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WORLD MARITIME UNIVERSITY

Malmö, Sweden

**PERCEPTION AND LIVELIHOOD VULNERABILITY OF
COASTAL COMMUNITIES TO CHANGES IN REEF RESOURCE
STRESSORS A CASE OF MAFIA ISLAND.**

By

JULIUS EDWARD SALEMA

Tanzania

A dissertation submitted to the World Maritime University in partial
fulfilment of the requirements for the reward of the degree of

MASTER OF SCIENCE

in

MARITIME AFFAIRS

(OCEAN SUSTAINABILITY, GOVERNANCE AND MANAGEMENT)

2020

Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): 

.....
(Date): 22/09/2020
.....

Supervised by: **Professor Mary Wisz**

Supervisor's affiliation: **World maritime University**

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Abstract

Title of Dissertation: Perception and Livelihood Vulnerability of Coastal Communities to Changes in Reef Resource Stressors. A Case of Mafia Island.

Degree: **Master of Science**

Coral reefs sustain millions of people's livelihoods globally. Most of the coastal communities in Mafia Islands depend on marine resources historically. Coral reefs are very important to these communities because they provide livelihood opportunities as well as good source of protein. Corals have been threatened globally by both human induced stressors and climate change causing enormous coral mortality. This leads to a serious reduction of ecosystem services provided by corals hence influencing the livelihood of communities relying on tourism and fishing activities. Their dependency on these resources marks them extremely vulnerable to any environmental stressor.

This study surveyed the coastal communities' vulnerability of Mafia Islands to a decrease in provision of reefs goods and services resulting from social-environmental changes, and building resilience to those changes. Data were collected using semi-structured interviews from community leaders in 10 villages in Mafia Island and selected 10 key institutions.

The interview findings were used to explain drivers of the usage of coral resources in Mafia Island. The key drivers' are; food and income requirements, population growth, building material requirements, and cultural issues. These drivers increase the fishing pressure on reef resources.

The vulnerability to livelihood was assessed using three components, namely, sensitivity, exposure and adaptive capacity. Sensitivity concerns the degree of reliance on these services and the availability of alternative income sources; Exposure tells about the status of reef resources, which was assessed on the basis of expectations of the current reef state and the perceived probability of potential coral threats. Adaptive capacity was focused on community access to approaches and alternative livelihood options to minimize pressure on marine habitats and increase resilience of minor rural coasts.

Since decreasing reef, resources can be expected to impact communities with less access to alternative livelihoods. However, they will still be affected by declining reef resources and climate change, as fishing is still an important source of protein, as well as culturally for their livelihoods. Farming, as a substitute livelihood if reef resources continue to decline, has become one of the key adaptation choices for fishing communities.

Therefore, through diversification into alternative livelihood, but not certainly, crop farming, seaweed farming and livestock keeping it needs substantial efforts to preserve and restore coral reefs for sustainably utilization of marine resources, despite the fact that shocks happen. Developing adaptive capacity is of paramount important in order to allow communities to be resilience with shocks when they occur, and to sensitize on the implementation of alternative livelihoods that are less reliant on climate sensitive resources.

KEYWORDS: Climate change adaptation, Perceptions and livelihood vulnerability, coastal communities, Coral reefs resource stressors, Alternative livelihood.

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List of Abbreviations

BMUs	Beach Management Units
CO ₂	Carbon Dioxide gas
DFID	Department for International Development
EEZ	Exclusive Economic Zone
GDP	Gross Domestic Product
ICZM	Integrated Coastal Zone Management
IPCC	Intergovernmental Panel on Climate Change
IRG	International Resource Group
MIMP	Mafia Island Marine Park
MoLFD	Ministry of Livestock and Fisheries Development
NFARA	National Fisheries and Aquaculture Research Agenda
NFP	National Fisheries Policy
NGOs	Nongovernmental Organizations
RUMAKI	Rufiji Mafia and Kilwa
SDGs	Sustainable Development Goals
SLA	Sustainable Livelihood Approach
SLF	Sustainable Livelihood Framework
SNC	Second National Communication
TANPESCA	Seafood Processing and Export in Tanzania
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
WMO	World Meteorological Organization

1. Introduction

Coral reefs support the livelihood of millions of people (Heron *et al.*, 2017). Globally, coral reefs occupy less than 1% of the world's oceans (Gattuso *et al.* 2014), with 16% of the world's coral reefs in the Western Indian Ocean (Obura *et al.*, 2017). Coral reefs are vital life-supporting elements of marine habitats offering enormous social-economic and ecological benefits (Saleh, 2016). This ecosystem is comparable with the evergreen tropical rainforest (WMO, 2010; Burke *et al.*, 2011) due to its high biodiversity and ocean productivity.

At least half of the global coral reefs have already been lost due to climate-induced bleaching, leading to major loss of biodiversity (Beyer *et al.*, 2018, Van Hoodonk *et al.* 2016). The collapse of these biodiversity "reservoirs" is expected to lead to a rapid decline in fish stocks that will threaten the nutrition, health, and livelihood of many of the world's most vulnerable coastal communities (Cinner *et al.* 2012). Since one-quarter of all marine species associate with coral reefs, the ecological impacts of changing climate and chemistry on overall marine biodiversity are potentially severe and prevalent (Nema *et al.* 2012). Coral reefs need a high concern currently since they are severely wedged by numerous stressors including sedimentation, pollutants disposal, illegal and unsustainable fishing, excessive nutrients and invasive alien species (Ban *et al.* 2014)

Deterioration of coastal ecosystems is increasingly alarming, with about 90% salt marshes lost/degraded, 35% of mangroves degraded/lost, 30% of coral reefs lost/degraded, and 20% of seagrass meadows already lost or degraded globally (Scott *et al.* 2011). On the other hand, food shortage due to drought-induced low productivity has resulted in over or unsustainable fishing, which has caused a change in the distribution and composition of fish stocks in some areas (Mwansasu, 2016). Therefore, with this situation, an integrated approach to dealing with these multiple stressors, both climate and non-climate related, must be addressed (Scott *et al.*, 2011).

The level of population changes occurs due to physiological intolerance to new environments, altered patterns of dispersal, and changes in species interactions (Doney *et al.*, 2011). Despite the local climate's invasion and extinction, these processes lead to changes in community structure, social structure and diversity,

as well as the emergence of a novel ecological system (Scott *et al.*, 2011). Local anthropogenic pressures further influence the impact of climate change (Harvey *et al.*, 2018). Interactive effects of anthropogenic stressors, such as overfishing, emission from industries and nutrient contamination, can alter the impact of marine ecosystems by-competition between coral and algae and destabilizing the coral microbiome, resulting in coral disease and mortality (Cinner *et al.*, 2012; Griffiths *et al.*, 2017; Rice *et al.*, 2019)

According to the IPCC report 2018, the impacts of temperature rise are evident. Warming due to temperature rise forces species to migrate to the areas where temperatures are more conducive to survival. In marine ecosystems, rising atmospheric CO₂ and climate change are associated with concurrent shifts in temperature, circulation, stratification, nutrient input, oxygen content, and ocean acidification, with potentially broad-ranging biological effects (Scott *et al.*, 2011).

Biodiversity and ecosystems are impacted and, in some cases plants and animals do migrate or die from climate change impacts (Doney, 2012), This affects affecting not only individual species and ecological interactions, but also the physical and living environment upon which humans depend (Barange *et al.*, 2014; Pecl *et al.*, 2017; Scheffers *et al.*, 2016). The IPCC 2014b reports show that over 850 million individuals worldwide live within 100 km of the coast who are impacted by changing coastal systems. The impacts of climate change and increasing human pressures have apparent and adverse effects on the coastal environment (Cinner *et al.*, 2012).

In Tanzania, the coastal areas have been impacted by extreme events. Rising sea level and associated shoreline, changes are uncertain; however, increased floods and environmental degradation will exacerbate erosion and sedimentation (Mwansasu, 2016). A coastal ecosystem such as coral reefs, seagrasses are extremely vulnerable because they have already been significantly altered by human activities (Liwenga *et al.*, 2019). According to Rufiji-Mafia-Kilwa (RUMAKI) seascape Vulnerability Assessment Report 2015, revealed that the seascape, including Rufiji Delta, is projected to suffer further losses of productivity and services that they provide. The threats to the marine resources in the seascape, including mangroves forest clearance, are mainly associated with over-harvesting for both domestic and commercial use and illicit alteration to agricultural land. The natural phenomena of climate change, such as rising sea level, flooding, and

increased sedimentation, are also implicated in transforming and compounding mangrove and coral reef degradation (Obura *et al.*, 2017). Therefore, as climate change continues, repeated disruption of lives, infrastructures, and economic activities will pose challenges to the coastal ecosystems and communities' livelihoods.

The coastal communities of Tanzania depend primarily on the marine environment, with the majority practicing artisanal fishing activities being carried out in both seagrass meadows, mangroves and coral reefs (Gustavson *et al.*, 2009). This small-scale fishing in Tanzania accounts for 98% of total fish production serving coastal communities as a source of food, income, and employment (MoLFD, 2016; Mwaipopo, 2017), thus contributing to 1.7% of National GDP (NFARA, 2019)

The coastal tourism activities in Tanzania include sport fishing, snorkelling, diving, swimming, and other recreational ecotourism activities, with hotels, resorts, and guesthouses built along the coast. Tourism forms a crucial source of foreign exchange, accounting for 16% of national GDP and about 25 % of total exports. Tourism's economic benefit increases coastal communities' jobs by engaging in diving and ecotourism activities such as boat tours and marine life viewing (Gustavson *et al.*, 2009). While Tanzania's tourism activities are highly concentrated in the hinterlands due to wildlife-based tourism, coastal tourism is showing a growth trend; a good example is on Mafia Island, whereby in 2000, the arrivals of tourists increased from 484 to 3,107 in 2007. However, coastal tourism does not grow as rapidly as inland tourism because of the inadequate national strategy to diversify this sector to coastal regions.

Coastal populations, in particular Mafia Island, are heavily dependent on productive coral resources (Silva, 2006). These reefs are important food sources for many coastal and inland populations that provide fish, crustaceans, and molluscs, and they are breeding grounds for the most valuable commercial fish species (De Fontaubert *et al.*, 1996; Muhando and Mwaipopo, 2008; Saleh, 2016). They are also vital to human survival (West & Salm, 2003), providing them with a variety of valuable products and services (Wagner, 2004; Chen *et al.*, 2018), and are recognised for their annual contribution to the global economy of over 30 billion dollars (WMO, 2010), tourism and recreation, commercial fisheries, coastal protection and development and as a sink for atmospheric carbon add to their key

socio-economic benefits ((McClanahan *et al.*, 2000; Heron *et al.*, 2017), resulting in an increased coastal population. The high demand for marine resources contributes to the introduction, among other coral stressors, of destructive fishing practices that affect resource sustainability.

Moreover, Mafia communities rely on natural resources, making them highly vulnerable to changes in any state of the reef environment (Pomeroy *et al.*, 2006). Changes socio-economic structures and the natural environment such as accessibility, the value of resources, and how to exploit them can influence the ecosystem goods and services delivered by reefs (Turner *et al.*, 2007; Kittinger *et al.*, 2012; Norström *et al.*, 2016). Decreasing natural resources will have a significant impact on these communities if they do not have alternative livelihoods, as coral reefs are threatened by human activities and climate-induced challenges, which in turn affect the normal living conditions of individuals whose livelihood depends on the resources of coral reefs (Pandolfi *et al.*, 2003; Burke *et al.*, 2011).

In this case therefore this study will address the main three research questions which are; What are the major ecosystem benefits provided by coral reefs to coastal communities? How do the components of vulnerability influence the livelihood of communities dependent on coral reefs resources? Lastly, Lastly, What measures might be taken to reduce vulnerability of coastal communities' dependent on coral reefs?

2. Background Information

2.1. Geographical Context

Mafia Island is a district in Tanzania's Pwani Region, situated 120 km southeast from Dar es Salaam City and 21 km east of the Rufiji Delta (Moshy *et al.*, 2013; Moshy & Bryceson, 2016)). It has a larger marine park area covering 407 km² of land and 565 km² of water, and it has a population of about 46,438 people in 2012 (Bryceson *et al.*, 2006; URT, 2013). Mafia Island extends across the trade wind system, where the northeastern monsoon blows from December through April, and the southeastern monsoon, which blows from June through October. Such winds affect climatic and oceanic conditions, including air temperature ranging from 20-32 ° C and the sea surface temperatures ranging from 25-31 ° C (Bryceson *et al.*, 2006).

Mafia Island has a wide variety of coral and fish (Garpe & Öhman 2007). In 1995, in the southern part of Mafia Island (Andersson & Ngazi 1995), a multi-use national park, the Mafia Island Marine Park (MIMP), was created. The Park is based on an integrated system of coastal management with core fishing zones prohibited or restricted (Kamukuru *et al.*, 2004).

Most of the coastline of the marine park is lined with mangroves, most of which are *Avicennia marina*, *Xylocarpus granatum*, *Bruguiera gymnorrhiza*, *Rhizophora mucronata* and *Sonneratia alba*. Chole Bay is a shallow and sheltered bay with a maximum depth of 15 m. This is covered by the fringing of the coral reefs that stretch along the east coast of Mafia Island from intense Indian Ocean wave action. A strong tidal current (up to 6 knots) provides water exchange with the open sea and outer reefs through 2m deep-water channels (Berkström *et al.*, 2013)

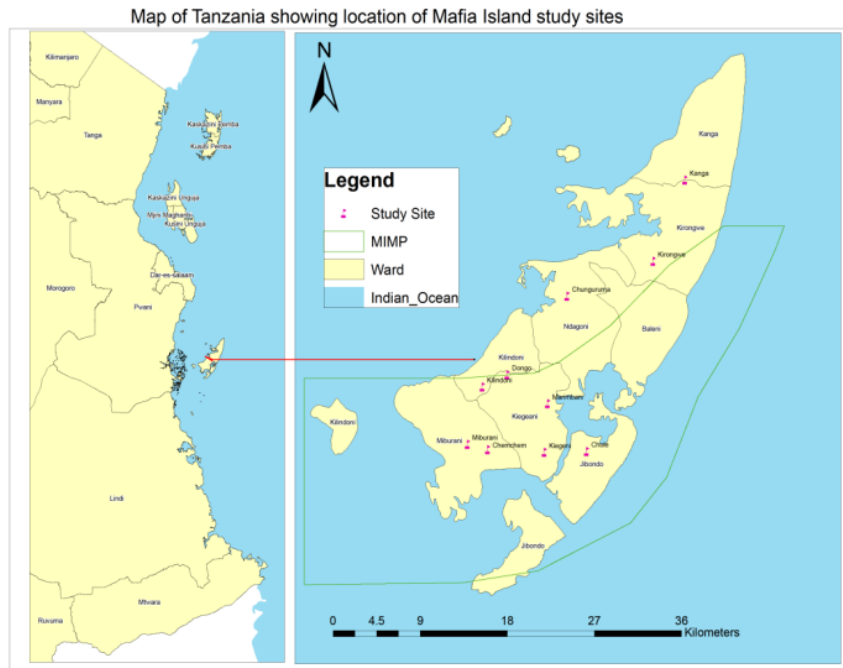


Figure 1: Location of Mafia Island in Tanzania Map.

Source: (Author)

2.2. Coastal Environmental Context

Tanzania's coastal zone comprises of varied ecosystems, such as beaches, seagrass meadows, coral reefs, mangroves forests, dunes, estuaries, rocky shores, and natural resource coastal forests. Coral reefs and mangroves according to (Gustavson *et al.*, 2009; Stæhr *et al.*, 2018) dominate the coastal and marine habitats.

Coral reefs occurring and distributed in Tanzania can be categorized into two types: fringing reefs and patch reefs. As a continuous band, fringing reefs occur, with the reef crest acting as a wave break, dissipating most of the wave energy. Back-reef lagoons lie behind the crest of the reef and the beach. Seaweed is cultivated in Zanzibar in these areas of the back-reef lagoon. Patch reefs can be located in the Zanzibar and Mafia channels, back-reef areas, and the Kilwa islets' complexes. Coral reefs are associated with a wide variety of fish assemblies and support up to 70% of artisanal fishing. In the estuaries, shallow waters of lagoons, and intertidal zones, seagrasses are found on soft bottoms. Seagrass beds

support valuable fishery resources, including prawns and finned fish, and provide feeding grounds for turtles (Potouroglou *et al.*, 2017; Gullström *et al.*, 2018).

Mangroves exist in many of the offshore islands along the entire continental coastline and fringe. Mangroves, the traditional littoral plant formations of the sheltered tropical and subtropical coasts, are the major component of the coastal forests. Along with those on Mafia Island, the mainland Tanzania mangroves occupy a combined area of 115,475 ha. Rufiji Delta contains the largest area of mangroves. Other large areas are also found in Tanga, Coast (Pwani), Mtwara and Kilwa Regions, and at the mouths of Ruvu, Wami, Pangani, and Ruvuma rivers. Mangroves in Zanzibar cover an area of approximately 18,000 ha. Tanzania is second in eastern Africa (after Madagascar) to have a larger mangrove area (Tumbo *et al.*, 2015).

Mangroves directly benefit coastal communities by providing an economic base, such as poles, timber, and firewood sales. Mangroves also have many indirect benefits by acting as a nursery and feeding ground for fish and invertebrates, defending against beach erosion, and trapping sediments that would otherwise threaten corals and related species (Tumbo *et al.*, 2015).

The remaining coastal forest supports affluent ecological communities. In general, the coastal forests of East Africa have surprisingly high endemism and diversity levels. There are many other marine and coastal resources that are not directly related to the ecosystems mentioned above. These include islands, rivers, minerals, oil and gas hydrocarbons, sand and gravel, salt, historic (archeological) attractions, and visual coastal resources. All coastal resources and ecosystems are located partly or wholly on the most critical coastal resource, the coastal land (Masalu, 2000).

2.2.1. Vulnerability Concept

IPCC (2007) describes the term vulnerability as a system's feature made up of three components namely exposure, sensitivity and capacity for adaptation. Researchers tried to indirectly combine environmental and social vulnerability using responsiveness to signify the response of ecological mechanisms to climate

change and adaptive capacity to replicate the response of the social system to changes in the biophysical environment (Allison *et al.*, 2009; Marshall *et al.*, 2013). It is important to identify and understand the properties that determine the vulnerability and adaptive potential of ecological and social systems while trying to establish resilience in a society. (Dolan & Walker, 2004; Cinner *et al.*, 2011; Cinner *et al.*, 2012; Amos *et al.*, 2015).

2.2.2. Vulnerability Components.

Most systems and studies addressed three components of vulnerability; exposure, sensitivity and adaptive capability (Morzaria-Luna *et al.*, 2014; Tumbo *et al.*, 2015; Ellison, 2015).

i. Exposure

Exposure in this study is characterized as the degree to which a system is stressed in terms of magnitude, frequency and duration by different environmental conditions or socio-political stress. (Adger, 2006; Mambo, 2017). Exposure is the situation to which climate-related events are exposed by a region, resource, or society, as mentioned in the 2007 IPCC report. In the context of Mafia Island coastal communities, exposure may be the degree to which environmental change affects the marine resources it relies on (Cinner *et al.*, 2013). Understanding that not only climate-related events but also human-related behaviors affect aquatic resources.

Studies have shown that factors such as overfishing, habitat loss and market processes can assess social vulnerability to resource depletion. (Cinner *et al.*, 2012, Moshy, 2016), population growth, urbanization, international financial pressures, socio-economic disparities and deficiencies in governance (Birkmann *et al.*, 2015). In determining the extent of vulnerability, therefore, the magnitude and exposure rate are important (UNDP, 2010; Lavell *et al.*, 2012)

ii. Sensitivity

Sensitivity to environmental change is the degree to which stress exposure is likely to affect a given component of a system (Adger, 2006). Sensitivity of the social system depends on economic, cultural, political and institutional variables that enable change to be buffered (Cinner *et al.*, 2012). If communities depend on

reef resources as their sole source of income or livelihood, they will be sensitive to any change in reef resources (Cinner et al., 2013). Therefore, if social networks are highly reliant on the natural resource that is affected by this stress, they are likely to be vulnerable to stress (Marshall et al., 2013). In this analysis, sensitivity will be proved by the degree of reliance of coastal communities on the reef resources as their primary source of livelihood.

Communities depend on coral reefs in tropical marine environments for coastal protection, employment, livelihood, recreation, and social and cultural benefits (Riedmiller, 2012); Dunning, 2015). Exposure and response depend on the coastal and marine social-ecological system components and stimulus or stress attributes and their relationships and characteristics (Glaser et al., 2012). The exposure and vulnerability of a community to any stress will depend on their livelihood assets or access to them, which will encouragement their response to the diverse exposures.

Reef-dependent communities' sensitivity to decreasing the availability of reef resources will be determined by social, economic, traditional, political, and environmental circumstances of a region (Cinner et al., 2013; Kittinger et al., 2015). Different populations have different sensitivities to stressors and their effects on communities are affected by the size or length of a stressor exposure (Luers et al., 2003). Vulnerability is not merely a invention of exposure and sensitivity to such stressors; the adaptive capacity and supporting environment of the community is more established (Gallopín, 2006). Sensitivity is key to determining social vulnerability of a community to climate change and variability.

iii. Adaptive Capacity

Adaptive capacity refers to the ability of a system to adapt and react to change, mitigate, cope with and recover from the impacts of change. The socio-economic components of adaptive ability can be broadly classified into four key clusters: resilience, learning capacity, organizational capacity, and assets. The capacity to adapt is related to and sometimes equated with resilience (Ferrol-Schulte et al., 2015). Usually, resilience is associated with adaptativeness and diversity including diversity of organisms, human capacity, and economic options. In line with this criterion, attempts at marine resource conservation call for adaptive

approaches and alternative livelihood options to minimize pressure on marine habitats and increase resilience of minor rural coasts (Ellison, 2015)

A community's ability to respond is not automatically evident immediately after stress or disruption but depends on the severity of the stress, and the time it happens (Brooks & Adger, 2005). Within the community, individuals need to concentrate on the nature of disruption and mobilize their capacity and ability to alter and adapt. Adaptation is intended to decrease vulnerability (Torell et al., 2017), while measures taken to adapt can also increase vulnerability. It is necessary to recognize that the other parts will be made more vulnerable by some adaptation measures (Yanda et al., 2019).

Communities that are more fragile and susceptible to some pressures or diseases may be more fragile, but if they can cope with these changing situations and adjust to them, this vulnerability can be reduced (Gasper & Mwevura, 2019). Most communities closely linked to their rights and legacies, i.e. well-down with the legal and customary right to exercise command over resources and food, should be expected to have more adjustment capacity (Mosberg, & Eriksen, 2015). (Cinner et al., 2013) mention that the opportunities created by changes in the availability of ecosystem services may be difficult for individuals or communities with low adaptive capacity to take advantage of it. Effective management of the ecosystem promotes resilience of reef resources, a term linked to adaptive capacity as the ability to recover and withstand disruptive effects (IPCC, 2014).

2.2.3. Framework and Models on Vulnerability

Many conceptual frameworks and vulnerability models have been developed and widely used (Brooks et al., 2005; Adger & Vincent, 2005; Marshall et al., 2013). Researchers have introduced and updated those mechanisms to strengthen the vulnerability concept (Metcalf et al., 2015; Cinner et al., 2012; Hobday et al., 2016).

Vulnerability was evaluated by two new conceptual frameworks; (i) The Risk Hazard model (RH) that sought to explain the impact of a threat as a consequence of exposure to the hazardous event and the exposed individual's response (Turner et al., 2003); and (ii) the Pressure and Release (PAR) model (Blaikie et al., 2014),

in which the hazard is explicitly defined as a stressor function and the exposed unit is vulnerable.

In these two models, Turner II et al. (2003a: 8074) discovered weaknesses; the RH model does not clarify "how the structures in question exacerbate or mitigate the hazard impacts" or render a "differentiation between exposed systems and components that results in substantial differences in the hazard consequences." It does not address "the role of political systems, especially social structures and institutions, in shaping differential exposures and consequences." On the other hand, the PAR model does not address the instability of the biophysical system and does not provide information on the nature of the causal series of threats, including the scale of nested interaction.

Conceptually, the development of the integrated human-climate vulnerability system by Turner II et al. in 2003 demonstrates the relationship between the global environment and human influence and how different factors affect vulnerability at different scales (Figure.2). This framework reveals the large class of elements that make up the vulnerability of a social-ecological or human nature system to stressors. These are human and environmental factors, (ii) the stressors that arise from these circumstances, and (iii) the troubling human environment coupling mechanism in which vulnerability is located, including exposure, sensitivity, and resilience (adaptive capacity takes the place of resilience). This paradigm takes a contextual approach when it comes to considering vulnerability within social-ecological frameworks. The term social-ecological is used to emphasize that the two components are equally relevant, that they function as a coupled, interdependent, and collaborative network, and to underline that the subsystem delineation is artificial (Berkes, 2015).

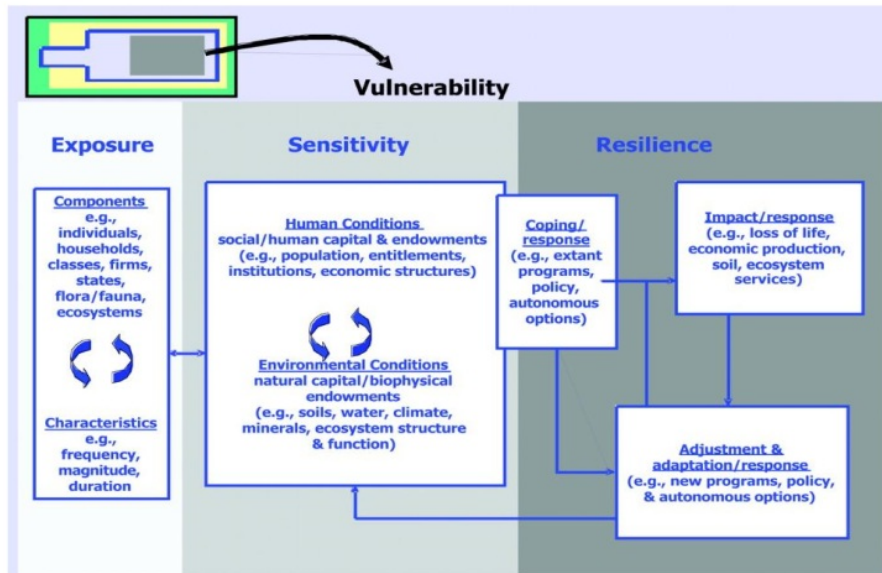


Figure 2: Vulnerability frameworks -Exposure, Sensitivity and Adaptive capacity

Source: (Turner et al, 2003)

The framework in Figure 2 describes the interconnectedness of various vulnerability components (exposure, sensitivity, and adaptive capacity) and the preconditions that would assess the vulnerability systems; In this context, the vulnerability of the community concerned will be dictated by the human-environment linkage and state, and how humans react when they are subjected to stress. (e.g. Declining reef resources). Turner et al., (2003) note that the state of the human-environment system will dictate its susceptibility to any behaviour that defines the various steps and responses to adaptation that societies can use.

Studies have shown that human settlement and ecosystem vulnerability is fundamentally related to various socio-cultural and environmental processes (Schroter et al., 2004; Adger, 2006; Williams et al., 2008; Cutter & Finch, 2008), an example was the establishment of a vulnerability framework for the assessment of European human-environmental systems. Similarly, Schroter used this framework in evaluating vulnerability to climate change (IPCC, 2007).

Further review of Marshall et al.'s (2009) vulnerability framework led to the creation of another vulnerability framework for evaluating climate vulnerability in socio-ecological systems that are climate sensitive (Figure 3). Two vulnerability models are combined in this context: one reflects the components of ecological

vulnerability to exposure to climate change, while the other reflects social vulnerability to ecological changes.

Ecological and social systems' co-dependence means that the vulnerability of one system cannot be reliably measured without a relation to the other (McLeod et al., 2015). The Marshall system used the resource dependence principle to operationally reflect the sensitivity of individual actors to changes in the condition of Great Barrier Reef resources on which their company depends. The system has been used in East African vulnerability research in coastal communities (Cinner et al., 2012).

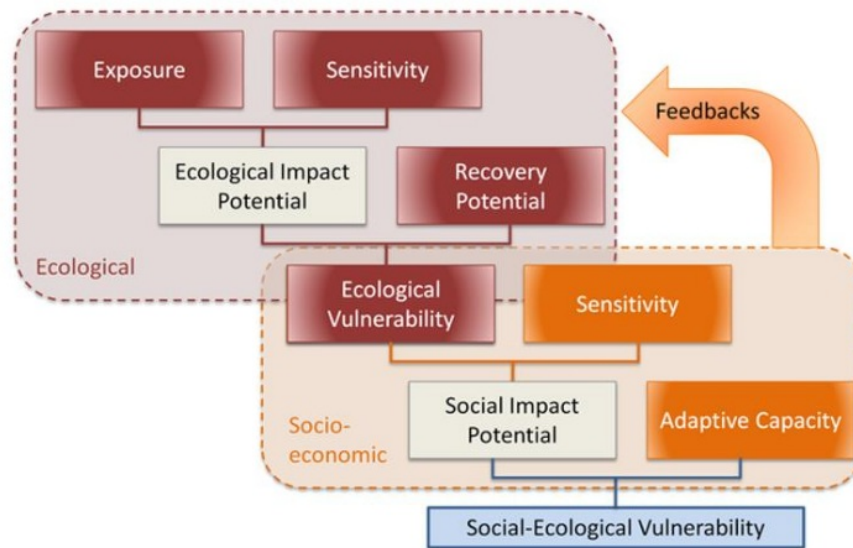


Figure 3: Socio-ecological Vulnerability Framework

Source: (Marshall et al, 2009)

The vulnerability of Mafia Islands coastal communities would be assumed to depend on the possible impact of degrading reef ecosystems on human communities that rely on them for their livelihoods with regard to Marshall and colleague's framework; community dependency on these reef resources and adaptive community capacity. Marshall et al., (2009) model shows that the potential impact of environmental exposure on communities depends on the nature of the dependence (sensitivity) of societies on natural resources. Coping would therefore have an effect on their vulnerability and communities will have access to adaptive approaches.

2.2.4. Sustainable Livelihood Concepts and Frameworks

i. Sustainable livelihood meaning

According to Maas (2015), Sustainable Livelihoods is a way of thinking that focuses on human development to recover and enhance the capacity and wealth of the present and future. Other authors define sustainable livelihood as a tool for economic survival (Soh & Omar 2017; Armitage et al., 2017).

In Mafia Island coastal communities, 'livelihood' based on the above definition can be called activities that would carry either food or cash to a person or household. These activities depend on which communities may have access to various capitals. In this report, the livelihoods of coastal communities in Mafia will be understood as a function of communities accessed livelihood assets and ability to use those assets. Most Mafia Island communities rely on marine resources for their living. Reducing these services will threaten communities living conditions that have little or no access to other livelihood assets, making them vulnerable.

ii. Sustainable Livelihood Approach

Globally, the SLF has been used to help communities engage in different approaches in achieving their subsistence goals (Ahmed et al., 2010). The sustainable livelihood approach has been specifically established to support or improve awareness of vulnerable communities or low-income earners to become more resilient to economic and environmental stressors / shocks, and to build on existing capacity (Serrat, 2017).

Cahn (2006) said the SLF could be a more coordinating mechanism for dealing with disadvantaged or oppressed groups and a useful tool. Studies in which the SLA system was implemented show that the system is most effective in evaluating livelihood assets in households where societies appear to draw on a wide variety of livelihoods in search of a better living standard (Ashley & Hussein, 2000). Integration and review of cultural, economic and natural assets between household and community data is given by the system (Scoones, 2009).

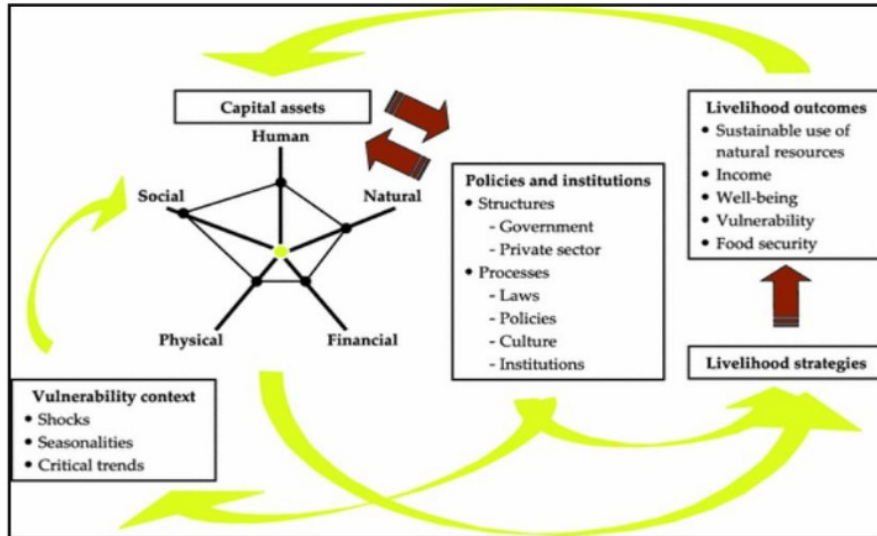


Figure 4: Sustainable Livelihood Framework

Source: (Serrat, 2017)

As realized in the SLF framework, this approach to livelihoods is related to the definition of vulnerability; any stress (context of vulnerability) will affect the different assets of capital, resulting in different livelihoods. Allison & Ellis (2001) emphasized that the SLA system incorporates three dimensions of vulnerability: exposure, sensitivity, and resilience / adaptive capability.

In their discussion, they maintain that stable living systems have high adaptive capacity and high resilience, and that vulnerable livelihoods have low adaptive capacity and high sensitivity. The present thesis adopts the Sustainable Livelihoods DFID Method (Fig. 4). Because of its capacity to connect to the frame of vulnerability, this structure was chosen.

With respect to the vulnerability system, reef resource dependence of coastal communities can be assessed using the SLF to illustrate how sensitive coastal communities are when these reef resources are declining. Similarly, in the context of insecurity, an assessment of the capital assets available to households would determine the adaptive capacity. The different livelihood strategies that communities participate in as governed by social and economic systems and processes would be characterized by access to these properties

Capital/Livelihood Assets

Scoones (1998) states that in order to achieve positive livelihood outcomes, people need a mix of assets or resources, and there is no single asset or resource that can achieve positive, sustainable livelihood outcomes alone. Therefore, good livelihood results depend on the relative availability, access to, and execution of all five domains. The following describes the capital assets in Fig 4.

- i. **Natural capital**-natural resource stocks (soil, water, air, genetic resources, etc.) and environmental services (hydrological cycle, pollution sinks, etc.) from which resource flows and services are derived that are useful for living.
- ii. **Financial or economic capital** – the capital base (credit / debt, cash, savings, and other economic assets, including and basic infrastructure and technologies) that is essential to any lifestyle strategy.
- iii. **Human capital** – the expertise, knowledge, capacity to work, and good health and physical abilities necessary for the productive implementation of various strategies for living.
- iv. **Social capital** – the social tools (networks, social statements, social ties, affiliations, associations) that people draw upon while following various subsistence strategies that involve concerted action.
- v. **Physical**-The basic setup and manufactured goods needed to sustain livelihood. These are the instruments and tools that people use to make their jobs more efficient.

2.2.5. Socio-economic structure and Processes

Knowing that Socio-economic systems and processes in most places regulate access to livelihood assets is important. Gautam & Andersen (2016) argued that livelihoods are dependent on a network of assets that is modified by access in a sense of stressors and shocks. The transformation of processes (i.e., policy levels, private sector, and civil society) and structures (i.e. legislation, rules, community, organisations, power relations) depends on access to capital (Bennett & Dearden, 2014).

Blythe et al., (2014) suggested that study on livelihood should focus on community level, yet it must not disregard the part of the state, public, and global levels in moulding these livelihoods. Series, for example, customs, principles, and convictions have been orally passed between ages in a gathering setting

and can change after some time. Livelihoods must be broken down as they are to be seen in the present, by and large (change additional time from past) and later on (for upcoming strategies) (Murray, 2001; Bennett & Dearden, 2014). Livelihood assets are exceptionally affected by structures and cycles that fundamentally influence individuals, families and communities (Scoones, 2009).

2.2.6. Livelihood outcomes and strategies

Livelihood approaches are the mixtures of practices and properties that people take an interest in as a method for endurance in the family. Those might be manageable or hurtful practices (Martin & Lorenzen, 2016). The strategy is depicted as "an arrangement intended to accomplish a particular objective" (Nzioka, 2012). Livelihood approaches incorporate viable practices, speculation methodologies, and propagative alternatives, which might be rehearsed centered around common assets and exercises dependent on non-normal assets (Kokofele & Junior, 2019). Their admittance to resources and strategy structures and series that regulator their capacity to utilize these benefits and accomplish fruitful life results comprise a noteworthy impact on individuals' decision of livelihood approaches (Badjeck et al., 2015).

As Speranza et al., (2014) said approaches to livelihoods are not static: as external environments, policies, systems, procedures change, and changes in asset management, they change. Scoones (2009) emphasizes that understanding the dynamic and historical context of how different livelihood tools are sequenced and integrated is crucial in pursuing different livelihood strategies, which can be divided into three: agricultural intensification, livelihood diversification and migration. Jayaweera, (2010) described livelihood diversification as the development of a large income portfolio (temporary or permanent) either to cope with adverse circumstances or to accumulate and reinvest. Khatun & Roy (2012) also identified the diversification of rural livelihoods as "the process by which households grow and improve their living standards by developing a diverse portfolio of survival activities and social support capacities."

Livelihood diversification decreases pressure on local resources, increases individual opportunities, generates individual human capital, increases cash flows to and from rural areas and promotes spatially diverse transactions (Mwawaza, 2015; Su et al., 2019). Livelihood diversification does not always offer

good results because of social, cultural, and economic factors (Cinner, 2014; Mutabazi et al., 2015). Scoones (2009) suggested that rural livelihood policies are often heavily dependent on the natural resource base.

Research in Laos has separated farming and non-farming livelihoods, demonstrating that richer households are more involved in non-farming than poorer households (Bouahom et al., 2004) are. The consequence of the livelihood they want is guided by the different methods in which households or societies participate. Positive livelihood outcomes can benefit from the direction of living and selection of combinations that households choose, but this is context-dependent (Scoones, 2009). Such predicted effects will include improved well-being, increased food security, increased jobs, reduced poverty and the sustainable use of natural resources, but they are contextual specific (Krantz, 2001).

2.2.7. The Use of Vulnerability and Sustainable Livelihood framework in this study.

Including SLF into the vulnerability, the system is critical when quantifying the vulnerability of coastal communities in Mafia Island to livelihood. For this analysis, the SLF (DFID, 1999) was integrated into the vulnerability system developed by Marshall et al., (2013) to answer specific questions raised. According to the SLF, stocks, patterns, and seasonality affect the livelihood assets on which people or households depend. 'Stress' or 'trend' is a low, predictable cumulative-effect disruption, normal, as defined by Scoones, 2009, while 'shock' is a large, unexpected, rare, immediate-impact disruption.

Patterns include populations, regional cultural patterns, shocks and patterns of natural resources, including floods, droughts, fires, epidemics and hurricanes; Seasonality includes market fluctuations, work opportunities, and wellbeing. Shocks and stresses on goods and services in an ecosystem may influence populations that make them vulnerable. For survival and health, people rely on ecosystems (Schaumlöffel, 2015), but human activities have been the driving force behind global climate change (Zickfeld et al., 2017; Scott et al., 2020). Human and anthropogenic factors (interacting indirectly or directly on numerous, spatial and temporal scales) cause environmental changes, influencing the ecological services and living conditions of individuals (Cumming, 2015)

Vulnerability is an element of interconnected social-natural frameworks, one made by staggered collaborations and cycles between social, political, monetary, and biological structures (Adger, 2006; Fischer, 2018). Subsequently, it is essential to see how vulnerability components and fishery-based employments connect to evaluate vulnerability to conditions of living (Islam et al., 2014). The hardship in living circumstances in most communities along the coast worldwide has been a central point for several studies. Simultaneously, several studies have explored the impact of climate change on the vulnerability and adaptive potential of the national fishing sector (Tucker et al., 2015; Cinner et al., 2018). Few studies discussed the vulnerability of coastal habitats, depending on the reef resources induced by the stresses and shocks on Mafia Island.

In compliance with the UNFCCC's Second National Communication (SNC). The effect of climate change on fisheries in 2014 was related to the degradation and destruction of fish nurseries, spawning and feeding areas (coral and mangrove). One way that climate change affects marine fisheries is through the distresses on coral reefs, which in coastal environments is a major habitat for fish. Coral bleaching due to increasing sea surface temperatures is one of the factors affecting marine fishing, and rising sea level, associated with global warming, is expected to cause rising seawater to a higher level of some corals (UNEP 2017).

The coverage of the mangrove ecosystem in Tanzania coastline has been declining, especially in Mtwara, Kilwa, and Bagamoyo, where significant economic investments have been introduced, including oil and gas exploration and extraction activities. Uncontrolled impacts from these investments, together with climate change impacts and extreme weather events including those related to the bleaching of coral reefs, migration of species, and low crop yield due to drought leading to coastal communities' dependence on fish and hence applying unsustainable fishing methods to maximize catch for their livelihoods. The pressure on mangroves from human populations varies immensely across the coastline (Msangameno *et al.*, 2017).

Climate change impacts have been observed in some coastal areas, including sea-level rise and beach erosion from strong sea waves in Pangani and Kunduchi. The intrusion of saltwater in the groundwater system has been reported in Dar es Salaam, Bagamoyo, and Nungwi in Zanzibar, 2 kilometres

within the coastline, which has affected the availability of fresh water to communities in the area (Mbwambo *et al.*, 2012).

It is projected that with increasing global temperature, thermal stress on coral reefs may also increase (Fujise *et al.*, 2014), and thus affecting the coral structure. Moreover, studies have projected that the increasing air temperature will damage coral reefs through bleaching and enhance carbon dioxide concentrations (acidification), which might adversely affect mangrove ecosystems that depend on the reefs to provide shelter from sea wave action (Yanda, 2013).

2.2.8. Coral reef support in achieving sustainable development in Mafia Island

2.2.8.1 Coral reef SDG model

This model explains the provision of ecosystem service and human use of a reef (Fig. 5). It expresses our knowledge of ecological function, how it affects service provision and benefits received by people (both monetary and non-monetary), how it affects broader social welfare aspects, and the effects of people and service-use on nature and their ability to provide services. As the model system, I use coral reefs and how they are embedded in a populated land- or seascape, whether rural or urban, emerging or developed.

The model is based on specific and observable interactions (e.g., fish extraction or tourism) that can be assessed to determine the viability of human-nature interactions, balance and reconcile monetary and other indicators that address the system's core dynamics, and provide explicit guidance for decision-making.

The model is implemented at the level of a land- or sea-scape coral reef, addressing where the environment and its wider spatial and temporal dimensions generate services that are used by people across diverse economic sectors. Literature well supports the relationships and connections in this model across varied models of ecosystems and human dimensions. Finally, it provides a framework for this model, which focuses on the flows between nature and humans, mediated by 'contributions from nature to people'

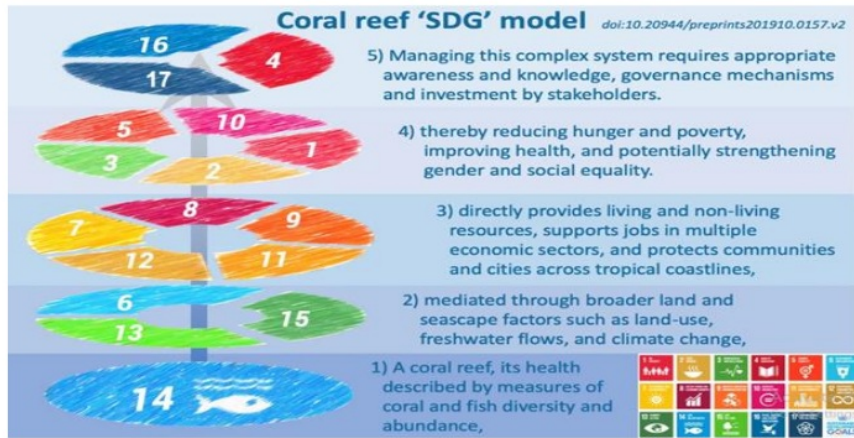


Figure 5: Coral reef SDG model

Source: Adapted from Obura, 2019

2.3. Objectives and Purpose of the study

This study's main objective is to assess the perception and livelihood vulnerability of coastal communities to changes in reef resource stressors. A case study of Mafia Island in Tanzania. Specific objectives of this study will be:

- i. To identify the perceived ecosystem benefits provided by the reefs to coastal communities
- ii. To examine the livelihood vulnerability to the coral reefs dependent communities through an analysis of the perceptions of communities
- iii. To suggest adaptation and mitigation measures to enhance sustainable community livelihood,, informed by the perception of stakeholders

2.4. Significance and implication

Natural resources conservation is one of the priority sectors in the United Republic of Tanzania, whereby its major growth targets have been stipulated in the National Five Years Development Plan II (2016/17-2020/21) with its main theme of nurturing industrialization for socio-economic development. This is in recognition of the role played by fisheries and tourism sectors in national socio-economic development. The fisheries and tourism industry provides employment, income, recreation, trade, and economic wellbeing for the present

and future generations. In 2014, the sector employed 183,800 full-time fishermen, and about 4.0 million people earned their livelihood income from the fisheries sector-related activities (NFP, 2015). In addition, the sector has been growing at a rate of 5.5%, contributing to the national GDP (NFP, 2015).

Despite the fact that the fisheries and tourism sectors are anticipating growth in the near future, there are some drawbacks, which needs to be, addressed which may retard these sectors, one of them is the climate change, which is affecting the corals, which forms a crucial habitat for fish species in the coastal environment as fish nursery grounds, breeding, and feeding areas (Carr et al., 2017). In this case, therefore, this study will examine the main challenges facing the future of corals and the coastal communities, and it will finally suggest the conservation measures, as well as the alternative livelihoods for the coral reef dependent communities, which all depends on the outcomes of communities' perceptions.

2.5. Research Question

- i. What are the major ecosystem benefits provided by coral reefs to coastal communities?
- ii. How do the components of vulnerability influence the livelihood of coral reef resources dependent on communities?
- iii. What measures might be taken to reduce vulnerability of coastal communities' dependent on coral reefs

3. Materials and Methods

3.1. The Study site.

Due to the existence of several interacting drivers of transition, Mafia district was chosen as a suitable area for this analysis. It is the richest marine biodiversity district in the country, it has the highest number of fish landing sites in coastal Tanzania (International Resource Group [IRG], 2008), and it has the country's first, largest, foreign marine finfish and octopus processing factory (TANPESCA Ltd.). The district has octopus-collecting businesses (Sea Products Ltd. and Bahari Foods Ltd.), and Tanzania's first marine park (MIMP). Founded in 1995, the MIMP comprises 13 villages (URT, 2011a).

3.2. Data Collection

The primary data is information that the researcher himself obtained (Sutton & Austin, 2015). Interview is the most widely used methodology in qualitative research to collect primary data (Young et al., 2018). A total of 20 semi-structured interviews were conducted with government officials, policy makers, academics, traders, ocean consumers, and entrepreneurs to collect primary data. Figure 5 demonstrates the principal phases of the interview process.



Figure 6: The basic stages of an interview

Source: Adapted from Young et al., 2018.

Data was compiled on local perceptions and vulnerability of coastal communities and responses to adaptations across 10 Mafia Island villages. These villages were chosen for this study to reflect regional differences in which five villages within the Mafia Marine Park area and five other villages outside the Mafia Marine park area were interviewed within each village via a semi-structured interview with a village/ward executive or village chairperson.

Data were collected between May and June 2020 for this study. This study was based on methods suggested by Huntington (2000), i.e., semi-structured interviews with ten village leaders and ten institutions, to collect data. Participants were selected purposely to share their knowledge on the changes in ecosystem services and the way it influences livelihood systems. Data collected from these communities situated in the vicinity of mangrove wetlands and nearshore coral reefs on which their income and livelihood depend on fisheries and other products, including fuelwood, food, and wood (Narayan et al., 2020).

Due to Covid 19, it was not possible for me to travel to the study area to carry out the interviews. It was also not feasible to carry out remote interviews with high-level community leaders. The interviews were carried out by an employee of the Mafia Island Marine Park during May and June 2020. The interviews were recorded, transcribed and coded.

In this case therefore this study addressed questions emanated from research questions, two separate set of questions were formulated, one for community leaders and one for institutions or authorities all represented in table 1 and 2 (including Government, Non-governmental organizations and private sector institutions. The list of questions, which were used in the interviews for this study is attached on annex one.

3.3. Semi structured Interviews

Researchers use three types of interview strategies to gather primary data, which were semi-structured, structured, and unstructured interviews (Stuckey, 2013).

The semi-structured interview is an exploratory interview most commonly used for qualitative research purposes or to collect data in the social sciences. It usually follows a guide or protocol that is conceived prior to the interview and is based on a central topic to provide a general structure; the semi-structured interview often allows for exploration, with room to follow topical trajectories as the conversation progresses (Magaldi & Berler (2020).

It is also a verbal exchange where one person, the interviewer, gathers information politely through a series of questions from another person, the interviewee, or the respondent (Robionet. 2011; Adhabi & Anozie, 2017). A common series of administrative questions had been used in semi-structured interviews. It is a useful qualitative method because it supports access to human perceptions on insights, values, beliefs, (Galletta, 2013; Young *et al.*, 2018).

The WMU Research Ethics Committee approved these administrative questions. However, when an interesting or new line of inquiry arose during the interview process, further questions were asked about the subject.

Therefore, Semi Structured Interview technique allowed an in-depth analysis of a particular subject. This versatility of asking more questions helped a lot to get more information. Whereas there was not that much versatility in the structured and unstructured interview, process to ask supplementary questions (Adhabi & Anozie, 2017). The Semi Structured Interview process was thus used to gather primary data.

3.4. Data Analysis

I transcribed and coded the interviews to identify themes and to inventory perceptions. Qualitative content was quantified, where possible using Microsoft Excel and/or Statistical Package for Social Science (SPSS) software

The data collected during the interviews were then compiled, reduced to a formal and manageable format to form a qualitative evaluation in assessing coastal communities' perception and livelihood vulnerability to changes in stressors to reef resources, the case of Mafia Island.

A total of 20 semi-structured interviews were conducted comprising ten respondents representing ten villages in Mafia Island and ten marine

stakeholders from both government, private sector and nongovernmental organizations, whose narratives/assessments are provided in the Results section, forming the basis for the final Conclusion and Recommendations.

3.5. Ethical issues

According to Smith (2003), the code of conduct of the study includes maintaining the confidentiality and obtaining informed research consent of participants. The researcher received a permission letter from the World Maritime University's Research Ethics Committee. The letter helped the researcher in introducing him/herself at the local level where data was collected.

By filling out the WMU Research Ethics Committee Consent Form attached as Appendix 2, I received written consent from the respondents. The respondents were assured of the disclosed information being anonymous and confidential since it was meant strictly for research purposes only.

4. Results

In this study, respondents were Coastal communities' leaders and institutions who are key stakeholders in marine resources use twenty (20) participants total. Ten (10) respondents were representatives from 10 villages (see Table 1) within the study area, and other ten (10) participants were representatives from institutions such as Ministries, Government agencies, NGOs and the Private sector (See Table 2). Respondents in this study presented their experience and perception on livelihood vulnerability with reference from marine resources utilization.

Respondents from both categories were well represented in gender, and in terms of education they range from primary level education to PhD level, on the other hand, most of them are in decision-making level in their institutions

Table 1: Respondents from villages consulted for interviews

S/N	Age	Position	Education
1	52	Village Executive Officer	Primary level
2	57	Village Chairman	Diploma
3	54	Village Executive Officer	Primary Education level
4	44	Village Executive Officer	Secondary Education Level
5	25	Ward Executive Officer	Bachelor Degree
6	56	Village Chairman	Primary Education Level
7	35	Village Executive Officer	Secondary Education level
8	32	Ward Executive Officer	Bachelor Degree
9	57	Village Chairman	Primary Education Level
10	36	Ward Executive Officer	Bachelor Degree

Table 2: Respondents from various Institutions consulted for interviews

S/N	Age	Position	Education	Institution
1	39	Senior Environmental Officer	Master's Degree	Fisheries Education Training Agency
2	42	Fisheries Officer	Diploma	Ministry of Livestock and Fisheries Development
3	52	Environmental coordinator	Master's Degree	National Environment Management Council
4	52	Marine Programme Officer	Master's degree	World Wildlife Fund
5	52	Principal Fisheries Officer	Master's Degree	Vice President Office
6	39	Research Scientist	PhD	Tanzania Fisheries Research Institute
7	53	Marine Programme Coordinator	PhD	The Nature Conservancy
8	33	Plant Manager	Master's Degree	Alphakrust Ltd
9	48	Senior Marine Conservation warden	Master's Degree	Mafia Island Marine Park
10	48	Lecturer	PhD	University of Dar es Salaam (Institute of Marine Science)

4.1. Sources of Income to Mafia Island Communities

Question one (What are the major activities that bring income to the families in the Mafia Island?). In responding this question respondents came up with a number of activities (See Figure 7), it was necessary to aggregate them into representative categories during data analysis. Activities mentioned includes fishing, crop farming (major crops mentioned include cassava, coconut, paddy, cashewnuts and bananas), livestock rearing (animals mentioned were cattle, goats, sheep and chicken), business (shops and restaurants), tourism (diving and boat riding), seaweed farming and other wage-earning employment. Figure 7 indicates the study percentage of respondents' ranking most important economic activities, which Mafia Island families depend on for their livelihood.

Based on respondent's views/perceptions and experiences 100% (all who were interviewed) of respondents mentioned that Mafia Island families engage in fishing and crop farming, about 80% shows that Mafia Island families engage in livestock keeping and 70% mentioned small business and restaurant and lastly 40% of respondents said that some members of households are engaging in seaweed farming while others are employed in tourism industry.

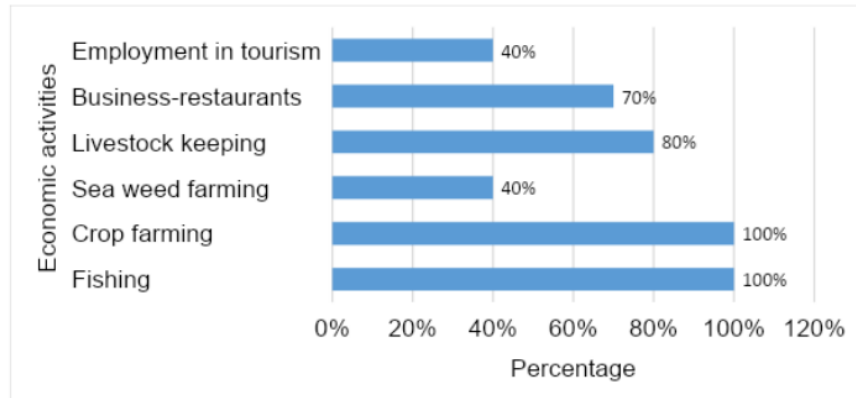


Figure 7: The percentage of interviewees who ranked different sources of income to Mafia Island communities.

Source: Field data for this dissertation

4.2. Gender roles and Marine resources use

Question two (Are there specific gender roles in this Island I terms of marine resource use and conservation? What are they?)

Respondent's perception share their experience with regard to gender roles in marine resources use and conservation. 90% of respondents show that fishing activities are done by men while 10% of respondents show that women also engage in fishing. 80% of respondents mention that women engage in seaweed farming while 10% of men engage in seaweed farming. 70% of respondents mention that women engage in restaurant while 20% mentioned men engage in restaurant and lastly respondents perceived that 70% of women engage in fish vending while 10% of men engage in food vending only as shown in Figure 8 below.

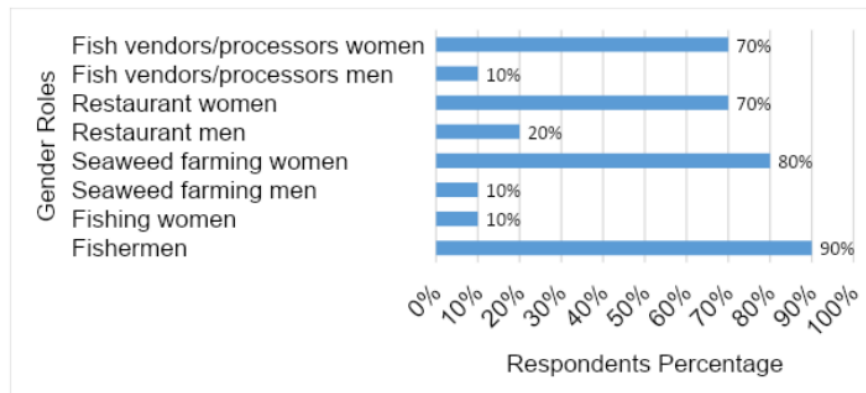


Figure 8: The percentage of interviewees showing gender roles in Mafia Island communities.

Source: Field data for this dissertation

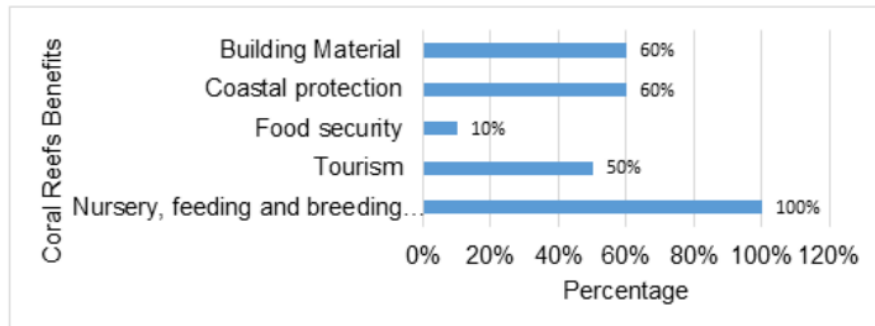
4.3. Major benefits communities obtain from coral reefs in Mafia Island

To determine how respondents appreciated the role of corals, the study posed a question on the benefits of corals to Mafia communities (what major benefits do communities obtain from coral reefs?)

Respondents' opinions show that these communities obtain enormous benefits from coral reefs such as tourism, coastal defence, food security, research, revenue, carbon sequestrations, and corals as nursery, feeding and breeding grounds for most marine organisms and lastly they mention building materials. Figure 9 below shows the percentage respondents who mentioned various

benefits coastal communities obtain from coral reefs in Mafia Island in village leaders perceptions and institutions perceptions.

(a). Village leaders respondents



(b) Institutions officials' perceptions

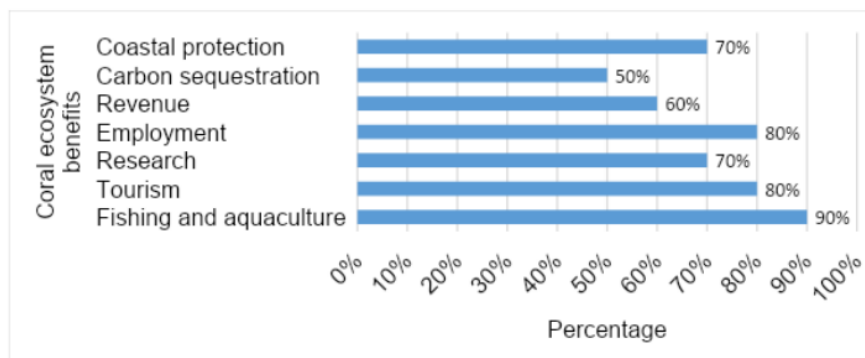


Figure 9: Percentage of respondents perceived major benefits communities obtain from Coral Reefs ecosystem

Source: Field data for this dissertation

4.4. Changes in availability of reef resources

In analysing this question, respondents were asked to state the reasons or challenges causing changes in the availability of reef resources. 0% of respondents mention Climate change as the main cause, 60% sited destructive fishing practices, 50% of respondents mentioned both habitat degradation and Covid 19. 40% mentioned both pollution and inadequate coordination as well as

funds for monitoring and lastly 30% of respondents perceive political interference as a reason for change as shown in figure 10 below.

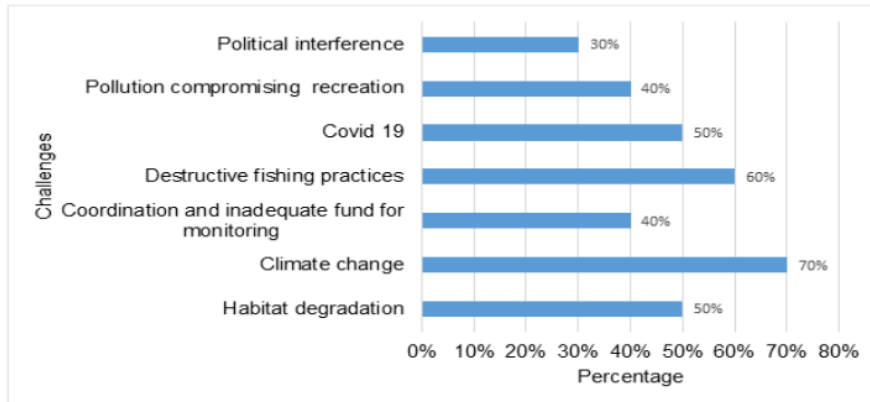


Figure 10: Percentage of respondents who mentioned main reasons for changing in availability of reef resources

Source: Field data for this dissertation

4.5. Livelihood opportunities with the highest economic value in Mafia Island

Question; (Which livelihood opportunities have the highest economic value in this village?) from the interview were asked to respondents to understand specific activities people rely on which will show how vulnerable they are.

The findings in Figure 11 shows that 90% of respondents mention fishing as the highest economic activity in the Mafia Island. On the other hand 80% of respondents mentioned crop farming; about 60% or respondents pointed out tourism and business such as small business/restaurants while the least activity being Livestock keeping with only 10% of respondents mentioned it.

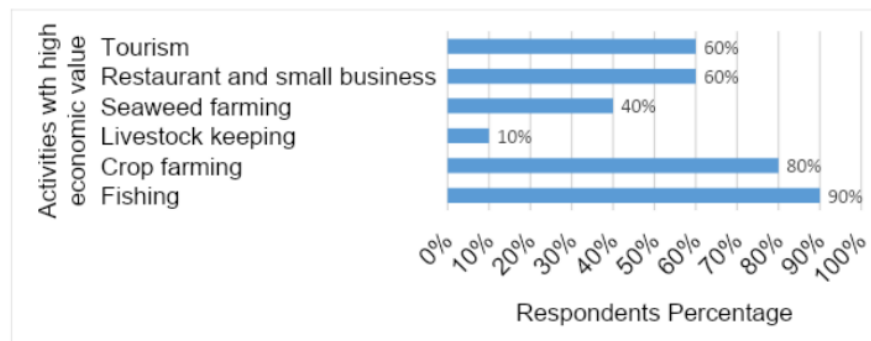


Figure 11: The percentage of interviewees showing activities with highest economic value in mafia.

Source: Field data for this dissertation

A follow up question was asked to respondents, which were; (Has the economy of these activities (in Fig 11 above) changed in the past two years? Reasons for change?)

In answering that, question respondents perceptions shows that, almost 100% accept that there are some activities, which change such as crop farming and fishing as shown in Table 3 below.

Table 3: Activities changed in the past two years

Activities that changes	Percentage of respondents
Crop farming	70%
Fishing	60%

On the other hand, the researcher wanted to know what the main reasons for the change? The findings in Figure 12 explains that there are both positive and negative changes. Major reasons for change perceived by respondents in this question include impacts of climate change, destructive fishing practices, unpredictable market, overexploitation of fish resources, strict regulations imposed by MPAs as well as COVID 19 pandemic.

Reasons that causes changes in activities with highest economic values in the past two years according to the surveys of 10 community leaders, and 10 representatives from government, private sectors, NGOs and research/academic institutions are represented below.

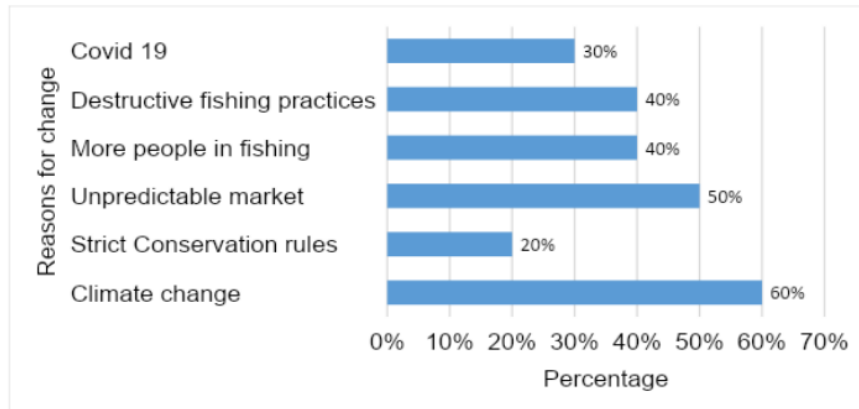


Figure 12: Reasons that causes changes in activities with highest economic values in the past two years

Source: Field data for this dissertation

4.6. Impacts of COVID 19 on communities and their livelihoods in Mafia Island

Following a question during interview which stated “From your perspective, how COVID 19 affected communities and their livelihoods here? Which activities are highly affected by COVID 19...? How long term do you think the effects might be?” The findings shows that; The percentage of respondents that perceived the following activities were affected by Covid 19 was as follows fisheries(50%), agriculture(30%), tourism(50%) and food vending business(60%) as presented in Table 4 below.

Table 4: Percentage of respondents who mention communities' activities affected by COVID 19 in Mafia Island

Activities Impacted by COVID 19	Respondents percentage
Fisheries	50%
Crop farming(Agriculture)	30%
Tourism	50%
Food vendors and other small business	60%

In the analysis of major impacts of COVID 19 to communities' livelihood, 90% of respondents mentioned reduction of communities' prices, closure of food vending business and 80% of respondents mentioned loss of employment in tourism from local villager's perceptions. On the other hand, the institution's perception with reference to this analysis shows that 90% of respondents mentioned that main

impacts include loss of employment, impact of the tourism industry and impact on both local and international markets as shown in Table 5.

Table 5: Percentage of village leaders and institutions that perceived an impact on employment, industry and markets

Impacts of COVID 19 to communities livelihood	Percentage respondents
Loss of employment in Tourism	80%
Commodities price reductions	90%
Local and international Market reduced	90%
Food vendors business closed	90%

Duration of the impact

On asking how long the effect will last, Analysis shows that 70% of respondents perceived that in less than one year the effect might end. 20% of respondents said that it will last for two years and only 10% of respondents mention that the impact will be more than two years as shown in the chart below.

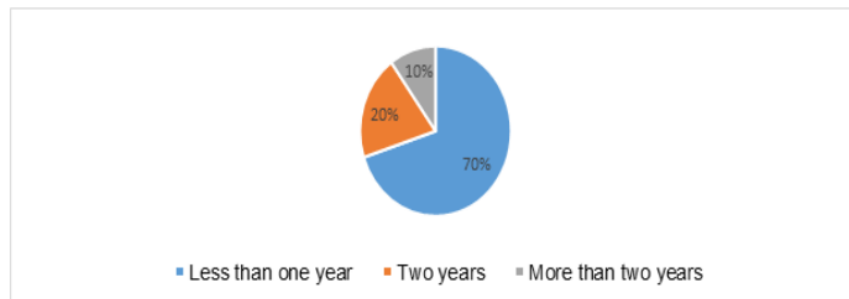


Figure 13: Percentage of interviewees that perceived the duration of the impact of COVID 19 on communities and livelihoods in Mafia Island

Source: Field data for this dissertation

4.7. Perceived COVID 19 impacts to marine environment in Mafia Island

In analysing this question, respondents provided their thoughts on how the marine environment might be impacted by this pandemic disease. Table 6 shows that 80% of respondents said that there would be high fishing pressure caused by increasing population, 70% of respondents mentioned that there is usage of destructive fishing practises. In addition, 20% said that there would be an increasing seaweed farming.

Table 6: Percentage of respondents reasons on how COVID 19 might affect marine environment

Reasons on how Marine Environment might be impacted	Percentage respondents
Fishing pressure caused by population increase	80%
Increasing seaweed farming	20%
Destructive fishing practices increase	70%

4.8. Perceived main threats to coral reefs in Mafia

Besides the major benefits communities obtain from coral reefs in Mafia Island, respondents who were interviewed in this study have pronounced a number of threats, 80% of respondents mentioned destructive fishing practices. 40% mentioned extraction of building materials and 30% mentioned climate change as shown in Table 7.

Table 7: Perceived main coral reef threats in Mafia Island by respondents

Perceived threat to corals in Mafia	Percentage respondents
Climate Change	30%
Building material	40%
Destructive fishing practices	80%

4.9. Impacts to communities due to coral reef declining

Respondents with reference to this case show that 100% of the Mafia mention that people will lose their employment; 60% of respondents show that coastal erosion will be a challenge and 10% of respondents outlined that marine parks will lose their integrity if corals will not be there and also communities who depend on dead corals for building material will also be impacted as represented in Figure 14 below.

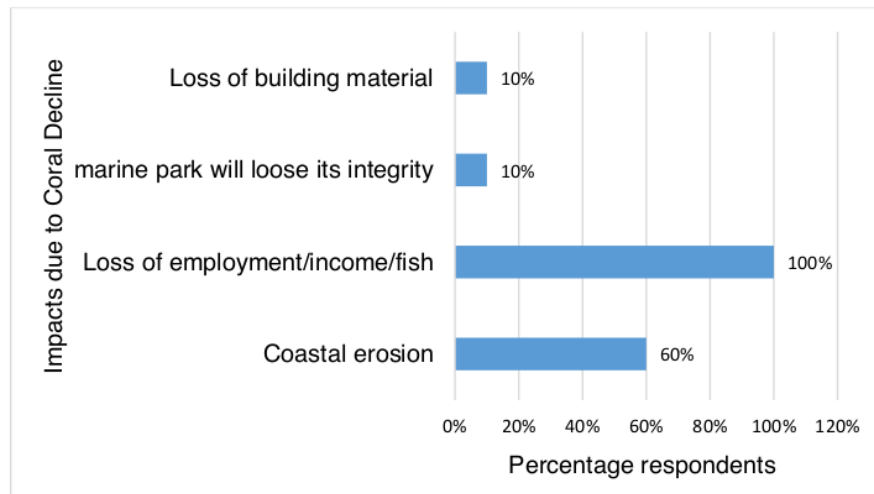


Figure 14: Perceived impacts due to coral reef decline

Source: Field data for this dissertation

4.10. Perceived Alternative livelihood to Mafia Communities.

To determine how respondents perceive alternative income sources to Mafia communities, results in Table 8 shows that 90% of respondents mentioned agriculture or crop farming as the major alternative livelihood whereby 70% of respondents mentioned small business and 60% pronounce livestock keeping as the third livelihood options.

Table 8: respondent's perception on alternative livelihood options

Alternative livelihood activities	Perceived respondents percentage
Agriculture (Crop farming)	90%
Livestock keeping	60%
Small business	70%

4.11. Protection of corals

In addressing ways to protect corals, respondents provided their opinions and the results in figure 15 shows that 100% respondents suggested that conservation education is the key. Whereby 70% mentioned law enforcement. 20% of respondents mentioned deployment of Integrated Coastal Zone Management as a key to protect corals and 10% mentioned that provision of alternative livelihood.

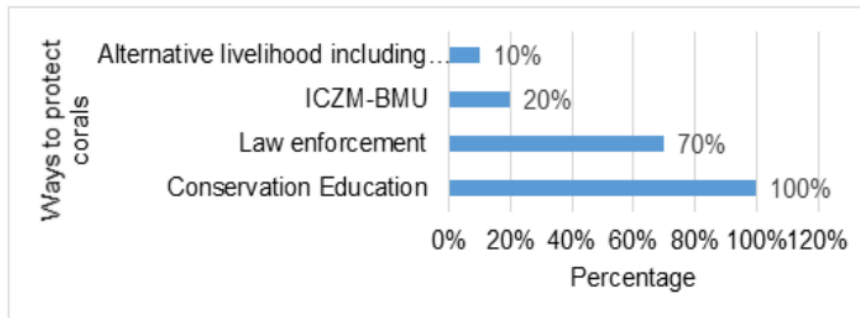


Figure 15: Percentage of respondents who mentioned various activities as the way to protect corals

Source: Field data for this dissertation

5. Discussions

The aim of this study was to assess the coastal communities' perception and vulnerability to changes in reef resources stressors. This section will be answering the main questions addressed during interviews and presented in the result section. The following are the interpretation of the evidence presented in the results.

5.1. Sources of Income to Mafia Island communities

From the analysis of the findings above it shows that most families in Mafia Island engage in more than one coral reef supported activity as a source of income to their families. To a large extent respondents' perception shows that families practice both fishing and crop farming as a major source of income, although in the findings Mafia island communities also engage in livestock keeping, small businesses, others employed in the tourism sector and seaweed farming (see Figure 7).

These findings support previous studies. Kincaid et al., 2014 also from Tanzania and Cakacaka, 2018 did a study in Caribbean came out with a study which shows communities engaging in more than one activity as a source of income.

5.2. Gender roles and marine resource use

The analysis shows that in Mafia Island there is a clear division of roles between men and women on some responsibilities. Although respondent number one explains that women also engage in fishing activities especially octopus fishing showing that there are no specific gender roles. It is an evidence that one respondent mention that: - "In Chemchem village women are the same as men, all of them do fishing activities such as octopus fishing"

That statement supports that women engage in various activities with regard to marine resource users in Mafia based on respondents' perception (see Figure 8), which shows that gender roles are divided among women and men. On the other

hand, due to respondents perceptions works such as fish vending, restaurants and seaweed farming are more dominated by women rather than men. A study by Máñez & Pauwelussen, (2016) carried out in Indonesia has the same findings and evidence of what this study found showing that women are key marine users and conservators due to their involvement in various activities which communities were only thinking that they are specifically for men. Women play a big role in conservation and in fishing, practices in Mafia Island based on respondent's perception: as harvesters and collectors of marine resources, as processors and traders, and as key players in informal networks that are particularly important to small-scale fisheries.

5.3. Livelihood with highest economic value

In viewing the sensitivity of Mafia, island communities' respondents were asked to provide their opinions on the highest economic value which most communities rely on, these would show whether changes of that activity would affect the livelihood of Mafia communities.

My study showed that 90% of the respondents noted that the economic activity that contributed the most to their income was fisheries (see Figure 11). This means that Mafia island communities are very highly sensitive to any changes of reef fish resources due to high dependence on their livelihood. It is an evidence that same study, which was done by Cinner et al., (2013), reveals that if the community is more dependent on a certain ecosystem, any slight change in environmental conditions may affect the social and economic dimension of such a community.

5.4. Ecosystem goods and services offered by corals in Mafia Island

Findings from this study indicate an awareness by interviewees from community leader groups and other governance actors (Ministries, government agencies, academia, private sectors and non-governmental organizations) that corals provide enormous benefits to Mafia Island communities by supporting their livelihood in terms of income generating activities in tourism, fishing for both commercial and family use, coastal protection, research activities as well as sequestering carbon from the atmosphere (see Figure 9).

My study findings are in line with a study carried out by Mwaipopo, 2017; Tumbo et al., 2015 both in Tanzania shows evidence that coral reef in Mafia support fisheries and tourism for coastal community's livelihood.

5.5. Changes of reef resources availability in Mafia.

From the analysis in Figure 10 respondent's shows that in comparison to last two years reef resources availability has been decreased due to various reasons, an evidence from one respondent stated:

"Changes in availability of reef resources yes, fish availability decreases, habitat degradation, pollution compromising recreation, shoreline encroachment-urbanization-beach development e.g. groins to say anthropogenic activities, destructive fishing gears"

The statement by the respondent is one of the evidence of changes in availability of marine resources, the overall findings from the research question pointed out the main reason as habitat degradation, climate change, Covid 19, destructive fishing practises, pollution, political interference and inadequate fund for monitoring (see Figure 10)

My findings are in line with a study carried out by Moshy (2016) in Tanzania who also reported in her findings on reasons for changing in availability of reef resources in Mafia Island communities.

5.6. Impacts of COVID 19 on Communities and their livelihood

Respondents had various experiences on major impacts caused by COVID 19 on communities including closure of tourism due to lack of tourists which causes most community members who were employed in the tourism industry such as in hotels, boating and diving activities lost their employment. Most women closed the food vendors business due to lack of customers. Commodities prices reduced as most of neighboring countries such as Democratic republic of Congo could no longer buy sardines in Mafia Island. The closure of the borders due to COVID caused a price collapse, as there were not buyers of the marine products (see Table 5).

It is evident that this study is in line with Bennett et al (2020), who also found that Covid 19's influence on coastal communities included economic knock-on effects due to market disruptions, total shutdowns of some fisheries, increased health risks to fishermen, added consequences for vulnerable groups, processors and populations, increased exposure to other social and environmental stressors and increased illegal, unreported and unregulated fishing.

5.7. Marine environment impacted by COVID 19

From the analysis of this question, respondent's perception shows that marine environment might be impacted in both positive and negative ways to Covid 19. Respondents' perception shows that there will be an increase in fishing pressure, which will be caused, by increasing the fishing population, which will result in destructive fishing practices (see Table 6).

This implies that, since other marine resource users like tourism activities have been reduced due to Covid 19 restriction in different parts of the world, many people employed in the tourism sector are losing their employment and therefore they will be shifting to fishing activities and or seaweed cultivation to meet their income and food demand for fish.

The findings of this study are evident and in line with a study carried out by Jones & Comfort (2020) that shows the main risk on the tourism sector during Covid 19 outbreak and how it will compromise sustainable development. Its implication is towards community members who lost their livelihood opportunities in the tourism sector and the way they will put more pressure on the marine environment, in particular the fishing sector. The essence is such pressure may compromise the sustainability of reef resources and will increase the vulnerability of coastal communities who rely on reef resources.

5.8. Major threats to corals in Mafia

From the analysis in Table 7 on threats to coral reefs, the perception of respondents shows that coral reefs are the most threatened ecosystem that have been partially or seriously affected by human activities. The findings show that major threats to coral reefs include destructive fishing practices, extraction of building materials and climate change.

Other studies which are evidence to major threats to coral reefs in Mafia and other parts are; Westmacott et al., 2000 found the major coral threat in Jordan east was climate change. Obura et al., 2000 carried out same study in east Africa of which Tanzania inclusive and found the main threat to corals are destructive fishing practices, pollution, coral mining for building materials, and human settlement and development. Last study was Tong *et al.*, 2018 and Hughes *et al.*, 2018 they found major coral threat are degradation caused by human activities as well as bleaching by climate change.

5.9. Impacts to communities due to coral reef decline

My interview results show that Mafia communities will likely continue to be highly impacted due to coral decline since there is a high degree of dependence on coral reefs, and most coral reef ecosystem goods and services will continue to diminish.

Most of the impacts mentioned include loss of employment or income by coastal communities of which all respondents mentioned it due to high dependency rate to coral resources, on the other hand they mentioned that there will be high coastal erosion, this is due to main function performed by corals in breaking waves, and lastly those communities who extract corals as building materials pointed out that such function will not be existing if all corals will die.

A study by Cakacaka (2018) shows evidence that individuals, households and communities will pose a serious risk to their livelihood if corals will be threatened and pointed out that communities the impacts will be on employment, food and coastal erosion as found in this study.

5.10. Components of vulnerability influencing communities livelihood

This study assessed the vulnerability of communities to the impacts of declining reef resources using locally applicable measures of exposure, sensitivity and adaptive capacity. It is important for effective management of reef resources to understand how these vulnerability components and their indicators interact, and how this affects the vulnerability of community livelihoods. From the analysis in Figure 7 respondents, perceptions show that Mafia communities are highly relied on coral resources as their main source of livelihood.

Exposure

Exposure was explained by Cinner et al., (2013) as the point that any environmental changes in a particular area may affect the availability of resources. If communities depend on reef resources as their primary source of income or livelihood, they will be vulnerable to any changes in reef resources

Based on respondents perception this study shows that Mafia Island coral resources are exposed to resource perceived to be exposed to resource degradation as revealed in Table 7 that most of coral threats are caused by habitat degradation, urban development, climate change, population growth and socio-economic inequalities and governance failure which was also found by studies carried out by several authors such as Cinner et al., 2012; Birkmann et al., 2015; Moshy, 2016, which stated that Communities that are more exposed and susceptible to stress or disease may be more vulnerable.

Adaptive capacity

The results of this study further revealed that Mafia Island populations perceive themselves as highly exposed to declining marine resources. The high level of perceived exposure observed represents high exposure levels and/or poor adaptive potential for these populations. Respondents indicated that reef resources in their fishing grounds had declined relative to previous years as shown in Table 7 in the results section, which all respondents show that reef resources declined. Gasper (2019) mentioned that vulnerability can be reduced communities are able to cope with and adapt to these changing circumstances. From the findings of these study respondents' perceptions with reference to coping strategies mentioned diversification of livelihood opportunities in either

agriculture, livestock keeping and establishing small businesses if they can obtain micro loans.

Many other studies have used ecological data and coral bleaching data (i.e. ecological surveys of coral and fish colonies) to measure exposure while defining the risk to livelihoods (Bennett et al., 2014; Cinner et al., 2012; Islam et al., 2014), which has been absent from this study.

5.11. Alternative livelihood for coastal communities' livelihoods.

From the analysis of the perceived alternative livelihood in Figure 15 above, the study respondents mentioned activities such as crop farming, livestock keeping and small business as the alternative income earning activities if corals will not exist in the future. A study by Cakacaka 2018 is an evidence obtained in this study showing that coastal communities rely on agriculture as an alternative livelihood.

According to secondary data Kokofele & Junior, (2019) livelihood approaches include investment strategies, sustainable practices, and generative options, which may be natural resource-focused practices and non-natural resource-based undertakings.

The implication of this study in marine conservation is that if less people use reef resources they will be more sustainable, so we should try to reduce people's reliance on coral reefs through programs such as alternative income projects. This simplistic narrative sounds rational and very enticing, but it is rarely accurate because it ignores the main reasons people fish for, and the role of diversification of livelihoods in collective action and enforcement. According to Cinner (2014), under some conditions, reducing people 's reliance on reef resources will make them less likely to comply with management measures and less willing to take collective action to solve resource management problems.

5.12. Coral Protection

From the findings in the results section, respondents provided their perception on methods to protect corals as presented in figure 15. Most respondents views were towards conservation education, law enforcement meaning that by dealing with existing laws they can prevent and protect the destruction of corals, the use of Integrated Coastal Zone Management that means the inclusion of communities such as Beach Management Units and provision of alternative livelihood other than use of marine resources could be the best option through provision of capital loans to coastal communities which will facilitate establishment of small businesses while minimizing the use of marine resources.

6. Recommendation and Conclusion

6.1. Recommendations

From the results elucidated using perception and experience, the following can suite as recommendations for decision makers during policy formulation

i. Channel capital to improve education so that communities are better equipped to take on alternative jobs. This means that people should embark on alternative livelihood sources (such as small business, agriculture, livestock keeping etc, to easy harvesting pressure on fishing and other marine resources while diversifying income opportunity

ii. Upscaling provision of education (training courses and publicity campaigns) to raise awareness on climate change among coastal populations, and to encourage household and community adaptation.

iii. Create structures to offer communities access to credit. Establishment of the tourism/fisheries development fund is important for the sector development. Advocacy is needed to hold the government responsible and support fund establishment. The fund will be useful for development of the supply chain

viii. Engage local people in decision making to ensure that local needs are addressed. BMUs in Mafia have been trained in lobbying and advocacy and they can continue to use knowledge acquired to give opinions, demand rights, participate in policy dialogues and decision-making, and engage with policy and decision makers including other duty bearers. The community is also groomed on co-management through BMUs. This is an opportunity for them to advance safeguarding of marine resources and sustain the benefits. The community can scale-up co-management and become in full control of resources around them

6.2. Summary and Conclusion

The key finding was that the declining reef resources would have less impact to communities with alternative livelihood opportunities. This is not a guarantee because of local population increase, changes in tourism flows due to Covid 19 and climate change which is caused by increasing global warming

The effects of declining reef resources on livelihoods will also depend on the degree to which alternative sources of protein and income are accessible to communities. In this study, respondents perception considered that reef resources in Mafia Island is were declining. Although these communities dependency on reef resources in Mafia Island varies due to engaging in more than one source of income for livelihood. Yet in this analysis, all communities are highly depending on reef resources as main source of livelihood, other sources are diversification to their income sources.

While the impact on fishing and tourism would cause them more vulnerable to reef resources, the impact on livelihoods would be dependent on (1) the degree to which other sources of livelihood (e.g. agriculture and tourism) have already been impacted by climate change, and (2) the degree to which other 'climate-proof' ways of accessing food and income may be embraced by societies. The latter, in turn, will clearly rely on the growth of adaptive capacity among Mafia Island coastal communities.

It is therefore wise to do everything possible to preserve the health of coral reefs and their fisheries, while 'preparing for the worst' by diversifying into alternative livelihoods, including, though not exclusively, agriculture. Increasing adaptive capacity is important both to allow communities to cope with shocks when they do occur and to encourage the adoption of alternative livelihoods that are less dependent on climate sensitive resources

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Appendices
Annex 1



RESEARCH QUESTIONNAIRE

1. Demographic Information

- i. Name of respondent
- ii. Age.....
- iii. Position
- iv. Education.....
- v. Street /village.....
- vi. Ward
- vii. District.....

2. Income and Occupation

- i. What are the major activities that bring income to the families in the Mafia?
(Mention at least four) both fishing and non-fishing activities. Rank in order of its importance.
 - a.
 - b.
 - c.
 - d.
- ii. Are there specific gender roles in this Island I terms of marine resource use and conservation? What are they?
- iii. Which livelihood opportunities have the highest economic value in this village
- iv. Has the economy of these activities changed in the past two years..... Reasons for change...
- v. How much do people earn per annum from these respective activities.....
- vi. From your perspective, how COVID 19 affected communities and their livelihoods here?.....which activities are highly affected by COVID 19...? How long term do you think the effects might be?
- vii. How do you think COVID19 will affect the way people interact with the marine environment in this village?

viii. How do you think the marine environment might be impacted by COVID 19 in this village?

3. Ecosystem Goods and Services offered by coral reefs

- i. Do you believe that coral reefs are important to Mafia Communities?.....
- ii. What major benefits do communities obtain from coral reefs?.....
- iii. What are the main threats to coral reefs here?.....
- iv. Do you think that these communities will be affected if the coral reefs continue to decline?.....How so?.....?
- v. What else will the communities do if the coral reefs are no longer productive (Alternative livelihood)
- vi. What do you think can be done to protect corals?

4. Questions for authorities. (This question will target the high authorities in Tourism, natural resources, fisheries department and non-government organization) opinions.

- i. What are the benefits that you/your constituency/your sector/your community obtains from the marine environment?
- ii. Can you tell me if you have noted changes in the recent years in the availability of these benefits? Can you tell me about any opportunities or challenges that have been encountered?
- iii. What do you think are the future challenges or opportunities for Mafia's communities/sectors etc in relation to the marine environment?
- iv. What are the socio-economic implications of COVID 19, and how might it change the way society benefits from the marine environment?
- v. Can you explain how you think that Mafia is prepared for these challenges or opportunities?
- vi. How might people change the way that they work with the marine environment going forward (short, medium, longer term) in response to changes? Do you see any potential synergies or conflicts that might emerge?

Appendix 2. Consent form



Dear Participant,

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation which will be written by me the interviewer, in partial fulfilment of the requirements for the degree of Master of Science in Maritime Affairs at the World Maritime University in Malmo, Sweden.

The topic of the Dissertation is Perception and livelihood vulnerability of coastal communities to changes in reef resource stressors, the case of Mafia Island Tanzania.

The information provided to me in this interview will be used for research purposes and the results will form part of a dissertation, which will be published online and made available to the public. Your personal information will not be published. You may withdraw from the research at any time, and your personal data will be immediately deleted.

Anonymised research data will be archived on a secure virtual drive linked to a World Maritime University email address. All the data will be deleted as soon as the degree is awarded.

Your participation in the interview is highly appreciated.

Student's name
Specialization
Email address

* * *

I consent to my personal data, as outlined above, being used for this study. I understand that all personal data relating to participants is held and processed in the strictest confidence, and will be deleted at the end of the researcher's enrolment.

Name:

Signature:

Date: