitment of the involved stakeholders to implement these measures to contribute to reducing substantial environmental damage associated with oil industry in the Island.

In addition government strategies to achieve broad-based and pro-poor economic growth aim to create an enabling environment that will promote private sectors to support development of agriculture including marine sectors which are currently generating higher employment shares of 39.1 and 37.3 percent, respectively, than tourism (RGoZ, 2010). Government policies should support sustainable management of marine resource because of its potential to contribute about 30% of GDP in Zanzibar (Lange and Jiddawi, 2009).

In recent years proponents of sustainability and resilience have come up with the concept of a 'green economy' suggesting that future economic growth and the securing of environmental services need to be intertwined (UNEP, 2011a). According to Rwanda's national policy, future economic growth will be focused on adoption of a green economy through the processes of mainstreaming climate resilience and low carbon development strategies which would allow the country to transform from a subsistence agriculture economy to a knowledge based society, attaining high economic growth with minimum impact on the environment (RoR, 2011). Assuming such a policy will achieve the stated objectives, the Zanzibar government could follow a similar path with the potential to increase the level of income for majority of people of Zanzibar.

At the household level, development of reliable alternative income opportunities is the most reliable and effective way to reduce the level of income poverty in Zanzibar. Access to diverse economic options is an important aspect for building future resilience of local communities who depend on their village resources for their livelihoods (Adger, 2000). Under the Techno-green scenario, the government support for the development of alternative income activities will not be limited to the introduction of a few income alternatives that the DFNRNR has emphasised. To overcome the inefficient and unsuitable nature of the introduced and available alternative income sources, government measures in collaboration with other stakeholders, will focus on improvement of economic productivity of the existing livelihood options but also introduction of new site specific income sources that will have good market value and provide economic profitability to compensate for the loss of benefits from mangrove/forest harvesting.

The success of these interventions will be dependent on several factors including high government commitment to timely allocation of resources in supporting the introduction of projects which is important to lessen high reliance on donor support especially after their projects end. UNEP (2011) suggested that commitment of top government decision makers on mangrove conservation can be promoted by assigning total economic value of all mangrove ecosystem services and integrate their significant (the figure) in the national economy accounts. This will raise interest and create positive will for decision makers to support local people's livelihood activities knowing that without supporting them, this could degrade the potential national wealth of the country.

It is important that introduced alternative income activities are preceded by a feasibility study to assess their viability in terms of market access and income to benefit the local community before a decision on wide scale support and implementation of the projects has been made. Development of alternative livelihood activities that have difficulties in finding market for the products has acted as a barrier to the success of most conservation (Fisher *et al.,* 2005). It is essential that the Government and or donor partners should focus on development of alternative income options that will generate long term benefits to cover a large proportion of people in need in the society. One of the possible options is carbon credit trading projects through REDD$^+$ initiatives as it has been increasingly recognised to have the potential to provide a direct economic benefit and the incentive to protect and sustainably use mangrove forests (Brown et *al.,* 2008). However, it is not clear how communities might gain financial benefits from the REDD$^+$ project in Zanzibar as many REDD$^+$ projects elsewhere have failed to give substantial benefits for small and poor community members (Liverman, 2009). For example, the prepared carbon forest management plans for the pilot REDD$^+$ project in Rufiji mangrove were threatening to deepen communities' poverty through dispossession which negatively impacted livelihoods of the Warufiji despite the original project emphasis on poverty alleviation through CBNRM (Beymer-farris and Bassett, 2011). For this project to work and serve as a reliable alternative income source for forest dependants it should generate substantial income benefits and provide alternatives that earn good market values to cover a large fraction of society.

The development of alternative income sources to improve economic growth of the villagers cannot be done by the Government alone. Thus Government should provide a policy environment enabling different stakeholders (in particular other development partners, the private sector and civil society organizations) to engage their actions to significantly enhance economic growth and thus reducing poverty (RGoZ, 2010). Zanzibar Investment policy has been established to promote participation of private sector investment to improve communities' economic growth through expansion of tourism, business services, sea transport and manufacturing; other areas are fisheries, air and agriculture (RGoZ, 2004). These initiatives have the potential to create employment or improve productivities of the livelihood activities engaged in by villagers.

The types and urgency of these interventions will vary to suit village conditions. In relatively less accessible mangrove SES like Charawe where the majority of people's livelihoods are achieved through commercial exploitation of mangrove wood provisioning services, and they have no access to tourism market, immediate government attention is required to develop more reliable and profitable livelihood activities than mangrove harvesting. Such alternative income activities should cover the 85% of the people who are in need and generate 67% of current average monthly household income. To switch Charawe people away from dependency on the mangrove harvesting, the introduced interventions should be able to generate the income that Michamvi peoples are obtaining from non-mangrove income sources. Likewise in areas like Pete mangrove SES where the majority of people are farmers, but the average earning from farming is lower than selling of harvested wood from terrestrial forests, significant support is required to increase income earning from agriculture and other livelihood activities above that of forest cutting. In mangrove SES like Michamvi, where the tourism market has provided communities opportunities for diverse and relatively reliable tourism related business, government leaders and decision makers should make significant efforts to maintain and improve the availability of these options while controlling the potential threats that might affect them in the future. Sustainable tourism – a kind of tourism which makes a low impact on the environment while helping to generate and meet the income and employment needs, and conservation of local ecosystems (Cater, 1993) gives a practical solution. Proponents of sustainable development suggested that sustainable tourism should shift in priority from promotion of broad-based socio-economic growth and give greater priority to pro-poor tourism that will create employment and business opportunities for the poor and improve their capacity to protect the environment (Neto, 2003).

Makame and Boon, (2008) suggested that sustainable tourism can achieve sustainable conservation of Kiwengwa – Pongwe forest reserve in Unguja Island if the Government will implement a well-planned tourism strategy that promotes the development of institutions to facilitate benefit sharing, create job opportunities and help sustain the local economy while preventing associated negative environmental and cultural change. Introduction of a pro-poor tourism approach has been successfully implemented in Namibia whereby a non-profit organisation (Namibia Community Based Tourism Organisation) supports poor local communities to access tourism economic benefits and promote environmental conservation and cultural traditions in the area (Neto, 2003).

Other approaches to achieve sustainable tourism have been suggested for conservation of Chitwan National Park in Nepal including ensuring changes of the management from private owned tourism industry to community managed development and establishment of defined mechanisms for profit sharing with local communities are in place before advocating ecotourism development (Bookbinder *et al.,* 1998). Strengthening local institution capacity is required in order that local people can improve management and benefit from tourism. Civil society can play a significant role in achieving sustainable tourism, as with mangrove management. Engaging with the local communities through their village conservation organisations would help to 'police' tourism developments and ensure that they are conducted in a manner commensurate with Zanzibar ethical and environmental standards.

As is clear from all cases study findings that the communities meet their household income needs from diverse livelihood activities, many of them related to different types of village natural resources, some of them are managed under different government sectors. Development of effective linkages between these sectors is necessary to provide joint efforts to address the livelihood needs of these communities. Conceivably some of these sectors' decision makers might have high influence on providing alternative income sources but with little interests to mangrove conservation, which in turn influence them to support development of reliable income sources for the mangrove/forest wood harvesters. In this context it is the role of higher level stakeholders interested in mangrove conservation (DFNRNR) to create and build the interest of non-interested powerful stakeholders (for example, from the Ministry of Labour, Economic Empowerment and Cooperatives) to support the livelihood of poor people around the protected areas. In other words, the introduction of alternative income means that have potential to reduce level of local communities' poverty cannot be achieved by DFNRNR or specifically from mangrove related interventions alone but contribution from different sectors is of vital importance. Such coordination will help to prevent negative impacts to a particular resource caused by managing one resource but leaving other resources outside the project area.

Apart from reducing poverty using short term income measures Government should put specific efforts in long-term poverty reduction using non-income dimensions. Scholars in economic development have established that knowledge created through innovation and technological progress is the long-term driver of economic growth. Government will focus on increasing access to quality education and health sectors so that by 2020 remarkable advances in these sectors will provide healthy and educated villagers who have the potential of acquiring well-paying jobs (RGoZ, 2010) and reduce dependence on forest cutting. Some Asian countries especially Japan and including more newly industrialized economies (e.g. Malaysia Korea, Taiwan, Hong Kong and Singapore) have shown remarkable success in moving toward a knowledge-based economy through creating a good governance environment that attracted large amount of direct foreign investments to support such initiatives (Chandra and Yokoyama, 2011).

Diverse availability of reliable and profitable livelihood activities will make the majority of residents self-sufficient in terms of income earning opportunity independent of cutting mangrove wood. Once communities realise the true benefits and have sufficient income, they will be capable of purchasing mangrove poles or switch to available cheap alternative energy sources for subsistence needs (discussed below) and therefore give the mangrove sufficient time to grow and maintain its identity.

- **Control of the wood biomass market**

Development of alternative reliable and affordable energy sources is necessary in Unguja in order to protect mangrove from severe overcutting and its consequences. Under the Techno-green scenario wood biomass fuel will not be a major source of energy for cooking by most Zanzibaris. This could be achieved through reducing the demand for biomass energy and influencing the supply of alternative energy. To reduce the demand for biomass energy the Government in collaboration with other stakeholders should put significant efforts towards developing reliable, affordable alternative energy sources that are cheaper than wood biomass and/ or modern energy expensive technologies that are heavily subsidized by the Government. Makame (2007) suggested that wide adoption of the use of improved charcoal cooking stoves provides a possible option of reducing fuel wood consumption in Zanzibar. The uses of LPG and electricity have potential to replace biomass use in Zanzibar (Magessa, 2008) if it will be subsidized by the Government. These measures can be complemented with the use of crop residues and biofuel plantation establishment. To increase the supply of alternative biomass wood energy, Hopkins and Dyess (2012) suggested five sources of renewable energy appropriate for developing countries to reduce forest harvestings. These include the use of biomass briquettes, solar, wind and biogas energy together with the development of micro-hydropower projects. Some of these initiatives can well be supported by private or donor agencies if the Government provides an enabling policy environment for investments. For example, a European Development Fund programme has recently launched a new Development Cooperation agreement directly supportive of the Zanzibar Renewable Energies and Energy Efficiency initiative which allocates EUR 3 million (6.8 billion TSHS) over 5 years (2014-2018) (Zanzinews, 2014b).

Since most of these measures take time to be realised and or adopted (e.g. raising trees for energy requires several years for them to grow before the first harvest) an immediate intensive campaign should be launched by the Government to supply the subsidized efficient energy sources to allow widespread switch-over and adaptation to new technologies by the majority of urban dwellers and rural communities before tree maturity. Successful adaptation of these energy technologies will significantly reduce the number of people who rely on trees and woody vegetation to meet their basic energy needs. In mangrove SES like Charawe, Pete and their neighbouring villages where local communities have high dependence on commercial harvesting of wood biomass fuel, including mangroves, people will have less incentive to harvest mangrove/forest products for firewood and charcoal because the market will not be available. In areas like Michamvi where most of the community members are not directly involved in commercial harvesting of forests/mangrove, the available energy sources will not have significant impacts on the rate of harvesting in mangroves. However, most of the villagers and their neighbours will not need to harvest wood products for meeting the biomass energy for subsistence needs because the availability of reliable energy sources will enable them to meet their domestic energy demand without cutting forests.

- **Institutional strengthening**

Although mangrove has been subject to different combinations of laws and regulations, the prevailing high rate of harvesting from most of the study sites indicates the inefficiency of the mangrove management approach. If the mangrove is to be protected and able to supply the ecosystem services desired by different stakeholders, an effective mangrove management regime will need to be put in place under the Techno-green scenario. The achievement of an effective mangrove management approach under this scenario requires the strengthening of the current management regime by addressing a number of issues that entail immediate government attention. The presence of real government commitment and positive political will is of critical importance to achieve conservation of mangrove in future. It has been suggested that if the government leaders would consider the total economic value of all mangrove ecosystem survives and integrate their potential financial value in the national economy accounts, would help to promote government commitment toward conservation of mangroves (UNEP, 2011). Supporting influential political and environmental activists, such as initiatives of the late Wangari Maathai in Kenya, to advocate and support the conservation and sustainable uses of forest resources contribute to government commitment toward supporting conservation programmes.

Positive political will provides Government with an incentive to prioritise mangrove conservation and allocate sufficient resources for conservation of the resources. In this way the management of mangroves will not be limited to development of bundles of formal restrictive legislations and plans at different spatial scales to protect mangroves and associated resources with no or irregular implementation according to donor interests. For example, Government through DFNRNR in collaboration with donor projects has been very keen to develop and formulate different plans and programmes related to mangrove conservation such as mangrove management plans, COFMAs, Forest monitoring plan, Forest long term plans, and other associated government plans such as ACAMP. Most of these plans remain on paper and have never been effectively implemented. A special policy reform is required to focus on effective and practical implementation of these legal instruments and plans rather than creating new ones. Timely availability of government funds and other resources will reduce high reliance on donor support allowing the Government to implement and follow their programmes as indicated in their plans.

At the same time the current forest acts, policy and village by-laws which only encourage community to conserve mangroves without clear decision making power and use right are not equitable or practicable. It is important that these legal instruments are put in place a legitimate and effective co-management approach that will recognise the realistic participation of local communities and their institutions in managing the resources. Practical, legitimate and effective community participation should consider the necessary conditions for successful CBNRM.

Importantly, this includes equal involvement of community and government actors (Ballet, *et al.,* 2009) community sense of security of resource tenure and decision making, availability of appropriate financial resources and facilitation support (Ostrom, 1990; Anderies *et al.,* 2006). Recognition of informal institutions will provide community rights and flexibility in decision making (Leach, 1999) allowing use of mangroves to meet emergency village/household needs while conserving the resources. This situation is illustrated by Michamvi SES where effective local institutions have shown significant success in Vijichuni mangrove conservation. Involvement of local communities in this way promotes participation of village elders and religious leaders to have influence on the management and control of the resources. Active participation of these village elders and religious leaders create interactions with young people, village conservation group and this suggests that the knowledge sharing and transfer is taking place among the society members (section 6.6, Chapter 6). Participation of multi-layered institutions improves the fit between knowledge, action, and social-ecological contexts in ways that allow societies to respond more adaptively at appropriate levels (Anderies *et al.,* 2006). In this case, local communities will be united and coordinated with high level stakeholders and this is likely to create more positive perceptions on mangrove conservation because they will also be given permission by the Government to do selective harvesting in specific areas to meet limited desirable subsistence emergency needs from mangrove wood products. Resource managers will learn about the changes that are taking place, and therefore understand how to manage, cope with, and adapt to changes (Anderies, *et al*., 2006; Resilience Alliance, 2010).

As mentioned earlier in this section, the communities' livelihood household needs are achieved through the exploitation of different types of village natural resources, often managed under different Government sectors including fishery, agriculture, tourism, forestry and energy and possibly minerals in the future. However, lack of coordinated visions has led to the development of different plans focused on single ecosystem management and thus contributing to inefficiency of the system (De la Torre-Castro, 2012). In addition, policies and laws which govern these sectors are developed at higher government scales, but they are implemented at lower scales where local communities are using these resources. Likewise although Zanzibar has taken initiatives towards national development of Integrated Coastal Areas Management (ICAM) by initiating a pilot coastal area management programme in the Chwaka Bay – Paje site since 1994 (ICAM, 1996), its implementation has remained very far from being realised (De la Torre-Castro, 2012). In the Techno-green scenario, there is a prompt need to implement an integrated management approach for the coastal resources that will recognise the role of cross-scale interactions and link mangroves management and other coastal resources management. Practical implementation of this approach will provide clear understanding about the dynamics of systems at multiple interacting scales, allowing the stakeholders to learn from mistakes, reduce management costs and providing the means of balancing the competing demand of different users of the same resources (Anderies *et al*, 2006). In this way the approach will overcome the institutional coordinating problem and fragmented ecosystem management of small-scale CBNRM (Saunders, *et al.,* 2010,) advocated in most of these sectors. The system will also allow decision makers to be aware of the cumulative impacts of their decisions to the peoples' livelihoods at village scale and thus provide a platform for collective decision making among the involved parties.

- **Changes of stakeholders' behaviours**

Resilience is a useful approach for understanding the behaviour and dynamic nature of the system which provides new insights to improve the management practices and long-term sustainability of ecosystems. Since the mangrove SES consists of a wide range of stakeholders with different interests at different scales, it is obvious that they have different behaviours, perceptions and attitudes which influence their decisions and actions. This study suggests that changes of stakeholders' behaviours based on the current activities particularly of policy and decision makers, donor agents, and communities, usually takes time, but are of critical importance for implementation of the Techno-green pathway (Table 36). Some examples of the types of attitudes and behaviour change needed are provided below.

Table 36 Changes of stakeholders' attitudes and behaviours towards a Techno-green pathway

Stakeholders	Examples of associated attitudes and behaviour change
Top government policy and decision makers	• Positive attitudes towards high priority on mangrove conservation • Consider mangroves as valuable resources • Make decision on resources allocation in a more inclusive way.
Head of government departments	• Positive attitudes towards high priority on mangrove conservation • Fair and equitable distribution of resources across department sectors and timely available to the relevant mangrove stakeholders • Introduce and support specific mangrove management projects. • Monitoring and evaluation of the efficiency of the interventions. • Prepare formal institutions that balance between conservation and addressing interests of local communities. • Supports local communities to prepare village-bylaws addressing their interests and resource ownership. • Improve incentives for communities to participate on mangrove conservation. • Implementation of the prepared laws and plans.
Donors	• Support specific mangrove conservation projects. • Their support focused on long term perspectives and phased reduction of their support before the end of the project. • Continue with long term technical information sharing network and project monitoring after project period. • Allocate substantial resources to supports local community livelihood activities.
Mangrove wood harvesters and traders	• Mangroves harvesting and trading are not perceived as the most beneficial way of providing high income sources. • Supports implementation of prepared village by-laws and other formal institutions toward mangrove conservation.
Village elders and religious leaders	• Willing to transfer and share the conservation knowledge to other members of society. • Supports implementation of village by-laws and other formal institutions toward mangrove conservation.
Village youth and local conservation organisations	• Willing to cooperate with village elders, in knowledge sharing and participate on mangrove management, uses and conservation activities.

Top government leaders who have influence on budget and other resource allocation to different ministries and departments, should realise the total value of the mangroves in the Island and consider mangrove conservation as a priority objective. This will create an incentive for these leaders to make decision on resource allocation in more inclusive way among government departments. Availability of government resources for mangrove conservation may also influence the behaviours of donors to support mangrove conservation in the island.

This also equally applies to heads of government department who should fairly distribute the available resources to support mangrove conservation. Both Government department and donors should also come up with specific projects dealing with mangrove conservation in the Island. This project may create required attention to address conservation of mangroves and contribute move towards Techno- green pathway.

Donors' support should have a focus on more commitment to partnerships with a longer term perspective. For example, most donor projects provide short-term support with abrupt project closure which normally creates rapid discontinuity of project activities. The behaviour of donor policy makers should focus towards phased reduction of project support to create moderate changes in the project which builds the capacity of recipient project members to cope and continue with the management activities with the minimum resources available. Whilst the donor fund will have finished at the end of the project it is important for project technical experts to continue with relationships and create a network that may provide opportunities for technical support such as information and knowledge sharing which are relevant for continuity beyond projects.

Most of the donor supported projects focus greatly on achieving conservation of resources with minimum focus on providing realistic income benefits to locals. Successful implementation of Techno-green scenario requires changing this donor policy towards balancing the interests of conservation and local community needs. This will encourage donors to enter into partnership activities that allow spending significant amount of project resources to support realistic economic opportunities for local communities to pay for conservation efforts and losses incurred through not using the mangroves.

Both Government and donors should not only focus on the introduction of small-scale community projects or CBNRM programme. Monitoring the impacts of the projects or programmes has been very rare or non-existent especially after the donor fund ended. Therefore there is a great need for changes of this behaviour by emphasising monitoring and evaluation of these projects so that the involved stakeholders can learn the mistakes and success of their interventions. This will also ensure accountability of all stakeholders involved in the projects.

Policy and decision makers at department level – The existing formal institutions do not establish the right for the local people to harvest any wood materials or own resources This is because the interests of local communities in most cases differ from the interests of powerful stakeholders at higher scales, who are setting up these institutions. In Unguja where conservation of mangrove resources is an ultimate government goal while the local communities have high dependence on the same resource, the behaviour of higher stakeholders should change towards development of mangrove conservation institutions (both formal and village by-laws) that will allow a level of protection while giving flexibility for the locals to use the resources within the allowable limits, and provide alternative incomes to minimise the negative impacts of the conservation interventions to the communities livelihoods.

Higher scale stakeholders especially those with influence on formulation of mangrove management institutions, should improve legislation that will focus on giving local communities a sense of ownership to the resources. This might provide local communities realistic empowerment and incentives to participate in conservation and reduce vulnerability of mangrove degradation caused by lack of community ownership rights.

For local communities to be strong custodians and effectively participate in conservation of mangroves, the government stakeholders who are ultimately responsible for mangrove conservation should strengthen the incentives programme that may attract locals in mangrove management activities. The behaviour of DFFRNR in collaboration with other partners should focus towards providing local communities with appropriate environment for their participation including availability of reliable material, equipment and other incentives that might be identified by the communities to protect mangrove. These interventions may have long-term impacts on behaviour changes by local communities in mangrove management activities at the time when project/department staff are not available.

At community level, mangrove harvesters and traders should change their perception that will lead towards changes in cultural and traditional habits of increasingly seeing mangroves harvesting as the most beneficial way of providing them direct income sources. At the same time village elders and religious leaders should be ready to share their mangrove conservation knowledge and collaborate with young societal members to engage on mangrove conservation. Changing of the local communities' behaviour can be more challenging because they can become 'locked into' particular behaviours due to a range of wider societal factors (limits and barriers) that are outside their control. For example, people of Charawe may want to stop harvesting but they cannot do that because of the economic reasons which unless resolved people will not have the capacity to remove from mangrove harvesting. However a local community behaviour change is possible with the right support which may focus on establishing strong lobbying groups that can enter into networks of other key outside stakeholders or organisations to help them learn, create and support the development of new reliable site specific income sources independent of mangrove harvesting. Such kind of networking that brings together people or organisations with different knowledge and experience may also help the local communities to create enabling environment of getting reliable market for other products such as agriculture and small-scale enterprises, thereby reducing dependence on mangrove harvesting. The identified interventions will form a base for the other stakeholders at higher scales intended to support development activities at the village scales.

The tendency of low level or lack of law enforcement for mangrove management and conservation in most of mangrove areas has been observed at all levels from local to national. For Techno-green scenario to be realised, stakeholders across scales should change their behaviour towards law enforcement of both formal and informal institutions (as detailed in their by-laws) regarding mangroves management and conservation as concerned. At village scale local people (village leaders, youth, and community organisations) should also change their belief that they have a right to do what they want to the mangrove forests.

These drivers and changes in people's behaviours will allow the key mangrove SES indicators to be maintained in the next 25 years which will enhance the capacity of Techno-green scenario to bring about resilient mangrove SES to future drivers and perturbations (Table 35). For example, the presence of low dependence on mangrove harvesting for subsistence needs will maintain a level of cutting below the thresholds that will allow the ecosystem to have sufficient number of dominant common mangrove tree species, number of mature plants capable of producing sufficient seedlings to re-organise the ecosystem. Mangrove will be able to provide the desired ecosystem services and therefore provide desirable resilience for the SES while the social resilience is enhanced.

Chapter 10

CONCLUSIONS

The ongoing mangrove wood harvesting by local communities has been claimed as the major threat that needs immediate controlling actions to achieve sustainable conservation. This concern has been raised without clear understanding of the complexity and capacity of the system to cope and adapt to this disturbance and other drivers of change. Application of the resilience based concept through the components-relationships-innovations-continuity framework to the mangrove management of Unguja has proved to be relevant in achieving this understanding.

Unguja mangrove SES resilience can be described by components-relationship-innovation-and continuity attributes that define the identity of the system and, when they are maintained, ensure the resilience of the system. Analysis of the changes indicated that the key variables that defined the identities of the mangrove SES were maintained at all case study sites between the 1920s and 1970s. The state of mangrove SES was considered desirable by local communities because they reported that the societies had relatively low populations, were socially cohesive and they were able to obtain diverse ecosystem services from the ecosystem.

The mangrove SES from each case study site was found to have changed over the past three decades in temporal and spatial scales and currently reside at different phases of change across the Adaptive Cycle. The current mangrove ecological systems of Pete is at back loop at re-organisation phase (α) while Charawe both inside and outside JCBNP and Kinani have moved toward the collapse phase (Ω) of the Adaptive Cycle. These mangrove ecosystems were found to have been degraded compared to the past, characterised by a decline in the quality and quantity of trees present, with a relatively high density of small-sized mature trees and correspondingly small basal areas and volumes, together with significant numbers of tree stumps in the ecosystems. The areas covered by mangrove vegetation in the study sites were also found to have declined. The decline in quality and quantity of trees was found to correspond with a reduction in desirable ecosystem services as reported by communities.

Mangroves in the study areas have abundance of three mangrove species from *Rhizophoraceae* family showing the common species composition that defines the identity of Zanzibar mangrove ecosystem. Whilst the changes in the proportion of each mangrove tree species in the study villages were not clearly defined, mangrove harvesters in Pete and Charawe experienced a decline in the availability of less dominant mangrove tree species. The ecosystems experiencing species loss produce ecosystems that are more vulnerable to ecological collapse, through the reduction of functional diversity and redundancy and thus decreased ecological resilience to future disturbances.

The social component of the system comprises the stakeholders with diverse knowledge systems, interests in ecosystem services and their institutions operating at different scales. The communities from the studied villages depend to varying extents on mangrove ecosystem services for meeting their livelihoods needs. The levels of dependence on mangrove wood provisioning ecosystem services and management approaches have changed across the case study sites. Whilst all mangroves have been formally declared forest reserves under the State management regime since 1965 Pete and Charawe mangroves were managed under a mixture of State and co-management of different management priorities. The stakeholders engaged in the management of these forests have diverse knowledge of conservation and management of the forests. However, despite the diverse management institutions and people's knowledge Pete and Charawe residents were not enabled to maintain a low level of dependence and achieve sustainable utilisation or conservation of resources. Consequently mangrove harvesting for charcoal and firewood has increased dramatically in Charawe while the supply of these services has slightly declined in Pete but with the communities still engaged in the current unsustainable rate of harvesting. Although a majority of people are engaged in exploitation of these services, they were considered undesirable to them compared to the extraction of poles which were harvested in the past.

Excessive rates of harvesting of mangrove wood was identified as the key direct driver for change in mangrove ecological systems, which was fuelled by several underlying drivers including poverty, population change, limited livelihood activities, inappropriate management regimes, and markets for trading mangrove wood ecosystem services.

Vijichuni mangrove (another part of Michamvi) was found to be an exceptional case whereby the quality and quantity of mangrove ecological variables had improved. This mangrove consists of a relatively high density of large-sized mature plants with correspondingly high basal area and volume. The total number of stumps has declined with the increase of areas covered by mangrove vegetation as reported by villagers. Residents close to this mangrove had low dependence on harvesting of wood provisioning ecosystem services enabling them to maintain a sustainable level of harvesting mangrove wood. Availability of reliable alternative income sources that fetched a higher market price than wood cutting in Michamvi by the majority of villagers and effective management institutions by locals had contributed to these changes.

The drivers identified were used to develop three alternative future scenarios to explore whether projected changes will result in the mangrove SES maintaining their identities in the future when compared to defined resilient mangrove SES indicators.

The scenarios analysis indicates that mangroves of Unguja are not resilient based on their current pathway as they will not be capable of coping with the future drivers of change leading to the loss of the most important variables that define the resilience identity and indicators of the system within the next 25 years. This is confirmed by the Pete, Charawe and Kinani (part of Michamvi) case study findings reflecting the Coastal Boom scenario which is increasingly dominant and most closely representative of the true image of all Unguja mangroves SES identity. It should be noted that, with a current high rate of mangrove harvesting from these villages under Coastal Boom scenario accelerated by poverty, and in the absence of appropriate alternative income sources to compensate the villagers income from mangroves/forest harvesting and without alternative energy sources, rules severely restricting the local people’s uses of the resources without regular enforcement are bound to fail. The current management regime is rather an ‘extractive knowledge capture’ approach which encourages communities to provide information and participate in activities that favour conservation. As long as communities are provided with insufficient alternative income sources it is not likely this will result in successful resilience outcomes. Instead it increases the vulnerability of mangroves SES to higher future cutting pressures that will result in the collapse of the system. These underlying drivers will consequently discourage local communities from conserving the resources and instead provide them with incentives to engage in excessive cutting of mangroves and thus result in loss of common mangrove tree species, sufficient number of mature trees and number of mangrove propagules, identity and ecological resilience. Limited income sources will consequently increase the people’s burden to meet their basic needs, reduce their capacity to engage in other economic opportunities, increase level of conflicts, limit the knowledge sharing mechanism and therefore degrade the social resilience.

The relatively resilient state of the Vijichuni mangrove (another part of Michamvi) shows a less representative and exceptional case for mangrove of Unguja which illustrates the point that the presence of high population close to the mangrove with low dependence on mangrove wood harvesting has no negative impact on the resilience of the system. It is rather economic stability of the people depending on the resources and effective resource governance through the presence of strong local institutions with their members highly committed to the management of the resources which are crucial factors. However, low government priority on mangroves and unplanned tourism featured under the current and dominant Coastal Boom scenario will allow the mangrove in tourism zones like Michamvi mangrove SES to be cleared in favour of tourism expansion and thus result in complete loss of ecosystem identity and resilience of the system. Unplanned tourism may also result in excessive population of immigrants that might exact competition on the available livelihood alternative activities and destroy social resilience.

This study suggests that to achieve a desirable resilient future for Unguja mangrove SES it is important for the Government to address the question of what makes communities continue to engage in unsustainable harvesting of mangrove wood despite the application of different management approaches; and then focus on how to give solutions to these drivers. Application of Techno-green scenario gives the best alternative resilient mangrove SES future option that allows the policy and decision makers to focus their attention on addressing the potential underlying drivers that accelerate the rate of mangrove harvesting in the island and play important roles in the dynamics and resilience of mangroves SES. To attain resilient mangrove SES future, government efforts on mangrove management should therefore not be limited to development of bundles of formal restrictive legislations and plans with few non-profitable income sources for local communities. Rather, Government in collaboration with other stakeholders should be committed and make substantial efforts to provide support that can diversify people's livelihoods that have realistic economic return to reduce poverty while investing in providing quality education for long-term poverty reduction to the majority of residents and develop and support wide adoption of alternative reliable and affordable energy sources on the Island.

Urgent government attention is required to strengthen the management institutions by considering mangrove conservation as a priority sector, allowing the local communities with their institutions to play strong and effective roles in shaping the local management plans to provide flexibility on addressing their interests and promoting performance while allocating the materials and financial resources for cross scale effective implementation, monitoring and evaluation of the prepared laws and plans. In mangrove SES located under tourism zones like Michamvi where local communities have access to diversified tourism income sources, Government in collaboration with responsible stakeholders across scales should make significant efforts to maintain and improve the availability and productivity of these options to wider societal members while controlling the potential threats that might affect these income sources, environment and people cultures. These efforts should be accompanied by changes in attitudes and behaviour of all stakeholders for successive implementation of these actions.

Such measures would control the market and reduce the demand for biomass fuel, increase people's economic capability and flexibility to respond, cope and adapt with changing conditions. Assurance of peoples' decision making power on the control of access to, and use of, the resources will provide communities with incentives to enforce and implement management laws and to avoid over-exploitation. Consequently, this would in turn, provide mangroves sufficient time to restore and sustain all key resilient indicators and resilience of these mangrove ecosystems.

Lastly, this study concluded that the selected research approach and framework has facilitated an analysis of resilience of Unguja mangrove SES to the perceived problem of increased demand for wood mangrove ecosystem services and other drivers and perturbations. This study established for the first time for Unguja mangrove SES resilient indicators across components-relationship-innovation-continuity attributes required to maintain the identity of the system. It provides managers and other decision makers with an insight on resilient mangrove SES indicators should be managed to prevent the system from moving to a non- resilient undesirable state. It is hoped, therefore, the research approach used in this study provides a sound basis for comparative resilience studies that can guide management options leading to desirable mangrove resilience futures. This approach can be used by other Zanzibar mangrove SESs and extended to other fields in most of African countries with a similar context to Zanzibar. However, application of resilience theory using a scenario building approach in under-researched areas requires involvement of a range of stakeholders who are knowledgeable about different aspects of the focal SES at different scale levels. Detailed systematic studies for the establishment of more precise quantifiable threshold levels of the established indicators such as sustainable level of harvesting, changes in mangrove areas and growth rate would inform a more systematic planning process and help to achieve longer-term effective resilience management practices.

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APPENDICES

Appendix 1. Wealth ranking criteria for Pete-Jozani Shehia

Pete household were categorised /stratified in four wealth groups based on the household asserts and or household income earning activities engaged b by the household members. Such groups include the Richest people, rich, poor and poorest households as indicated below:

a. Richest people

The richest people in Pete were those who own valuable assets such as good modern houses/valuable houses (not necessarily have electricity), have *Casuarina* wood lots, more than five hectors of agricultural land in the village (either inherited or bought) and some of them employ other people to do small-scale commercial farming activities in their farms. It also include private or government employed personnel and households whose members engaged on trading activities such as establishment of village shops and investing in cutting or selling of wood products especially firewood and charcoal.

b. Moderately rich/average wealth earning people:

Include household members who own small sized piece of agricultural land of from one to four hectares, involve in farming themselves for small-scale selling and subsistence. They are engaged in terrestrial wood cutting, self-employed or temporarily employed government in low wage works (get less than 100,000 a month). Most of them have small-scale businesses and engaged in saving and credit groups in the village.

c. Poor

They have one or more of the following characteristics. Involves very small-scale farmers for subsistence, own very small piece of agricultural land or works on other villagers lands for their crop production. They are intensively engaged in wood cutting both from mangroves (when available) and other forest types for selling purposes. Few of them have small-scale business and engaged in SACOS

d. Poorest

They do not own any pieces of land but engaged in small-scale farming on other villager's lands or do farming on payment basis by the richest people. It involve sick, disabled or old members of the societies, some of them not get income supports from their relatives or other society members. Apart from this members they also include people who are young but they are unable to work probably because they don't have specific activities engaged on it but they work only when they get/asked to work under special request.

Appendix 2 Wealth ranking criteria for Michamvi Shehia

Michamvi households were divided into four major wealth groups based on household asserts or the economic activities engaged by majority of the household members

a. **Richest people**

It Include households whose members have investment or valuable assert that considered to generate income to support daily household needs. Most of investments were obtained for those people who sold part of their land and used the money to buy economic assert. Such investment/assert includes vehicles for public transportation, and owners of tourist restaurants, guest houses in the village. Own economical asserts especially large sized fishing boat for deep sea fishing

b. **Rich people**

These are the people who have permanent government employment, suppliers of local /marine food to tourist hotels and owners of shops or in the villages. They also include people who sold parts of their agricultural plot to tourist investors but invest on activities that they are less productive. Such investment include owners of rented (*nyumba ya kukodisha*) house in towns. Some of the household members engaged in small-scale farming and deep sea fishing using rented boats.

c. **Poor**

This category represents households whose residents own agricultural land and/or some of them sold it but without any investment afterwards. This group include small-scale fishers, farmers, part time tourist hotel employee (as a cleaner, gardener masons and related works), forest cutters, beekeepers, ecotourism, and those engaged on saving and credit groups to run their small-scale projects.

d. **Poorest**

This group includes small-scale fishers engaged on collections of fish, crabs or octopus close and other marine organism. They also include small-scale farmers who do not own any pieces of land. It also include old, sick or retired elders in the village.

Appendix 3 Wealth ranking criteria for Charawe Shehia

Charawe households were divided into four wealth groups based on the household asserts and or income generated from livelihood engaged by members of the households as follow

a. **Richest people**

These are the household with their members have the financial capital to engage on community livelihood activities that have potential to generate income to meet household needs. Members of these households include business person called *Tajiri* (means rich person) in the village because they have village shops for selling food products, engaged in trading of wood products from mangrove and non-mangrove especially firewood, charcoal and building poles and crabs and sell it to town traders low scale harvesting of wood . It includes household members who own economic asserts especially large sized fishing boats for renting other village fishers and seaweed farmers. Some of the household members engage in low scale harvesting of wood and planted commercial trees such as lime and mango plants in their farms.

b. Moderately rich/average wealth earning people

Include those who have got employment (private or government) few fishers who own small fishing boat or rent it from rich people. This category involves household whose members engaged on large scale cutting of mangrove and non-mangrove wood products (firewood, charcoal, building poles, and lime) and selling either to the village wood traders or to town traders who come to the village to buy the products. It also include farmers engaged on food crop production and plant few permanent trees especially *Casuarina* woodlots.

c. Poor

They are forest wood cutters both mangroves and other forest types for selling purposes but in small-scale basis. They are also includes small-scale farmers and fishers including crab collectors who do not own any fishing vessels. Other people in this category are livestock and/or beekeepers, seaweed farmers, and most of them have small-scale business (village food vendor) and engaged in SACOS.

d. Poorest

These are very old, sick or disabled members of the society. Some of them engaged in small-scale activities such as agriculture or get assistance to do other livelihood activities to get with little income (beekeeping wood harvesting). They area also get income supports from their relatives or other village members.

Appendix 4 Timeline chart to guide focused discussion with community members

Column of events and year was completed first from as far back as respondents can remember to the present. Emphases were on trends and reasons for change.

Important event and year	Mangrove characteristics	Prioritised uses of mangroves	Users (local communities/outsiders		Mangrove management arrangements	Livelihood activities and alternatives	Challenge and Incentives
			subsistence	sales			
	Area, Dominant tree species and average sizes						

Other Questions asked to facilitate Focus Group discussion

1. On Uses of mangrove ecosystem:

- Who were the key stakeholders and what their interests on mangrove ecosystem?
- How do the stakeholders relate to each other?
- What other ecosystem services are available from the mangroves?
- What are the interests of other stakeholders on mangroves and changes over time?
- Investigate the reason for changes
- The impact of changes on their livelihood and provision of ecosystem services

2. On Management arrangement, assess:

- Institutions and organisations governing mangrove resources
- Management activities by each stakeholder
- How effective the institutional arrangement to implement the existed management arrangement
- What was the arrangement regarding to the access and use of mangrove? What was accepted and not accepted
- Participation of local communities in the management system
- How the management arrangement changed over time?
- What were the reasons for change?

3. On alternative activities, development intervention and challenges, assess:

- Types of livelihood activities and or alternatives and changes over time
- What were the reasons of change?
- What benefits did local communities obtain through mangrove conservation?
- Has the developed alternatives got sufficient income to reduce level of dependence on mangrove ecosystem
- How efficient and effective (strength and weakness) the developed interventions/incentives to achieve the intended goals
- Management challenges/ constraints to sustainable mangrove production

4. What are your views on the following potential social ecological variables to be used as indicators for resilience assessment?

- Components: species diversity, number of mature trees/ha, preferred ecosystem services, stakeholders diversity and level of educations
- Relationship: Engagement on mangrove management system, - type of aninmal and plant interaction in the mangrove system
- Continuity: Number of seedlings/ha, level of dependence on ecosystem services, presence and application of knowledge sharing mechanism
- Innovation: diversity of species, stakeholders, management institutions and diversity of livelihoods

5. What are the possible mangrove future states if the community will be affected by different drivers of changes in the next 25 years?

Appendix 5 Checklist to guide discussions with government officials

Date…………………..Name of Organisation ………………………

Officer designation….…………………………………..

1. As an organisation, what are your interests and objectives in mangrove?
2. Describe your current activities to achieve your interests/objectives
3. Is your interests and activities varies overtime and why
4. What is the current management approach and how is implemented
5. What is situation of mangrove management and use in the pasts
6. Can you briefly explain on the collapse of opening and closing management strategies in Chwaka bay
7. What are the causes and impacts of these changes to the ecosystem
8. Give the list of institutions governing mangrove systems (Policies, regulations, village bylaws) and how these have changed overtime
9. What are the mangrove management programme/interventions in your organisation (e.g. specific programmes or projects) and how is implemented
10. For each type of mangrove management institution and intervention what are the main objectives, means of implementation, time periods, strengths (i.e. what aspects worked/ are working) and weaknesses (what didn't work so well/ is not working).

Interventions	Types	Aims	Means of implementation	Time period	Strengths	Weakness
Policies						
Programmes						
Projects						
Village bylaws						

11. Are there any coordination/linkages between you and other organisations whose activities have influence on mangroves (e.g. Ministry of energy, Ministry of land, environment, fisheries, tourism, other NGOs)
12. What are the constraints to sustainable mangrove production?
13. As an organisation what you think should change/do to restore the situation

Appendix 6 Household questionnaire for mangrove social ecological survey

A Household Questionnaire for Mangrove Social Economic Survey 2011 and 2013

	1.0 IDENTIFICATION DETAILS **Questionnaire Number:**	
	1.1Location	
S/N	**Location Name**	**Codes**
1.1.1	Region: South Unguja	
1.1.2	District:	
	(District codes: South.....1, Central.....2)	
1.1.3	Name of Shehia/Village:	
	(1.1.3 Codes: Charawe...1, Pete-Jozani...2, Michamvi...3	
1.2	**Details of the Household Information**	
S/N		**Codes**
1.2.1	Name of Households Head/Respondent:	
1.2.2	Age Class for the Head of Household/ Respondent	
	(***1.2.2 Codes:*** 0 to 5...***1***, 6 to 10...***2***, 11 to 20...***3***, 21 to 35...***4***, 36 to 50...5, and Above 50....***6***)	
1.2.3	Respondent Sex *(Male...1, Female...2)*	
1.2.4	Level of Education of Respondent	
	(***1.2.4 Codes:*** *Under standard one...00, Standard one...01, Standard two...02,Standard three...03, Standard four...04,Standard five...05, Standard six...06, Standard seven...07, Form one...08, Form two...09, Form three...10, Form four...11, Advanced education...12, Knowledge after advance...13, University education...14, Elders education...15, Never attend to school...16)*	
1.2.5	Number of Persons in Household	
	(1.2.5 codes: *One member...1, Two members...2, Three members...3, Four Members...4, Five members...5, Six members...6, Seven Members...7, Eight Members...8, Nine members...9, Ten members...10, Eleven and Above members...11)*	
1.2.6	Number of Household Members engaged in Economic Activities	
	(Codes 1.2.6: One member..1, Two Members..2, Above three Members..3, No one involved..4)	

1.2.7 Outline Number of Household Membership in Village Organisation

s/n	Type of Organisation	Number of member involved
1	VCC	
2	JECA/JOCDG	
3	Shehia committee	
4	Fishing committee	
5	Others	

Q2. Types of economic activities engaged by household members

s/n	Type of Economic Activity	Any Household member involved in this activity? (Yes..1, No..2)	Average Monthly Income (Tshs)
1	Mangrove cutting for charcoal		
2	Mangrove cutting for fire wood		
3	Mangrove cutting for other products		
4	Terrestrial woodcutting		
5	Beekeeping		
6	Tourist..		
7	Agriculture		
8	Employment		
9	Fishing		
10	Small Scale enterprises		
11	Seaweed..		
12	Hotel business		
13	Hotel food supplier..		
14	Crab collection		
15	Drivers		
16	Butterfly farming		
17	Woodlots harvesting		

Q. 3	Do you get direct benefit from Mangrove ecosystem? *(Yes...1, No...2)*	
	If Answer is No go to Question 3b	
3a	If Yes Specify how much is collected per month for home uses and sell together with the unit prices. (Use Table below to specify)	

S/n	Type of Mangrove Product	**Preferred mangrove Spp.** *(Mkomafi..01, Msisi/Mfunzi/Mchonga..02, Mkandaa mwekundu..03, Mliana..04, Mchu..05, Mkoko mwekundu..06, Kilalamba cha kijani..07, Kilalambadume..08, Kikandaa/Mkaa pwani..09, Other mangrove Spp..10)*	Monthly Harvested for subsistence used	Monthly Harvested for commercial uses	Unit Price per Product
1	Charcoal (sacks)				
2	Fire wood (bundles)				
3	Lime(Kilns)				
4	Poles- Mapau (scores)				
5	Building Poles-Nguzo/Majengo (scores)				
6	Beams- Boriti (scores)				
7	Withes- Fito(scores)				
8	Timber – Mbao (Pieces)				
9	Medicine and part of plants used (Pieces)				
10	Honey (Bottles)				
11	Seaweed (Kgs)				
12	Crabs (Kg)				
13	Ecotourism (Trips)				

Note: Scores consists of20 individual poles

3.b Mention other source of poles and the uses of mangrove poles in house construction

3.b.1	What is the main use of Mangrove Poles?	
	(3.b.1 codes: Roof...1, Window frame..2, Wall..3, Others..4)	
3.b.2	What is the Other Sources of building Poles/Timber	
	(3.b.2 Codes: Mangrove pole from Town..1, Poles from terrestrial forests..2, Sown timber from town..3, Others..4)	
3c	***Do you know any other benefit from mangrove ecosystem of your area***	
	(3.c Codes: I know.....1, I don't know.....2). If Answer 2 go to Question 3d	

3c.1 Indicate other mangrove benefits familiar to you.

s/n	Name of the benefits	Choose Answer (*Yes...1 or No..2)*
3c.1.1	Breeding site for Fishes and Crabs	
3c.1.2	Homes for other animals (e.g. monkey & birds)	
3c.1.3	Control beach erosion	
3c.1.4	Control of Strong winds and waves from the sea	
3c.1.5	Contribute to climate regulation (means carbon fixation)	
3c.1.6	Coral reef protection	
3c.1.7	Others (e.g. Education, spiritual, recreational)	

3d. Mention the types of common mangrove fish species you know. (Select all applicable)

s/n	Mangrove Fish Species	Choose Answer (*Yes...1 or No..2)*
3.d.1	Mafiro	
3.d.2	Mkunga Mweusi	
3.d.3	Kaa	
3.d.4	Suka	
3.d.5	Chandaza	
3.d.6	Matobwe	
3.d.7	Kamba	
3.d.8	Vikoa	

s/n	Mangrove Fish Species	Choose Answer (*Yes...1 or No..2)*
3.d.9	Miwange	
3.d.10	Chewa	
3.d.11	Komba	
3.d.12	Mkizi	
3.d.13	Simachi	
3.d.14	Misanga	
3.d.15	Machokota	

Q4	Have you experienced any changes on the availability and uses of mangrove benefits?	
	(Q4 codes: Yes...1, No...2) If Answer 2 go to Question 4b)	

4a. Indicate the change occurred in mangrove ecosystem and benefits

s/n	Type of Change	*(Write 1 to indicate Change Occurred).*
4a.1	Reduction of Mangrove tree cover	
4a.2	Decline of the average tree sizes	
4a.3	Mangrove start to recover	
4a.4	Increased Planting Activities	
4a.5	Others	

4b.What are the changes you have observed in the societies in relation to mangrove?

4b.What are changes you have observed in the societies in relation to mangrove?

s/n	Type of Changes Observed	*(Write 1 to indicate Change You have Observed).*
4b.1	Increased number of stakeholders interested with mangrove	
4b.2	Increased of Mangrove Harvesters and dependence	
4b.3	Decreased of Mangrove Harvesters and dependence	
4b.4	Decline of local management arrangements	
4b.5	Increase of conservation knowledge	
4b.6	Limited participation of Government and local people in patrolling	
4b.7	Reduction other village resources	
4b.8	Changes in the management arrangement	

Q5 What are the factors have contributed to the changes in mangrove social and ecological condition?

s/n	Factor	*Write 1 to indicate factor that contribute.*
5.1	Poverty	
5.2	Lack of Employment for young's	
5.3	Lack of effective alternative income activities	
5.4	Increase in restrictions on other sectors of economy	
5.5	High population growth with dependence in the ecosystem	
5.6	Local management initiatives and mangrove planting	
5.7	Availability of alternative income	
5.8	Controls of mangrove poles harvesting permits	
5.9	Low level of government commitment on implementation, monitoring and coordination	
5.10	Lack of ownership to the resources	
5.11	Market Availability for mangrove products	
5.12	Type of Products available	

Q6a. Mention the impacts of changes in Ecological system. .(Select all that applied)

s/n	Type of Impact of Change in Ecological System	*Write 1 to indicate impact of change*
6a.1	Limited availability of or increased difficulties on the availability of the preferred mangrove wood products	
6a.2	Intensive wood cutting in the National park	
6a.3	Increase of beach erosion and fall down of mature trees	
6a.4	Decline of some fish species	
6a.5	Reduction of Mangrove Species	
6a.6	Increase of mangrove cover and associated organism	

Q6b. If you notice decline in mangrove fish species, mention them in order of their rarity.*(Select all that applied)*

s/n	Mangrove Fish Species	Choose Answer (*Yes...1 or No..2)*
6b.1	Mafiro	
6b .2	Mkunga Mweusi	
6b .3	Kaa	
6b .4	Suka	
6b .5	Chandaza	
6b .6	Matobwe	
6b .7	Kamba	
6b .8	Vikoa	

s/n	Mangrove Fish Species	Choose Answer (*Yes...1 or No..2)*
6b .9	Miwange	
6b .10	Chewa	
6b .11	Komba	
6b .12	Mkizi	
6b .13	Simachi	
6b .14	Misanga	
6b .15	Machokota	

Q6c. What are the impacts of the changes in the society?. ***(Select all that applied)***

s/n	Type of Impact of Change in Society	*Write 1 to indicate impact of change*
6c.1	Change in mangrove utilization to non-destructive uses	
6c.2	Change in mangrove utilization to destructive uses	
6c.3	Health effects (increases coughing of wound incidences)	
6c.4	Decline in dependence of mangrove/forest harvesting	
6c.5	Increase of school age dropout,	
6c.6	Good cooperation between VCC and other village residents	
6c,7	Increased level of conflicts	
6c.8	Others	

Q7. What can be done to improve the collection of mangrove forests, society and sustainable availability of mangrove products and services? ***(Select all that applied)***

s/n	Type of Intervention to be done	*Write 1 to indicate type of intervention for improvement*
7.1	Government should provide reliable alternative incomes sources to majority of residents	
7.2	Government should provide resources to implement plans and agreements	
7.3	Realistic participation, use rights benefits should be realised by local communities	
7.4	Specific mangrove areas or low scale harvesting should be allowed to meet community's needs	
7.5	Greater government commitment and priority to conserve the resources through community participation	
7.6	Other intervention	