ASSESSMENT OF SOCIO-ECONOMIC VALUE OF THE SMALL PELAGIC FISHERY IN MAFIA ISLAND, TANZANIA

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ABSTRACT

Small pelagic fish species are important fisheries resources for food and have valuable contribution in employment creation. The overall objective of this study was to assess the socioeconomic value of small pelagic fishery in Mafia Island. The fishery is artisanal and dominated by men. The dependents of the small pelagic fishery include fishers, fish processors, fish traders, fish transporters, fish carriers, boat builders, and net repairers. They all make contribution to the value chain. The main fishing gear for targeting small pelagic are purse seine and ring nets. The main targeted species are sardine and mackerel. Motorised fishing vessel are mostly used to target sardine while non-motorised target mackerel. Motorised vessels get more catch per day than non-motorised ones, but they have high production cost. Large vessels >10 meters are characterised by having a high number of crew on board. Fishers using small vessels < 6 meters are generating more profit to take home than crew in large vessels (> 10 meters). The benefit for boat owners is much high than the benefits for crew. Therefore, the use of vessel with low production cost is encouraged to fishers, for more profit generation. To ensure application of ecosystem approach to fisheries management in the small pelagic fishery, there is a need for capacity building for fishers and other stakeholders on Fisheries Act and Regulations, fish hygiene and good manufacturing practices, resources management, record keeping and savings. This will help to raise awareness of sustainable fisheries, adequate food security, and poverty reduction.

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LIST OF ABBREVIATIONS

DRC	Democratic Republic of Congo
DHA	Docosahexaenoic Acid
EPA	Eicosapentaenoic Acid
FAO	Food and Agriculture Organisation
FRD	Fisheries Resource Development
FSD	Fisheries Division
IUU	Illegal, Unreported and Unregulated
MALF	Ministry of Agriculture, Livestock and Fisheries
MALF	Ministry of Agriculture, Livestock and Fisheries
NE	North East
SE	South East
SWIOFish	South West Indian Ocean Fisheries Governance and Shared Growth Project
TBS	Tanzania Bureau of Statistics
MLF	Ministry of Livestock and Fisheries Development
FRD	Fisheries Resource Development
LVFO	Lake Victoria Fisheries Organisation
MACEMP	Marine and Coastal Environmental Management Project
RUMAKI	Rufiji and Mafia and Kilwa

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1 INTRODUCTION

Marine resources are critical to Tanzania's economic and social development. The resources support the livelihoods of the coastal communities who depend on them for food and income. However, there are indicators that these resources are being degraded resulting in loss of income among the resource users. Rapid increase in human population alongside lack of appropriate economic development plans have resulted in poor management and utilization of marine resources. This has resulted in local communities exploiting the resources without due regard to sustainability. This is further compounded by lack of alternative income earning opportunities in the coastal areas. Marine resources have also been overexploited using destructive fishing gears and methods (MLFD, 2012).

Livelihoods of the coastal communities in Tanzania are characterized by extreme poverty with low per capita income of less than US$100, large families, and high illiteracy levels (URT, 2005). They depend mainly on artisanal fishing, seaweed farming, livestock husbandry, petty trade, small holder farming as well as lime and salt production.

Most of the coastal communities depend on fishing for their livelihood underscoring the need for sustainable utilization of the fishery resources as a way of securing their future. It is in view of this that the Government of the United Republic of Tanzania in 2015 initiated the Management Plan for the artisanal fishers targeting small and medium pelagic fish. The management plan is supported by the World Bank project known as South West Indian Ocean Fisheries Governance and shared growth Project (SWIOFish) with the intention to strengthen the capacity to sustainably manage marine and fisheries resources. One of the project objectives is to empower coastal communities to develop and improve their social wellbeing.

This project also aims to support artisanal fishers (fisher folk) to improve fishing gear and vessels as well as engage in alternative income generating activities which integrate conservation with improved livelihood in coastal areas to reduce poverty and vulnerability.

1.1 Overview of Tanzania

Tanzania is a coastal state on the western Indian Ocean situated in the eastern part of Africa (Figure 1). It is richly endowed with natural water bodies and fisheries play an important role as a basis for subsistence and commercial livelihood (FAO, 2002).

The population of Tanzania was estimated at 44 million in July 2012 (NBS, 2012), The country's economy depends heavily on agriculture which accounts for more than 25% of the GDP. Industries traditionally featured are the processing of food and other agricultural products. Within the food processing industry, fisheries are the most important sub-sector.

Figure 1: Tanzania Map

1.2 Overview of Tanzania fisheries

Tanzania fisheries resources are of considerable economic and social importance, and fisheries contributes around 2.5% to the National GDP (MALF, 2015). The fisheries are the main source of protein to nearly one third of the country's population (FRD, 2015) and provide livelihoods to a substantial number of people. According to the 2016 marine fisheries frame survey, about 54,000 people were employed as full-time fishers (MALF, 2016), while more than 500,000 coastal habitants derive their economic livelihood from fisheries related activities such as boat building, net mending, processing and marketing (FSD, 2014a). Fishing is also a source of recreation, tourism, and foreign exchange. Fish and fishery products contribute around 30% to the total animal protein intake in the country (MALF, 2015b).

The Tanzania fishing industry is divided into the artisanal (small scale) and commercial/ industrial (large scale) fisheries. Artisanal operates in shore and operates under the management of fisheries division while industrial operates in deep sea under the management of Deep Sea Fishing Authority. The artisanal fishery in Tanzania is the most important fishery as it lands most of the inland and the marine catches and contributes about 98% of total landings. In terms of output value and employment, artisanal fisheries are much more important than industrial fisheries. Historically, artisanal fisheries have provided the economic base for the majority of fisherman in Tanzania.

The capture fishery of Tanzania is divided into two components, freshwater and marine water. Fisheries in freshwater are carried out in the major lakes (Moshy *et al.* 2013), the minor lakes, dams, and rivers. Both Freshwater and marine fishery is dominated by artisanal fishers who use small boats of between 7 to 11 m long, mainly motorized by outboard engines and a few with inboard engines. Other crafts used include dugout canoes and dhows (Sobo, 2006).

1.3 Coastal fisheries

Tanzania's marine coastline extends 1,424 km from latitude 4º49'S at the border with Kenya at Jasini landing site to the border with Mozambique at latitude 10º28'S at Bahasha landing site. Fishers are limited to inshore area as they lack suitable vessels and gear to fish offshore. The inshore marine fishery is extremely important to coastal communities in Tanzania. Most of the fishing is conducted by poor, artisanal fishers, often from coastal areas with marginal soil productivity and with few economic alternatives. The importance and impact of the fishing extends beyond full-time fishers; therefore, a collapse of the fishery would not only affect the fishermen but a whole group of people who are dependent on it. Among the fish stocks caught by these fishers are small pelagic species which consists primarily of sardine, small tuna and mackerel. These are mainly caught by purse seines or ring nets.

1.4 Overview of Tanzania marine small pelagic fishery

The small marine pelagic fish species fall under three families, namely *Clupidae* (14 species), Engraulidae (9 species) and *Scrombridae* (1 species) (Bianchi, 1985).

The most common fishing gears used are purse seines, ring nets, the illegal beach seines, scoop nets, and cast nets. Fishing is carried out in groups of 5 up to 15 fishers. Fishers sell fish to fishmongers at the landing sites either directly or through auctioning. Fishmonger then sell fresh fish directly to consumers.

Fried sardines and mackerel are sold at the local and national level in Tanzania. However, sun dried sardines are sold in the local markets and some find their way to the regional markets in the Democratic Republic of Congo (DRC), Zambia, Rwanda, Burundi, Malawi and some frozen mackerel is also exported to Kenya and Uganda (MALF, 2015).

The government has conducted stock assessment on other types of fisheries such as the prawn fishery in 2015 but no such assessment has been conducted on small pelagic fish species. Although information on the biomass of the stocks is not easily accessible, it is generally considered that there is still some room for increasing the landings without jeopardizing their sustainability. Fishers have not observed a decline in small pelagic catches over the years (FSD, 2014b). Small pelagic fisheries contribute 22 percent of total artisanal landings (MALF, 2015). Improved management of small pelagic and research work are required to confirm the reality of the status of small pelagic species.

1.5 Management of pelagic fisheries in Tanzania marine waters

The management of artisanal pelagic fisheries has relied on conventional methods where human activities are managed in a way that maximizes fisheries production, economic benefits, employment and national revenues (FSD, 2015). Currently there is the broader effect to fisheries stocks and the environment caused by fishing and other human activities (FSD, 2015).

In response, Tanzania Mainland, in collaboration with FAO is implementing an Ecosystem Approach to Fisheries Management which include small pelagic stocks. Management plan is supported by a World Bank project known as South West Indian Ocean Fisheries Governance and Shared Growth Program (SWIOFish). The main objective of the SWIOFish project is to improve management effectiveness of selected priority fisheries at the national and

community level. The project also aims to change the social life and improve economic benefits to fishing communities.

1.6 Problem statement

The Government of Tanzania continues to give high priority to the development of the small pelagic fishery because it is not only a source of revenue and foreign exchange earnings for the country but also an opportunity for increasing employment, improving nutritional dietary intake of the citizenry, alleviation of poverty and ensuring adequate food security.

Fish are susceptible to overexploitation, leading in biological, social and economic loss. To minimize the risk of intervention failure, fisheries planners, researchers and administrators need biological, social and economic information, especially when setting realistic goals and in determining their associated technical and socio-economic scale of intervention.

Even though the issue of fisheries resources has been widely researched in Mafia, limited research has been carried out on the small pelagic fishery. There is the lack of economic and social information on the aspect of marine small pelagic fisheries in Tanzania (FSD, 2014b). For the purpose of planning and development of small pelagic fisheries resources, information on socio-economic value of small pelagic fishery is needed.

1.7 Significance of the study

This study will contribute to the body of knowledge about the socio-economic value of small pelagic fisheries and the results obtained will help other researchers, policy makers, fisheries resources managers and other stakeholders to develop appropriate fisheries resource management options. It will also enable small pelagic artisanal fishers to understand the returns of their investment and to guide their decisions on where to allocate resources (human, financial etc.). It will also provide the baseline information for comparison in future studies.

1.8 Study area

Mafia is one of the sixteen districts that form the Coast Region of Tanzania having a total population of 46 thousand (TBS, 2012). Mafia Island and its chain of small islets lie approximately 120 km south of Dar es Salaam and 20 km offshore from the eastern extent of the Rufiji Delta (Figure 2). Rufiji is one of the largest delta systems in Africa.

The main island of Mafia is about 48 km long and 17 km wide at its widest point. Several smaller islands and islets are scattered to the west and south. Agricultural crops, such as cashew nuts, coconuts, paddy, fruits and vegetables are cultivated. Together with captured fish, some are transported and sold in the Dar es Salaam market through Nyamisati in the Rufiji delta. Most of the people in Mafia are poor subsistence farmers, of the coastal Swahili culture with strong religious and family ties.

Figure 2: Mafia Island map

Mafia Island is known for marine biodiversity, with about 350 species of fish including small pelagic species (Sobo, 2015) Fishing is an important economic activity engaging most local people in Mafia. Mafia is considered throughout coastal Tanzania as a premier fishing ground and has attracted fishers from other parts of the country, at least since the 1960s when fishing first became a significant activity amongst residents. The decline of fisheries in near-shore areas throughout the Tanzanian mainland has led to an influx of fishermen from other parts of Tanzania. The influx of fishermen from outside Mafia has caused conflicts within villages in Mafia. Since most coastal communities in Tanzania share common characteristics, it is believed that findings from this study will shed light of what is happening in other marine coastal communities in Tanzania.

1.9 Social and economic dynamics of small pelagic fishing activities in Mafia

Small pelagic fishery is known to harbour immigrant fishers. For example fishers from Zanzibar acquire temporary residence in Mafia and do participate in the sardine fishery. This has resulted in intermarriages with Mafia residents. Migrant fishers are known to be more efficient at fishing, netting greater sardine catches and are thus economically more powerful than resident fishers. This greater economic power allows migrant fishers to marry residents and influence decision-making in fisheries management at the local level (Haule, 2015).

The small pelagic fishery is threatened by dynamiters, where the main target are fishes other than sardines. In the aftermath of the explosion, blast fishing or dynamite fishing is the practice of using explosives to stun or kill schools of fish for easy collection. This illegal practice can be extremely destructive to the surrounding ecosystem, as the explosion often destroys the underlying habitat (such as coral reefs) that supports the fish. Sardines are not collected by the dynamite users because sardines do not fetch good price compared to mackerels.

Before the 1980s, fisheries exploitation in Mafia was low. Families rather than individuals formed the central units of society. Emphasis was given to reciprocal rather than individual resource accumulation, and this was manifested in social events such as weddings and other traditional events where food was collectively distributed, including marine small pelagic fish products. Individual and family fishing occurred on a daily basis, and villages sometimes organized groups that moved to other areas beyond village areas of jurisdiction to fish for certain species.

Resource management in villages fell under customary rules, that did not allow individual usage rights. Noted that, perceived changes in the fisheries, particularly a decline in the fish catch and the loss of important species, placed fishing pressure upon these social structures. The decline of catch atracted costal community to increase unwanted fishing gear and method for the purpose of increasing individual benefit (Katikiro *et al.* 2014).

1.10 Objectives of the Study

The overall objective of this study is to conduct assessment of the socio-economic value of the small pelagic fishery to the local coastal community in Mafia Island.

Specific Objectives

- To define and describe the -artisanal small pelagic fishery
- To assess the number of dependents of secondary small pelagic employment activities in Mafia Island
- To assess the cost and net benefit gained from small pelagic fishing
- To identify and advise on improvement of the artisanal pelagic fishery in Mafia

2 LITERATURE REVIEW

2.1 Habitat of pelagic fish

By definition, pelagic fish live in the pelagic domain, that is, they move freely in the water-column where they spend most of their time. Most of the small pelagic fish species are epipelagic, that is, they live in the uppermost layer of the ocean, usually at depths of 0–200 m, although the limit of the deeper boundary varies according to the species and region. For instance, many medium-sized pelagic fish are found in a wider range of depths, typically from the surface to 500 m.

The view that pelagic fish are remote from the sea floor is largely incorrect. Firstly, a minority of pelagic species, lay adhesive eggs on the bottom (Fréon *et al.*, 2005). Secondly, many pelagic species, especially medium-sized ones, are frequently found close to the bottom during (daytime and are therefore vulnerable to semi-pelagic fishing gear and even to bottom trawls). Some of these species (e.g. horse-mackerel and mackerel) feed on or near the bottom, but for others, like the gilt sardine *S. aurita*, only the sediment found in their stomachs testifies to their bottom activity and suggests that they might make use of the bacterial film (Nieland, 1982).

2.2 Morphology of small pelagic

Small pelagic fish are characterized by a streamlined body shape (fusiform and laterally compressed) and forked caudal fin. These characteristics make them good and fast swimmers, despite their small size. Another typical phenotypic trait of coastal pelagic fish is their discrete coloration, ranging from dark grey to silver. The flanks are usually highly reflective and the dorsal surface dark in order to render the fish inconspicuous to predators: light is reflected in such a way that it matches the background light against which the fish is viewed (Blaxter and Hunter, 1982).

The body of most small pelagic fish species is fragile, comprised of soft tissue and a thin skin. Physical protection is provided by small scales that cover nearly the whole body in most species, and by the mucus produced by their skin. Scales and mucus are easily lost by manipulation or contact with fishing gears, leaving the thin skin exposed to wound infection by bacteria, fungal diseases, or external parasites. Small pelagic species are extremely frail, subjected to unexpectedly large mortality occurring during the catch process; most of the small pelagic fish that come into contact with fishing gear but escape it, or make close contact with other fish during fishing, are likely to die (Beltestand and Misund, 1996). Furthermore, when excess catch, or when non-target-species or sizes are caught, fish are dumped, and most, if not all, die. These additional sources of mortality are usually not reported by fishers and are difficult to estimate (Fréon *et al.*, 2005).

2.3 Nutritional value of small pelagic fish species

Fish, especially small pelagic species, are an excellent source of high-quality animal protein. The high content of lysine and other essential amino acids makes these species a suitable complement to carbohydrate-rich diets that are consumed in places where protein sources are limited, such as in most developing countries (Sánchez and Gallo, 2009). These resources are a valuable source of energy and are very rich in micronutrients not usually found in basic foods. In addition to being high in potassium, iron, phosphorus and calcium, the fatty component of fish contains significant amounts of vitamins A and D. Fish also constitute a valuable source of fatty acids, which are very important for proper development of the brain and body (Sánchez and Gallo, 2009).

Pelagic fish are high in the polyunsaturated fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The consumption of which yields many benefits in terms of human physiology, including a significant decrease in blood cholesterol levels and prevention of cardiovascular disease. The consumption of small quantities of these species of fish associated with basic foods can significantly improve the nutritional value of the food and the biological value of the diet, particularly in the case of children who have difficulty in digesting carbohydrates (Sánchez and Gallo, 2009).

3 RESEARCH METHODOLOGY

3.1 Data collections

A literature review was done to acquire the necessary information and secondary data were extracted from different articles (reports and journals) related to the topic of study. Data about production cost of different fishing units were collected from small pelagic fisher in Mafia through structured questionnaires. Information on fish processing and trading cost were collected through consultation with processors and traders. Other information was obtained from the previous research report carried out in Mafia. Other information was extracted from the following sources described below.

3.1.1 Tanzania marine catch assessment data base

CAS Database like others is used to store fisheries information and organize it into practical forms and software applications giving the user great flexibility with the data. Data on both frame surveys and catch assessment surveys are entered into the database. The database interface provides users with features to organize their information simply and specifically and gives the ability to modify templates to personalize them for specific purposes.

The collected catch data and frame survey are used to estimate the total fish production obtained from artisanal fishing. The data collected are entered in the installed database in 5 coastal districts, which belong to 5 administrative regions. This is to reduce heavy workload for Fisheries Division headquarters. The districts have an option to validate the data locally monthly, with flexibility as far as fisheries statistics is concerned.

3.1.2 Frame survey reports

Frame survey is an inventory of fish producing factors such as number of landing sites, number of fishermen, number of fishing vessels and gears by type and size. It is also a description of fishing and landing activity patterns, processing and marketing patterns, as well as describing supply centers for goods and services. The frame survey is also referred to as fisheries census, which means the fishing effort is obtained by complete total enumeration (Cowx *et al.* 2003). For responsible fisheries management, evaluation of fishing capacity and analysis of fisheries information must be known and monitored. Therefore, fisheries frame surveys are used to generate important information required both for management planning purposes and for helping design catch assessment surveys by providing the sampling frame. Frame survey data can also be used to study fishing and gear use patterns, which could potentially be used to study the socio-economics of a community (FAO, 2002).

3.1.3 Catch assessment survey reports

These are surveys of landings, which are conducted at selected landing sites. The collected information includes data on catch, species composition, associated effort, and other secondary data such as prices, weight of fish, and number of fish caught for bigger fish. In Tanzania, catch and effort data are collected on sampling basis. The primary sampling unit is the landing site of which few landing sites are randomly selected from a frame survey list. In marine waters, there are 22 landing sites where CAS data are collected daily out of 259 landing sites that were recorded during the 2005 frame survey. The secondary sampling unit is the day, which are also selected randomly. The data are collected for 10 days per month.

3.2 Data Analysis and Method

Descriptive statistics were used to describe small pelagic fishery and in identification of dependents of small pelagic secondary activities.

For cost of production, simulation Model were used to run the analysis. Data collected within fish landing sites was entered into Excel, then analyzed using Statistical Analysis System (SAS) software. More elaborate statistical analyses of variable relationships were done for selected data, mainly using cross tabulations.

3.2.1 Regression analysis of primary data

Regression analysis was used to determine the relationship among the variables, using the relationship between catch as the dependent variable and effort, such as type of fishing vessel and number of fishers, as independent variable.

Analyses were carried out to determine whether there was any significant variation in the catch landed by different fishing units, and the production cost within the study area. Also, to determine the significant variation between production cost of different fishing units and fishers.

The estimated catch, cost, revenue, and profit of each fishing vessel categories was calculated using the model below (Table 16 and 17).

$$catch_i = a_i + b_i n_i + u_i$$
$$cost_i = \alpha_i + \beta_i n_i + e_i$$

where n_i is the number of fishermen aboard vessel i, a_i is the estimated intercept of catch for vessel type i, b_i is the effect of the number of fishers per vessel on catch and u_i is a stochastic residual. Similarly, α is the estimated intercept of cost for vessel type i, β_i is the effect of the number of fishers per vessel on cost and e_i is the residual.

4 DESCRIPTION OF SMALL PELAGIC FISHERY IN MAFIA

4.1 Small pelagic fishery

Small pelagic fishery in Tanzania are normally operated by traditional fishers involving fishing households, using relatively small amounts of capital and energy, relatively small fishing vessels, making short fishing trips close to shore using the catch mainly for local consumptions but can also be of commercial nature. In Tanzania small pelagic fisheries can be of subsistence or commercial nature, providing for local consumption or export to regional market. They are sometimes also referred to as small-scale fisheries (MALF, 2014).

4.2 Social structure

Social structure is defined as the patterned relationships that persist between people over time. Behaviours and attitudes are determined by our place in the social structure. Components of social structure are culture, social class, social status, roles, groups and institutions (Henslin,

1993**)**. Culture refers to a group's language, beliefs, values, behaviours, and gestures. It includes the material objects used by a group. It determines what kind of people we will become. Social class is based on income, education, and occupational prestige. Large numbers of people who have similar income and education and who work at jobs that are roughly comparable in prestige make up a social class. Social value refers to the positions that an individual occupies (Henslin, 1993).

The importance of small pelagic fisheries in coastal communities as a source of food and economic activity makes it a major determinant of social structure. Key actors are the fishers, mainly men in the formal fishing sectors while women play a prominent role in the processing and marketing of fish (Jiddawi and Öhman, 2002).

4.3 Fishing effort in Mafia

4.3.1 Number and type of fishers

According to Tanzania fisheries database there are 5764 artisanal fishers in Mafia island. About 600 are engaged in small pelagic which comprises 10% of all fishers on Island. Mostly (96%) are male.

Fishers in Mafia are grouped into two groups, owners and crew. The number of craft owner in Mafia is 1,733 which is equivalent to 30%, while the total number of crew are 4,031 which is equivalent to 70% of all fishers. Most of the craft owners are male (96%). No women fishers in Mafia target small pelagic fish, but most are involved in small pelagic fishing processing activities.

The trends of fishers in Mafia from 2005 to 2016 indicates the fluctuation, increase and decrease of fishers on the Island (Table 1).

Table 1: Trend of fishers in Mafia Island

Year	Total fishers	Small pelagic fishers	Migrant fisher
2005	4,551	465	1,100
2007	5,734	599	1,359
2009	4,200	332	160
2016	5,797	596	749

Immigrant fishers

Immigrant/seasonal fishers in Mafia locally known as '*dago'* indicated that, the dago activity is strongly influenced by the monsoon winds which are seasonally reversing winds. These are the North-East (NE) monsoon locally known as ''Kaskazi'' which prevails from October to April and the other is the South-East (SE) monsoon locally known as ''Kusi'' which prevails from May to September. The Catch of small pelagic are always high during north east monsoon. The NE monsoon is normally characterized by high air temperatures and low winds

with relatively calm seas while the SE monsoon is characterized by strong winds. The total number of immigrant/seasonal fishers counted during the 2016 frame survey were 749. The number of immigrant/seasonal fishers during the NE-Monsoon 503 (67.1%), which outweigh the number of immigrant/seasonal fishers during SE Monsoon 246 (32.8%) (Table 2).

Table 2: Migrant fishers in Mafia Island with seasons

SE-Monsoon	NE-Monsoon
May- September.	**October - April**
246	503

(Source: Frame survey, 2016 report)

Age structure of fishers in Mafia

Age structure of people who engage in fishing activities in Mafia, are dominated by men of age class 19 - 45 years, while fishers above the age of 45 years and below 18 years are not commonly engaged because the activity is tedious and needs young, energetic and strong people, whereas children and elderly people may not be able to participate fully because they cannot manage manual fishing operations and overcome any unforeseen disasters.

4.3.2 Number and type of fishing vessels

In 2016, there were 1064 fishing vessels in Mafia. Dugout canoe (70%), boat with outboard engine (12%), planked canoe (3%), outrigger canoe (11%), and dhow (4%). The size of fishing vessel varies from >5 meters (82%), 6-10 (17%) and >10 meters (2%). Most of the vessels targeting small pelagic fisheries are boat using outboard engine, dugout canoe, and dhow, But the most available fishing vessel in Mafia are dugout canoe sized <5 meters (Figure 3).

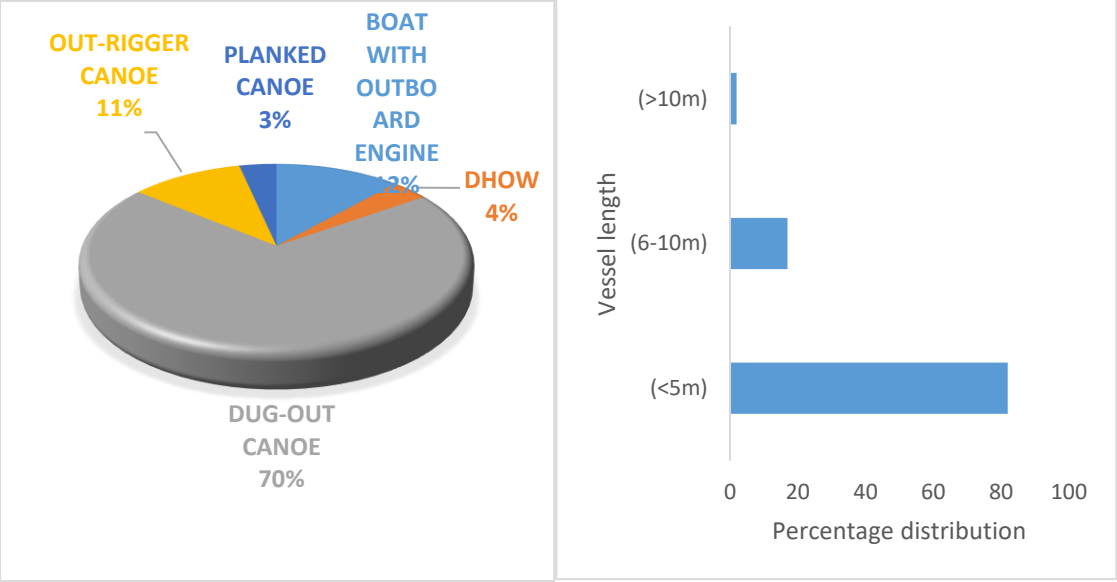

Figure 3: Vessel distribution and size in Mafia (Source: Tanzania marine CAS data base).

Fishing vessel propulsion

Most of the fishing vessels in Mafia island use paddles as a means of propulsion, approximately 63%, where the second most common means of propulsion is sails, approximately 21% followed by outboard engines, approximately 13% in which most are used in sardine fishing (Figure 4).

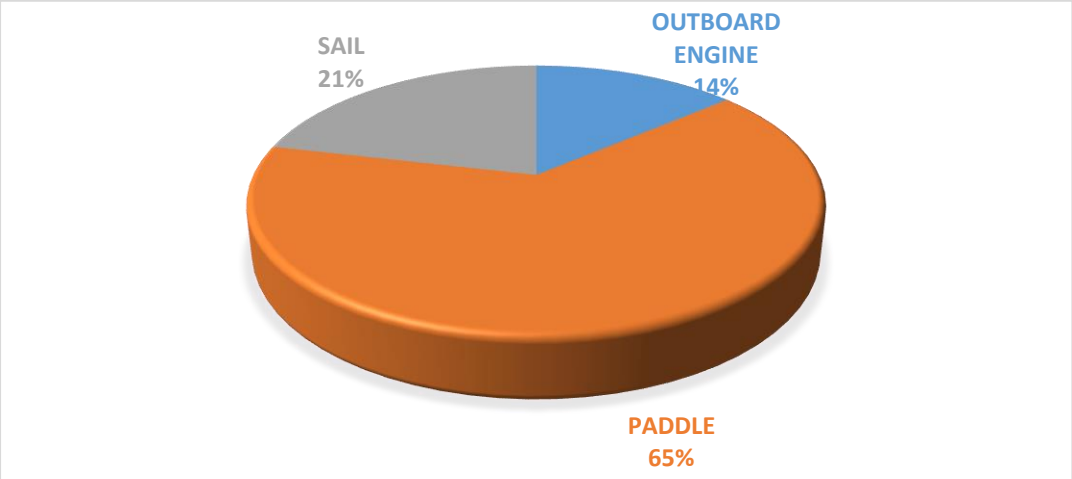

Figure 4: Fishing vessel propulsion in Mafia (Source Tanzania marine CAS data base)

Vessel targeting small pelagic fisheries in Mafia

Small pelagic fish in mafia is mostly targeted by boat using outboard engine, dugout canoe, and dhow.

Boats using outboard engines

Such boats are constructed from several planks, bottom is V or U shaped with a keel, size ranges between 7 to 9 m, and is propelled by an engine (Figure 5). The main gear used are purse sine net mainly for inshore waters.

Figure 5 : Boat using outboard engine

Dugout canoe

Dugout canoes locally known as “Mtumbwi” are constructed from the long tree baobab, mango tree or any large tree. The size of dugout canoe ranges from 3 to 5 meters, always propelled by using paddle, and mainly used in inshore waters. The most common gears used are seine nets, gill nets, basket traps and scoop nets (Figure 6).

Figure 6: Dugout canoe

Dhow

Dhow are locally known as “Dau” is a wooden planked boat with pointed bow and rounded stern, usually propelled by sail having one or more masts. Both ends are pointed (no transom). They are normally used for transport but sometimes can be used for fishing (Figure 7).

Figure 7: Dhow

Number of fishing vessel in Mafia across different years

Total number of fishing vessel and the vessel targeting small pelagic in Mafia from 2005, 2007, 2009 and 2016 shows fluctuation. The frame survey conducted in 2016 indicated an increase of in 1% in total vessels and a 33% increase in small pelagic in Mafia (Table 3).

Table 3: Number of vessel across different years in Mafia

Year	Total vessel	Small pelagic vessels
2005	1228	38
2007	1263	39
2009	965	30
2016	1064	33

4.3.3 Number and type of fishing gear

The number of gear targeting small pelagic in Mafia are 31 (Frame survey, 2016), mostly being purse seine nets 25 (81%), beach seines 3 (10%), ring nets 2 (6%), and lift nets 1 (3%) (Figure 8).

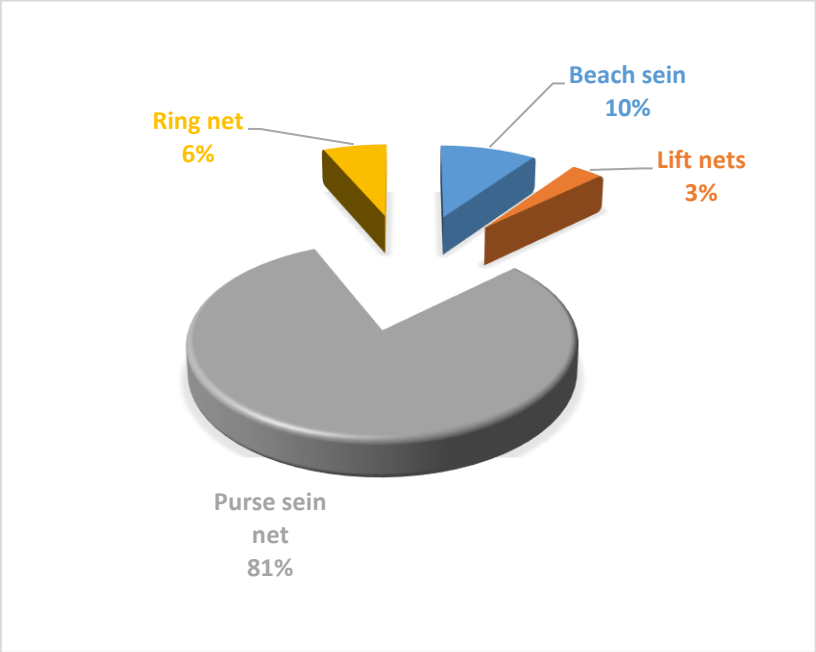

Figure 8: Gear targeting small pelagic in Mafia

Gear operations

Fishing is undertaken at night, on fish concentrated around lighted dinghies, using purse seines and to a lesser extent scoop nets. The dimensions of the purse seines used from the traditional boats sized >10 meters are 100 m to 150 m in length and about 15 m deep. These latter boats are each supported by a net-boat (3-5 m length) and lamp dinghies. In the case of all the boats, the hauling of the purse seine nets is done by hand. Ring net is simply a surrounding net, used to surround a shoal of small pelagic fish. These gears are operated either by sail or out board engine boats. The number of crew in the vessel sometimes depend on the size of fishing gear used e.g. purse seine net of 150 meters long and 15 widths is operated by15 to 20 crew.

4.3.4 Catch

The total fish production from artisanal fishers in Mafia was 3,182 metric tonnes in 2015 with 974 metric tonnes caught from small pelagic fisheries (31% of the total fish production). Fish production has remained relatively stable over the last six years as has the proportion of small pelagics (Table 4).

Table 4: Trend of total fish catch and small pelagic in Mafia Island

Year	Total fish production in metric tonnes	Small Pelagic production in metric tonnes
2009	4,563	999
2010	3,380	976
2011	3,246	937
2012	3,213	927
2013	3,391	979
2014	3,326	972
2015	3,182	974

The bulk of the caught small pelagic catch in Mafia is made up of (*Sardinela neglecta* (dagaa)) and (*Rastrelliger kanagurta* (indian mackerel)) locally known as vibua. The catch landed from the traditional boats are recorded within the official statistics as part of the artisanal catches. Sardine and mackerel contribute significantly to food security, income, and employment, as well as the integration of the fisheries sector into the economy. Mackerel are most caught while sardine have slender input but overall small proportion (Table 5).

Table 5: Trend of Sardine and mackerel caught in Mafia in Metric tonnes

Year	Sardine (metric tonne)	Mackerel (metric tonne)	Total small pelagic catch (metric tonne)
2010	33	943	976
2011	32	905	937
2012	31	896	927
2013	33	946	979
2014	30	942	972
2015	35	939	974

(Source: Annual fisheries Statistic reports)

Seasonality in the small pelagic fishes

The catch of small pelagic are always high during north east monsoon, October to April, and low during the south-east monsoon, May to September (Figure 9).

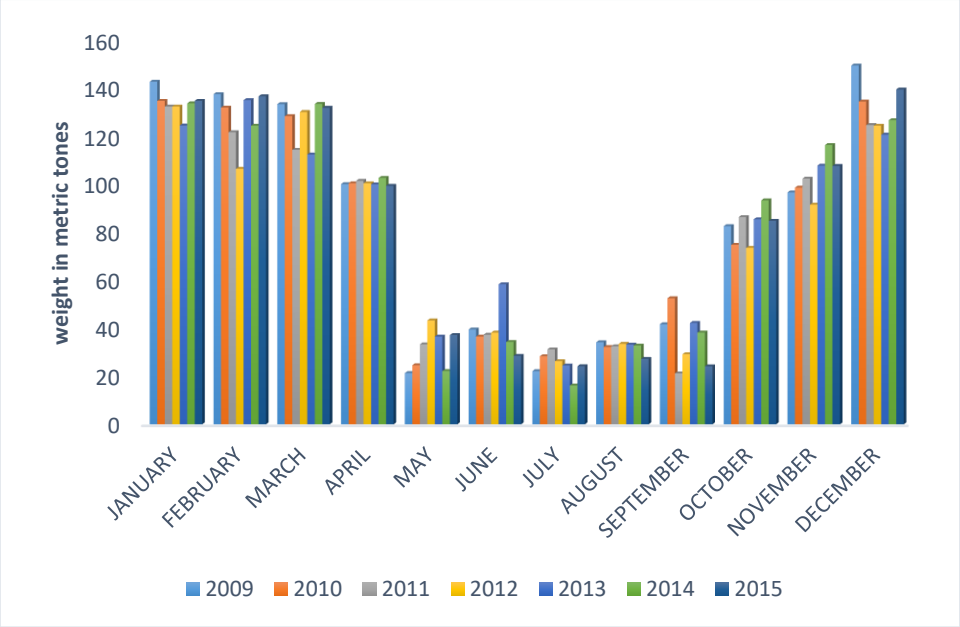

Figure 9: Trend of small pelagic catch by month and years in Mafia (Source: Annual fisheries statistics

5 DEPENDANCE OF SECONDARY ACTIVITIES RELATED TO SMALL PELAGIC IN MAFIA

5.1 Number of dependent of small pelagic fishing related activities

Fisheries provide employment and livelihoods to a substantial number of people in Mafia. In this study, the term livelihoods refer to activities, assets, capabilities and strategies required and employed by fishing communities in satisfying fundamental needs of a household. Livelihoods are about how actors can mobilize their capital assets and capabilities to achieve wellbeing. Number of fisheries derived jobs from the small pelagic fisheries include fish traders 240 (26%) fish processors 282 (30%), fish carriers 78 (8%), boat builders 78(8%), net repairers 59(6%), fish transporters 212(22%), and fish traders making a total of 958 (Figure 10).

Engagement in small pelagic fisheries is of vital socio-economic importance to the people in Mafia. Fish processors spend about 10 hours per day and 5 days a week in small pelagic fish processing activities. The average fishers have 5 members in household, which means that the income accrued from the sector cannot be ignored. Thus, any negative impact to small pelagic fishery would, therefore, threaten the livelihood of Mafia communities.

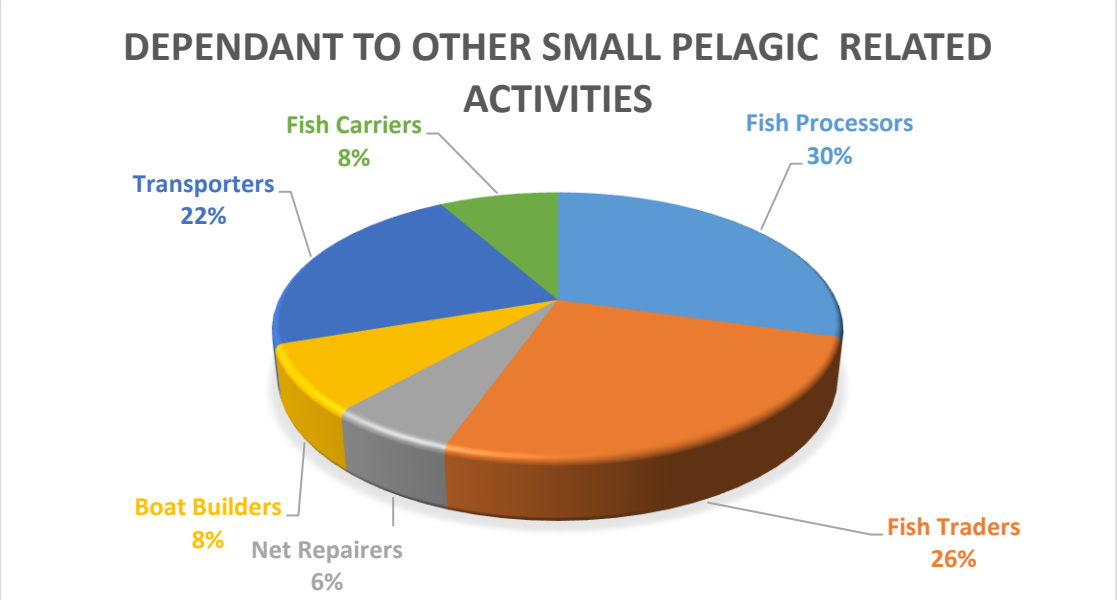

Figure 10: Dependants of secondary activities related to small pelagic (Source: Tanzania Marine CAS data base)

5.2 Contribution of beneficiaries to value chain

The value chain consists of different key players such as fishers, fish carriers, processors, traders, transporters, distributors, retailers and consumers. They play big roles in social and economic dynamics in post-harvest activities. The marketing of small pelagic particularly sardine and mackerel is based on the local markets, national, and regional markets (Mosha, 2014).

With regards to supply chain of small pelagic fish, such as dried sardines and mackerel some major channels were identified and can be defined as the intermediaries in supply chain.

5.2.1 Fishers

Firstly, fishermen harvest the mackerel and sardines from the sea. Fishing is based on light attraction using artificial light (pressure lamps) during the dark periods of the month. The number of fishing days per month ranges from 18 to 20 days depending on the lunar cycle. Fishing duration varies but is normally from 4 to 10 hours. The catch is stored in the vessel hatches and on arrival at the landing site are removed from the hatches in baskets (Figure 11) ready for sale.

Figure 11: Baskets for carrying fish

The cost of investment in fishing activities in small pelagic was divided into two major categories, operational and fixed cost (Table 6). The operational costs of inputs are directly influenced by the quantity of fish caught per day such as fuel, food, repair and maintenance, licences and ice cost. Fixed costs are related to investments in a boat, fishing gear and other equipment. The cost of operation for the fishermen depends on the type of craft and the size. Small pelagic fishing boats are individually owned with very few which are group owned and the cost of production are mostly incurred by boat owners.

Table 6: Estimated cost for fishing small pelagic fishery by motorised vessel

	Unit Cost (Tsh)	Annual Depreciation	Cost per Kgs (Tsh) per fishing day	% of total cost
FISHING				
Investment cost				
Boat	12,000,000	2,400,000	71.53	34
Engine	9,000,000	1,800,000	53.65	25
Fishing Gear	12,000,000	12,000,000	71.53	34
Other Equipment	1,500,000	1,500,000	8.94	4.26
Total	**34,500,000**		**206**	97
Operating cost				
Fuel	150,000		160.94	0.5
Crew food	300,000		321.89	0.85
repair and maintenance	150,000		160.94	0.5
Spare parts	70,000		75.11	0.2
license and landing taxes	30,000		32.19	0.08
Total	**700,000**		**751**	2
GRAND TOTAL COST			**957**	100

5.2.2 Fish processors

There are 282 fish processors in Mafia (Frame survey, 2016). Women play a role in fish processing, small pelagic fish such as sardine and mackerel are processed by frying, direct sun dried, salted and boiled in sea water prior to direct sun drying while others use fire for drying. Drying is carried out using the traditional racks (Figure 24), on sheets, on sand and surrounding fire. Drying on the ground results on high post-harvest loss especially during the rainy seasons and the processor are challenged to dry the catch in a timely fashion. The quality of sardine is heavily degraded if it rains before the drying processing completed. According to Mafia fisheries officer, several trainning activities have been conducted on quality and handling aspect and on fish processing methos. As the result most processors start using racks intead of drying into the ground on sand. Fried mackerel and sardine are for home consumption and street side sales. Fish Processors at Kilindoni landing site in Mafia, make an average income of 20,500 with minimum of 5,000 and maximum of 80,000 TZS per day. The method used for drying fish are illustrated in Figure 12, 13 and 14.

Figure 12: Small pelagic drying racks in Mafia

Figure 13: Fish processor with sardine boiling charcoal at Kilindoni landing site in Mafia

Figure 14: Sardine dried on sheets and surrounding fire at Kilindoni landing site in Mafia

The cost of fish processing for both direct sun-dried sardine and boiled sun dried varies, the cost for boiled sun dried is high than direct sun dried. Table 7 it illustrates the processing cost for both direct sun dried and boiled sun-dried sardine

Table 7: cost of processing sardine

	Unit Cost (Tsh)	Cost per Kgs sun dried Sardine (Tsh)	Cost per Kgs Boiled sun-dried Sardine (Tsh)
Wet fish value (at cost) (fishing)		956.72	956.72
Labour	1000	82.86	40
Rent Drying Racks	700	30	28
Bags/sucks	1500	9.37	7.89
salting and boiling (firewood)	600		25.72
		1038.97/30%	1058.34/30%
Total Cost (Tsh)		**3,463.22**	**3,527.80**

Market of small pelagic fish

Market of processed fried sardine, anchovy, and mackerel are found within Mafia district, but the sun-dried sardine and anchovy are sold in other Tanzanian fish markets, and other are transported to reginal markets such as Democratic Republic of Congo and Zambia. Fresh sardine is mostly transported to Ferry international fish market in Dar es Salaam.

Price for dried sardine fluctuate in response to supply and demand. Normally, the fish is sold in bulk in sacks that are not weighed. However, those selling to the local people for

consumption use two size of tins 1kg and 4 kg. 1kg of dried sardine cost at the price of 4000 Tshs. of dry dried sardine. One suck of the dried sardine is 160 kilograms. (Figures 15)

Figure 15: Already packed dried sardine for market at Kilindoni in Mafia

5.2.3 Fish transporters

Fish transporters distribute the fish within Mafia and from Mafia to various fish markets. Fresh sardine, however, is transported by male bicycle vendors to different areas where they are bought by consumers who prefer to process the fish themselves. The current number of fish transporters in Mafia is 212 (Frame survey, 2016). Processed products are transported from Mafia Island by using sailing vessels via Nyamisati and Kisiju landing sites, some to Kilwa Kivinje in Kilwa district, and to various other fish markets within and outside the country.

The transportation cost within Mafia differs according to quantities of fish to be transported, the distance covered, and is the matter of negotiation. The means of transportation within Mafia includes motorcycle (44), bicycle (37), car (16), bajaji (1), and foot (30) (Frame survey, 2016), but the means of transportation outside Mafia are boats (Figure 16), where the cost of transportation depends on the weight of the fish to be transported. Example cost of transporting one bag of dried sardines of 130kg - 150kg from Kilindoni Mafia to Kisiju is 5000 Tshs.

Figure 16: Dried Sardine Transportation at Kilindoni landing site in Mafia

5.2.4 Fish traders

Fish traders provide opportunities for fishermen who cannot afford to buy their own gear or vessels. They usually own gear (seine or gill nets) or vessels (dhows or boats with engines), which they rent to fishers. The money obtained from the catch is typically divided into three parts: for the owner, for boat and gear operation and maintenance, and for all fishermen on the boat, regardless how many they are. Traders then distribute the fish inland. According to fish traders, they can make an income of 5,000 to 70,000 Tshs per day.

Fish traders also play a role in the value chain product by buying the dried sardine from Mafia landing site at Kilindoni and distributing it to the internal and regional market such as Zambia and Democratic Republic of Congo.

The cost of operation for the traders/wholesaler were calculated based on the expenses incurred by the service providers in the supply chain (Table 8).

Table 8: Estimated cost for sardine trading

	Unit Cost (Tshs)	Cost per Kgs sun dried Sardine (Tshs)	Cost per Kgs Boiled sun-dried sardine (Tshs)
Purchasing at cost		3463	3528
Filling sucks	5,000	31	26
Loading levy	6,500	40	34
Government tax/fee (in)	10,000	62	53
Transport	25,000	156	132
Loading charges (export-Tunduma)	5,000	31	26
Tax charges Export-Tunduma border	5,000	31	26
Transport to regional market	25,050	463	464
Total Cost (Tsh)		**4280**	**4289**

5.2.5 Fish carriers

When the fishers land the fish at the landing site, the fish is carried out by the fish carriers up to the processing area or selling place using baskets locally known as (vikapu) (Figure 17). The payment cost is by negotiation between the middle man and the fish carriers but mostly depending on the weight of the fish to be carried and the distance to the processing area or market.

Figure 17: A Fish carrier at Kilindoni landing sites in Mafia

5.2.6 Boat builders

Boat builders in Mafia are local people who work together in the groups of three to five persons using traditional methods of construction by using simple tools like machete, trees, knifes, hammer and axe. The cost of construction depends on type of wood or tree to be used, type of vessels, and size. For example, the small dugout canoe (<5 meters) can cost up to 2,000,000

Tshs, while the large boat >10 meters can cost up to 12,000,000 Tshs. Figure 18 indicates the boat building area in mafia

Figure 18: Boat building area at Chole landing site in Mafia

According to Mafia fisheries officers, there are very little cash reserves in the value chain. Volumes are said to be too small and what ever profits are made often gets used for immediate domestic needs.The fish distribution channel starts from the fisher to small-scale processors/traders who in turn either sell to consumers directly or to wholesalers and the chain continues down to retailers and consumers (Figure 19).

Value chain of small pelagic fish

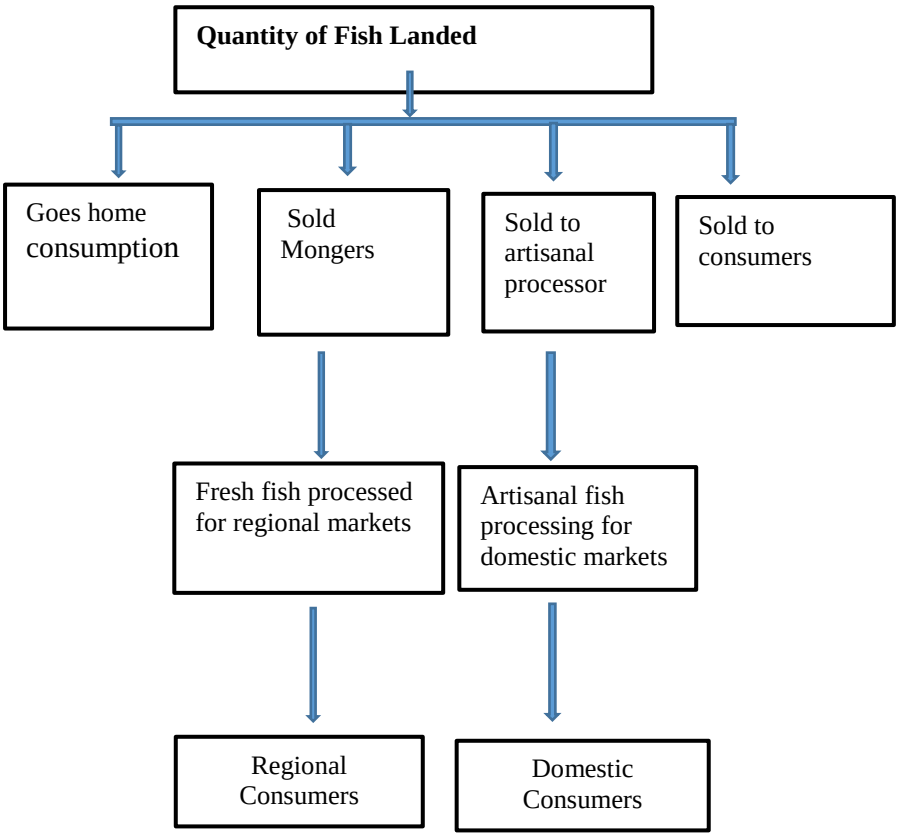

Figure 19: Small pelagic value chain

5.3 Benefits of direct sun-dried sardine and boiled and sun-dried sardine within the processing chain

5.3.1 Direct sun dried and boiled sun-dried sardine on sites

The profit distribution within the chain is the variation between the cost and revenue. The profit is the revenue after deducting all production cost. The wet landed sardine is sold at 957 Tsh per kg at the landing site, production cost for direct sun-dried sardine is estimated to be 3,463 Tsh per kg, and the indicating selling price after processing is 4,000 Tsh per kg. Therefore, the fish processor on site makes a profit of 537 Tsh per kg. In case of the dried boiled and sun-dried sardine, the fresh landed sardine is sold at 957 Tsh. The cost of processing dried boiled and sun-dried sardines is estimated to be 3,528 Tsh per kg, the indicated selling price after processing is 4,000 to 5,500 Tsh per kg, so the profit gained ranges from 472 to 1,972Tsh per kg.

5.3.2 Direct sun-dried and boiled sardine at the local market

Production cost for direct sun-dried sardine at the local market is estimated to be 3,463 Tsh, the indicated selling price after processing is 5,000 to 7,000 Tsh per kg, therefore, fish processors at the local market make the profit of 3,246 Tsh per kg. Boiled and sun-dried sardines processing cost is estimated to be 3,773 Tsh per kg and the indicated selling price is 6,000 to 8,000 Tsh per kg, so the profit gained by processors at the local market is estimated to be 2,226 to 4,228 Tsh per kg.

5.3.3 Direct sun dried and Boiled sun-dried sardine at regional markets

Production cost of direct sun-dried sardine at the local market is estimated to be 4,280 Tsh per kg. The indicated selling price after processing is 9,926 Tsh per kg, so the fish processor at the local regional market makes a profit of 5,646 Tsh per kg. Production cost of dried boiled and sun-dried sardine at the local market is estimated to be 4,289 Tsh per kg, the indicated selling price after processing is 10,824 Tsh per kg, so the fish processor at the regional market makes a profit of 6,534 Tsh per kg. Table 9 indicates the cost and benefit of direct sun-dried sardine and boiled sun-dried sardine within the value chain.

Table 9: Summary of cost and profit for direct sun dried and boiled sun-dried sardine.

	Direct sun-dried Sardines			Boiled and sun-dried sardines		
	Estimated Production Cost (Tsh/Kg)	Indicated Selling Price range (Tsh/Kg)	Profit per kg (Tsh)	Estimated Production Cost (Tsh/Kg)	Indicated Selling Price range (Tsh/Kg)	Profits per kg (Tsh)
Fresh landed sardine	957			957		
Dried sardine on site	3,463	4,000	537	3,528	4,000 to 5,500	472 to 1,972
Dried sardine local markets	3,754	7,000	3,246	3,773	6,000 to 8,000	2,226 to 4,228
Dried sardine regional markets	4,280	9,926	5,646	4,289	10,824	6,535

6 CONTRIBUTION OF SMALL PELAGIC TO LOCAL GOVERNMENT ECONOMY

The small pelagic fishery contributes in terms of income generation and foreign exchange earnings, but also provides social benefits through increased food security, employment, and poverty reduction within fishing communities. The revenue collected contributes to maintaining social infrastructure within the local government.

6.1 Government revenue

The government collects revenue by issuing fishing licenses both to fishers and vessel owners, and revenue generated through fish landings and post-harvest products.

6.1.1 Licensing

Under the Fisheries Act (2003) section 17 (c) all fishing vessels are required to be licensed and section 17 (d) all fishers are required to be licensed.

All fishing vessels are subjected to registration fees which are paid when vessels are commissioned for the first time, vessel and fishing licence fees are paid annually. Registration fees are aimed to keep track of how many vessels enter the industry and to collect revenue, while licence fees are means to control entry to some extent, keep track of how many vessels are actively engaged in fishing activities each year, and also as a way to collect revenue.

Vessel license depends on the size of the vessel. For vessels sized <11 meters, registered local government charges 22,000 Tsh (10 USD) per year and the fishing license also costs the same amount. Vessel >11 meters are registered and licensed by the central government, however the vessel license costs 110,000 Tsh (50 USD) and the fishing license costs the same amount. If all fishing vessels and fishers were to pay fishing licenses, according to number of fishers and vessel counted in 2016 frame survey, Mafia district could collect 151 million Tsh per year (Table 10), however, getting information and particularly the contribution of small pelagic species proves to be impossible given the current licensing system that does not specify the type of fishery given to a particular fisher.

Table 10: Total fishers and fishing vessels category licences in mafia, 2016 (In Tshs)

FISH LICENSING / VESSEL & FISHERS	Number of fishers and vessel	License fee per vessel/fisher per year	Total License fees (GVA) (Tsh: 000)
Fishers: including foot fishers	5,797	22,000	127,534
Non-motorized dugout	889	22,000	19,558
Motorized small canoes (<11 meter)	180	22,000	3,960
Total mafia artisanal Licensing	**6,866**		**151,052**

6.1.2 Taxes

The local government collects revenue through taxes, all small pelagic fish sold at Kilindoni fish market in Mafia are taxed and it costs 5 percent of the sales value of fresh sardine and mackerel, and 5,000 Tsh per sack of dried sardine with one sack having a maximum weight of

160 kg. The average landing of small pelagic in Mafia per day for three types of vessels, boat using outboard engine, dugout canoe, and dhow of different size is estimated to be 441 kilograms per day with the average selling price as 4,200 Tsh per kg, Thus, Mafia local government should get 92,610 Tsh per day from the sale of small pelagic. The government also collects revenue from fish exporters as some of the small pelagic are exported outside the country especially in the regional market in Zambia, Malawi, Burundi, and Democratic republic of Congo.

6.2 Social benefits from small pelagic fishery

6.2.1 Infrastructure

The revenue collected from small pelagic fisheries has contributed to the government in setting various infrastructures within the local government authority such as road, school, health clinic, banking services etc. Money collected is used to develop the sector in terms of management, training and monitoring of the resource utilization, all along the coast. However, getting the information, particularly the contribution of small pelagic fisheries, has proven to be impossible due to the current licensing system which does not specify the type of fishery given to fishers. Table 11 indicates the available infrastructure in Mafia island.

Table 11: Infrastructure and social services within Mafia Island

Infrastructures and social services	Number of infrastructure and social serves
School	27
Health Clinic	20
Bank Facility	1
Orphan centre	11
Jetty	1
Road Accessible all over the year	16
Cold room	2
Tape of portable water supply	8
Drying racks	2

(Source: Tanzania marine CAS survey)

6.2.2 Employment

Small pelagic fishing activities is clearly an important source of employment, this study indicates that almost 600 are directly employed as fishers of small pelagics in Mafia and more than 900 depend on small pelagics related activities such as fish processing, fish trading, fish transporting, fish carriers, boat builders, net repairers, and some people own shops that sells fishing gear (Table 12).

Table 12: Number of employment in small pelagic fisheries sector and related activities in Mafia Island

No	Employee	Number of employment
1	Fishers	596
2	fish processing	282
3	fish transporters,	212
4	fish carriers	78
5	boat builders	78
6	Fish traders	249
7	Gear shop	8
8	Engine repair	2
9	Fisheries Development staffs	32

(Source: Tanzania marine CAS data base)

7 OPTIMAL FLEET OPERATION

Purchasing the new fishing vessel varies according to type of vessel, size and type of tree used for contractions (Table 13). Gear purchasing cost differs according to size of the net and material used. The investment costs of these different types of vessels being used for artisanal small pelagic fishing in Mafia island are shown in Table 14.

Table 13: Most type of tree used for vessel construction and their economic life spurn in Mafia

English name	Local name	Economic life spurn
Ailbizia versicolor (Minosaccae)	Mkingu	7 – 9 years
Surplus	Msaplasi	5 – 6 years
milicia excelsa (chlorophora excelsa)	Mvule	4 – 5 years
Mango tree	Muembe	2 – 3 years
Cashew	Mkorosho	1 – 1.6 year
Kapok	Msufi	8 months – 1 Year

7.1 Purchasing cost for different fishing units

According to vessel owners and crew in Mafia, some of the boat owners invest money in fishing equipment by getting a loan from the bank but in most case of artisanal small pelagic fishers, fish traders and fish processors finance their investment cost. The reason for financing their operational cost rather than taking loan from financial institutions was to avoid consequences when not meeting the loan agreement. The Table 14 the purchasing cost of different fishing units is outlined.

Table 14: Estimated Purchasing cost of different Fishing Units

Boat with engine	Purchasing cost in (Ths:000)	Gear type	Purchasing cost in (Tsh:000)
<5 m	9,000	Purse sein	4,800
6-10m	10,500	Purse sein	7,200
>10 m	12,600	purse sein	8,600
>10 m		Ring net	9,500
Dhow			
0<5 m	1,000	Purse sein	1,000
6-10m	2,000	Ring net	3,000
Dugout canoe			
0<5 m	1,500	purse sein	750
0<5 m		Beach sein	500

7.2 Common operating costs

Common production costs are those directly incurred in the normal activity of fishing such as fuel, labour, food on board, ice, and maintenance cost.

7.3 Type of fishing vessel

The vessel is categorised according to size and mode of propulsion. The size of the vessel was categorised into three, >5-meter, 6-10 meter and >10 meter (Table 15).

Table 15: Number and categories of fishing vessel by size

	Vessel size			
Vessel	>5 meters	6-10 meter	>10 meter	Total
Non-motorised	24	3	0	27
Motorised	0	10	13	23
Total	24	13	13	50

Vessel using paddle and sail were grouped as non-motorised vessel and those using outboard engine were termed as motorised vessel. The study indicates that most motorised vessel are targeting sardine (70%), mackerel (13%) and targeting both sardine and mackerel are 17%. Non-motorised are targeting mackerel species (78%), sardine (11%) and non-motorised targeting both sardine and mackerel are 11% (Figure 20).

Targeting of sardines requires more motorised boat to help during net cycling when setting the net at sea. Mostly sardines are targeted by large motorised vessels > 6 meters. Vessels targeting mackerel mostly are dugout canoe that do not require high manpower, and most are <5 meters in size.

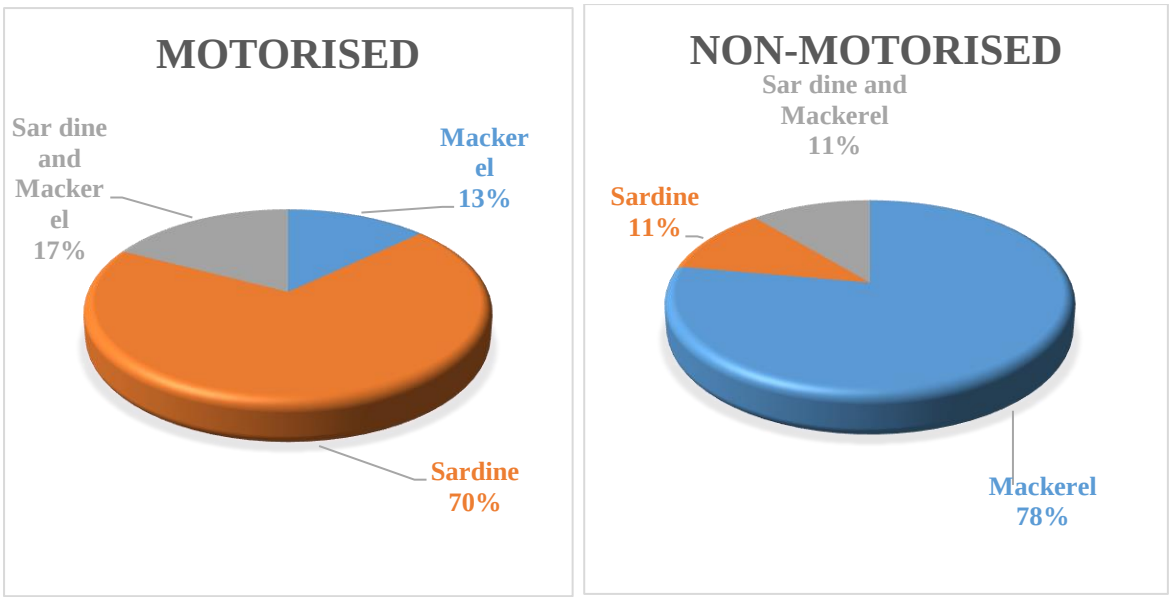

Figure 20: Motorised and non-motorised vessel with targeting species.

7.4 Number of fishers on vessel

The result indicates that the larger the vessel the higher the number of fishers on vessel, the small vessel dugout canoe have the maximum number of 3 crew. Non-motorised and motorised have maximum number of 9 crew. Larger vessel > 10 meters has the maximum of 20 crew (Figure 21). Thus, the size of vessel always determines the number of fishers to work on board. For the vessel >6 meters and above, the high number of fishers on board is influenced by the size of gear (net) used, normally big purse seine or ring nets are used that require high man power during fishing operation. Small vessel < 5 (dugout canoe) has small number of crew because of the structure and size.

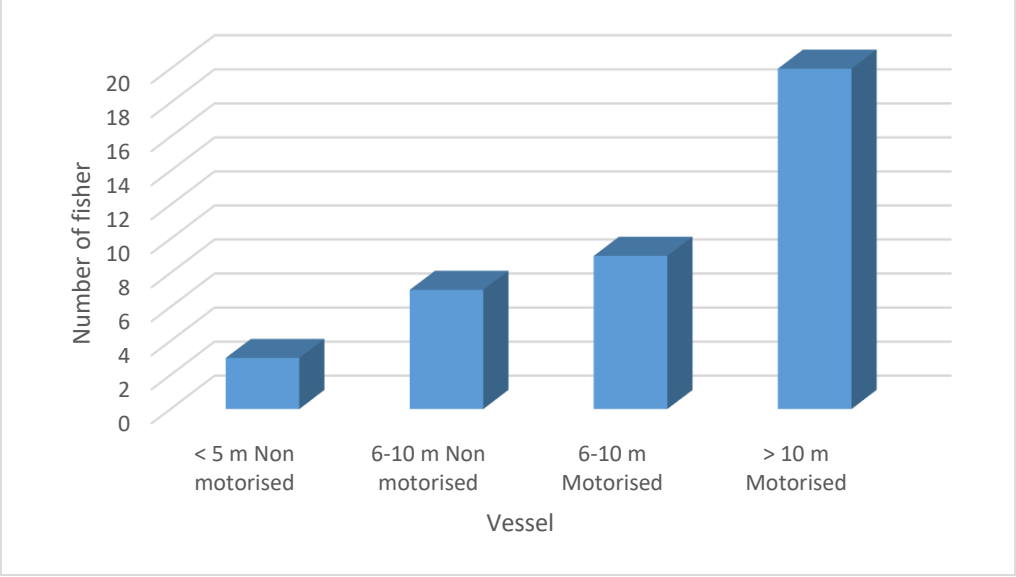

Figure 21: Number of fishers on vessel

7.5 Catch per vessel per day

The landings of catch depend on the type and size of the vessel; results indicate large sized vessels get high catch per day than the smaller vessels. Vessels <5 meters are estimated to land 19 kg, non-motorised lands 40 kg, motorised 6-10 meters lands 89 kg, while motorised > 10 meter lands 134 kg (Figure 22).

Size of the vessel is determining the catch of the day. It indicates that mode of propulsion is the factor in fish production because all motorised vessels are seen to have high catchability than non-motorised. Motorised vessel uses less time in the way to the fishing grounds compared to non-motorised. Motorised vessels have more fishing time than non-motorised and can go farther away to the fishing ground than non-motorised.

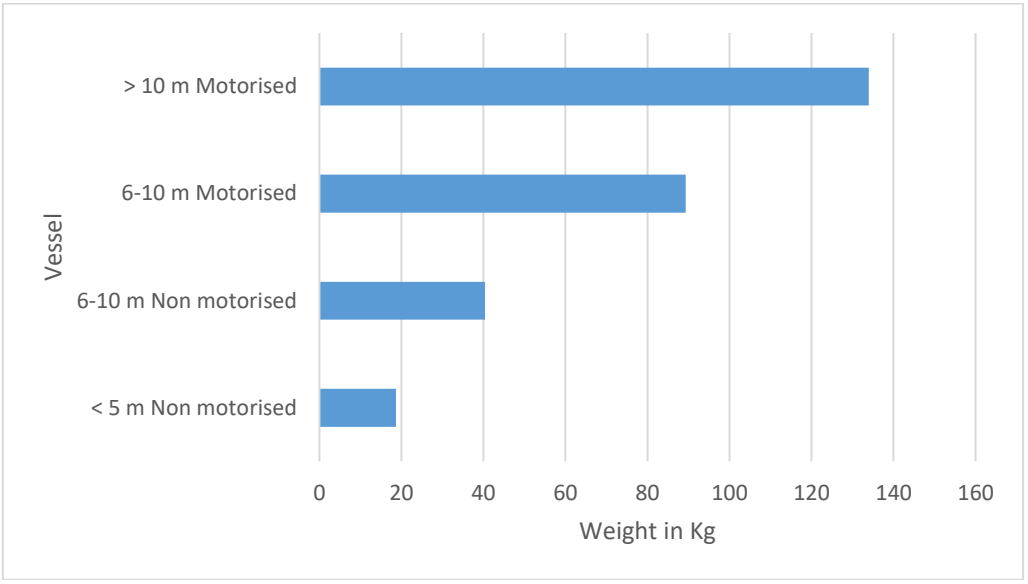

Figure 22: Estimated catch per vessel per day

Table 16 shows the regression results for the relationship between catch, vessel type and number of crew. Further details can be found in the Appendix.

Table 16: Regression estimates for catch

Parameter	Estimate	Standard Error	t Value	Pr > |t|
No motor 0-5 meters	13.5	23.81	0.57	0.5729
No motor 6-10 meter	55.9	30.39	1.84	0.0728
motor 6-10 meter	109.2	30.29	3.61	0.0008
motor >10 meter	359.8	49.21	7.31	<,0001
FISHERS* 0-5 meters	1.71	5.94	0.29	0.7753
FISHERS* 6-10 meter	-2.22	4.72	-0.47	0.6407
FISHERS* >10 meter	-11.29	2.66	-4.24	0.0001

As seen in Table 16, catch depends on vessel type but the number of crew only significantly affects the catch of the biggest vessels. Interestingly, this effect is negative, indicating that the larger the crew is the smaller the catch.

7.6 Cost and profit of the fishing vessel

The results indicate, motorised vessel has high production cost per day than non-motorised vessel. The production cost per day for non-motorised vessel <5 meter is estimated to be 13,782 Tsh with the profit of 60, 798 Tshs; non-motorised 6-10 meters is estimated to be 45,470 Tsh with the profit of 116,040 Tshs; motorised 6-10 meters is estimated at 326,107 Tshs with profit of 31,063 Tshs, while motorised >10 meters is 301,131 Tshs with profit of 234,744 Tshs. The profit of each fishing unit was obtained after subtracting all production cost per day from revenue gained (Figure 23).

Motorised vessels have high production cost because it incurs the cost of fuel, food for crew, maintenance, ice and fish carrier cost. Non-motorised vessels mostly incur only food and maintenance cost, and do not incur the cost of ice, and do not pay for fish carrier after landing. They always carry fish themselves to the processing area or selling place. Motorised vessels require regular maintenance of engine and use high number of crew that increases food cost. Non-motorised vessels get high benefits because it uses less cost for fishing.

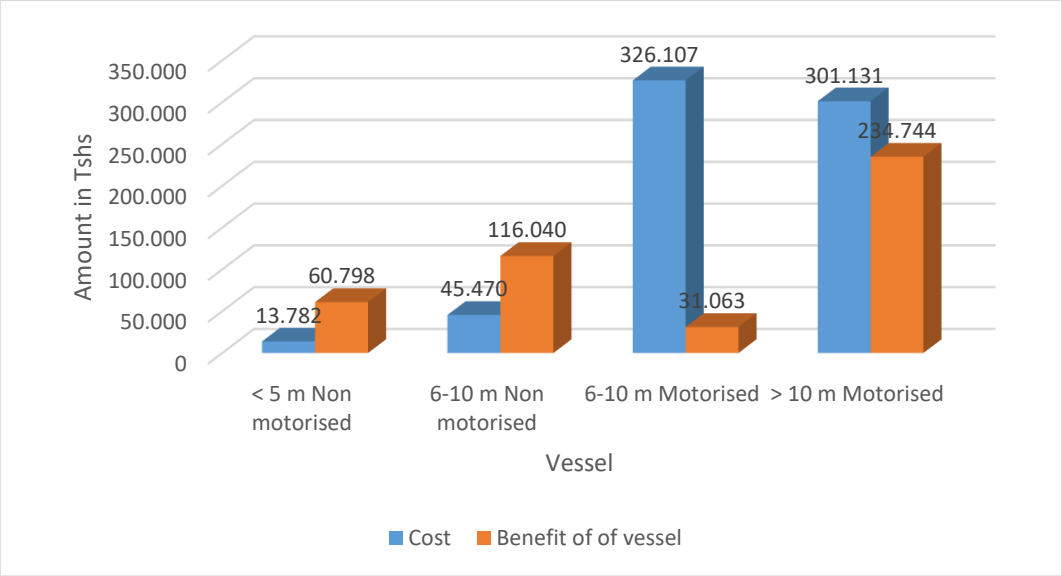

Figure 23: Estimated cost and profit per vessel per day

Table 17: Regression estimates for cost

Parameter	Estimate	Standard Error	t Value	Pr > |t|
No motor 0-5 meters	5070	42720	0.12	0.9061
No motor 6-10 meter	-61297	54528	-1.12	0.2672
motor 6-10 meter	188835	54352	3.47	0.0012
motor >10 meter	676673	88295	7.66	<,0001
FISHERS* 0-5 meters	2904	10652	0.27	0.7865
FISHERS* 6-10 meter	15252	8461	1.8	0.0784
FISHERS* >10 meter	-18777	4774	-3.93	0.0003

Table 17 shows that cost depends on propulsion and vessel size and the number of crew members lowers cost significantly for the largest vessels. This result is rather counterintuitive.

7.7 Profit sharing among the fishers

Profit sharing of the crew depends on the catch of the day, the common production cost incurred, and the agreement of share between crew and boat owner. The mode of income distribution between boat owners and the crew is 50% to 50% after deduction of all daily production cost such as fuel, labour, labour, food and ice cost. The distribution of income between crew are also distributed equally depending on the number of crew on boat.

The results indicate that the estimated profit sharing per day among crew are as follows; <5 meter non-motorised 20,266 Tshs, non-motorised 16,577 Tshs, motorised 3,451 Tshs, while motorised >10 meter gets 11,737 Tshs.

Benefit gained depends on amount of catch per day, the higher the catch the higher the benefit shared. Also, as the number of fishers increase in the vessel, the less the profit crew take home. This type of system in benefit sharing favours more the boat owners than the crew as he/she takes half of the profit generated, and the remaining is distributed equally depending on the number of crew on board the vessel. Fishers using small fishing vessel make high profit sharing as they are few in number compared with crew in large vessels (Figure 24).

This result implies that mackerel fishing is more profitable to fishermen than the sardine fishing. This is, probably, the reason that the small pelagic fishing vessel in Mafia target mackerel rather than sardine. In general, the sardine fishery is of low value compared to other fisheries in Mafia.

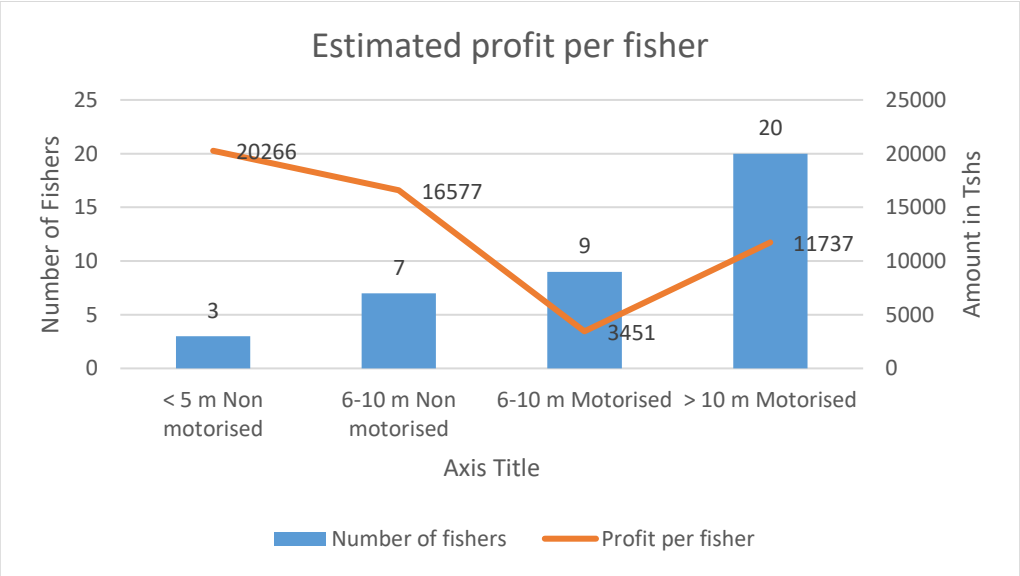

Figure 24: Estimated profit per fisher per vessel

The 6-10m motorised vessel incurs similar production costs as the >10 m vessels since they both have fuel and maintenance cost and use the same gear type. The only difference is the extra crew the larger vessels employ. Since catch is directly dependent on the number of crew, the 9 crew in the 6-10m vessel cannot haul the catch that 20 crew can. Smaller vessels do not allow the nets to be full to not exceed the manpower available leading to low catch at high

costs. This results in a lower catch compared to the larger vessels that has adequate manpower available. Higher catch translates to higher net profits for crew. The marginal cost of extra crew in the larger vessel results in much higher benefits for the entire crew and owner.

8 CONCLUSION AND RECOMMENDATION

The results show that the small pelagic fishery in Mafia is very important as a source of employment, government revenue and food for the local community. The results further indicate that although the resource does not seem to be overexploited the effort exceeds the most profitable level and crew sizes also exceed optimal levels on larger vessels targeting sardine. Policy should focus on improving profitability by facilitating fleet restructuring and consolidation. This would help small pelagic fishers to free themselves from poverty.

In order to insure application of ecosystem approach to fisheries management, there is the need for capacity building. Fishers and other stakeholders require knowledge on Fisheries Act and Regulation, fish hygiene and good manufacturing practices, resources management, record keeping and savings. This will help in sustainable fisheries awareness, adequate food security and poverty reduction.

To insure the implementation of small pelagic data collection, it is recommended that beach management unit should be strengthened to support the implementation of the existing small pelagic management plan.

The overall effort in the small pelagic fishing in Mafia is increasing. Although there are no clear signs of overexploitation, this still puts pressure on the ecosystem in many ways, e.g. on the forest for boat building and fish smoking. There is therefore a need for intervention, e.g. the departments of fisheries and forestry to conduct a study on alternatives to the use of forest resources and to enter into a Memorandum of Understanding (MOU) for exploitation of these products in the short term.

Currently, the government investment into the fisheries infrastructure in Mafia is inadequate. Therefore, if the goal is to have fisheries that can contribute significantly to economic development of the country, there is a need of dedicated fisheries investment such as establishment of fish processing facilities such as cold storage, drying racks and ice plant at the landing sites. This will help to reduce post-harvest fish loss and increase the value of catch.

One of the aims of Tanzania fisheries policy is to help the artisanal fishers to free themselves from poverty. This is achieved through various fisheries project such as MACEMP, RUMAKI and RECOMAP. One of the strategies is to provide fishing equipment to fishers e.g. small vessels that has low running cost. For large vessels the policy is to mobilize fishers in groups to avoid the share of boat owners.

Poor hygienic handling of sardines by spreading the sardine on bare sands is of great concern and greatly contributes to poor finished products. This phenomenon is common in Mafia Island in low as well as in peak seasons. This is also influenced by limited drying spaces. Generally, sorting of sands from sundried fish is very difficult as the sand grains become part of the fish body. Therefore, raised and galvanized drying racks are highly recommended as a means of improving the finished products.

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9 APPENDICES

APPENDIX 1. QUESTIONAIRE FOR KEY INFORMATION

(Dugout cone, Planked canoe, Outrigger canoe, Boat)

Respondent…….... (Crew or Vessel owner)

Age of Respondent…….

Number of respondent dependent in the house hold……

A) EFFORT IN USE

- What type of fishing vessel do you use for fishing and number of fishers in vessel?
- Dugout canoe ……
- Planked canoe …….
- Outrigger canoe……
- Boat with outboard engine ……. (HP)…...
- What type of fishing gear do you use for fishing and number of gear?

a) Beach sein…….
b) Scoop net……
c) Ring net……
d) Parse sein net……
e) Others (mention) …….

B) CATCH TARGETED

What type of fish do you target and the average catch per day?

a) Sardinella neglecta (Dagaa papa) ……
b) Stolephorus commersonnii (dagaa Mchele) .....
c) Rastrelliger kanagurta (Kibua) …….
d) Other (mention)…….
e) What are the price of fish per kilogram? ……
f) Number of fishing days per week……

C) OTHER SMALL PELAGIC RELATED ACTIVITIES

- How many peoples engage in other Small pelagic fishing related activities?

a) Fish processing…….
b) Fish transporters……
c) Net repairers……
d) boat builders…….

e) fish carriers……

D) OPERATING COST

- What are the investment and fishing operating cost per year?
    - Vessel construction or Purchasing cost …….....
    - Gear Construction or Purchasing cost……
    - Boat & Gear Maintenance cost…….
    - Boat & Gear repair Cost……
- What are common fishing operating cost per year?
    - Fuel and lubricant cost…….
    - Food cost…….
    - Ice cost…….
    - Labor cost …….

Average Economic life of fishing equipment?

a) Dugout canoe…….

b) Planked canoe……

c) Outrigger canoe……....

d) Boat with outboard engine…….

APPENDIX 2. ANALYSIS RESULT

The SAS System

The GLM Procedure

Dependent Variable: CATCH_kg
CATCH_kg

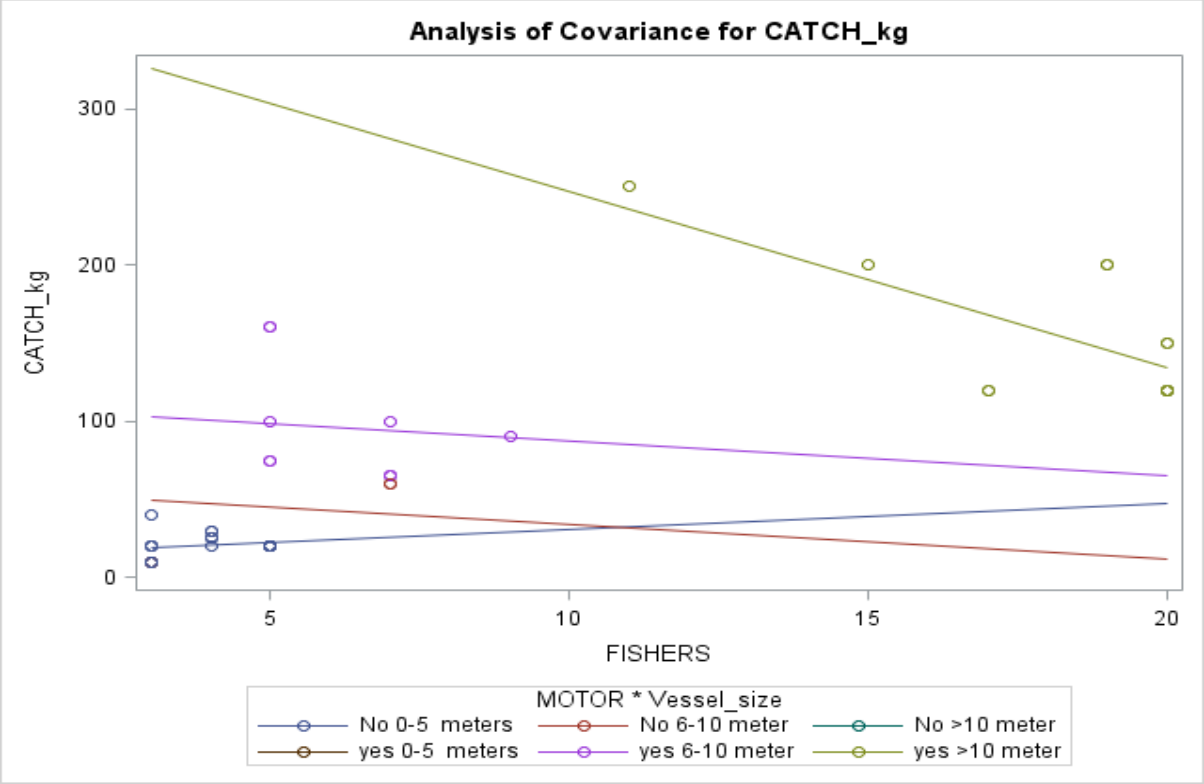
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	422767.9793	60395.4256	96.07	<,0001
Error	43	27032.0207	628.6516		
Uncorrected Total	50	449800			

R-Square	Coeff Var	Root MSE	CATCH_kg Mean
0.862312	35.21478	25.07293	71.2

Source	DF	Type I SS	Mean Square	F Value	Pr > F
MOTOR*Vessel_size	4	411259.9519	102814.988	163.55	<,0001
FISHERS*Vessel_size	3	11508.0274	3836.0091	6.1	0.0015

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MOTOR*Vessel_size	4	45327.74505	11331.93626	18.03	<,0001
FISHERS*Vessel_size	3	11508.02742	3836.00914	6.1	0.0015

Parameter	Estimate	Standard Error	t Value	Pr > |t|
MOTOR*Vessel_size No 0-5 meters	13.5280374	23.81095397	0.57	0.5729
MOTOR*Vessel_size No 6-10 meter	55.8962264	30.39247881	1.84	0.0728
MOTOR*Vessel_size yes 6-10 meter	109.245283	30.29475355	3.61	0.0008
MOTOR*Vessel_size yes >10 meter	359.7920277	49.2137946	7.31	<,0001
FISHERS*Vessel_size 0-5 meters	1.7056075	5.93729686	0.29	0.7753
FISHERS*Vessel_size 6-10 meter	-2.2169811	4.71593411	-0.47	0.6407
FISHERS*Vessel_size >10 meter	-11.2911612	2.66117723	-4.24	0.0001



The SAS System

The GLM Procedure

Dependent Variable: Common_p_cost Common_p_cost

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	2.29E+12	3.27189E+11	161.69	<,0001
Error	43	87011661397	2023527009		
Uncorrected Total	50	2.38E+12			

R-Square	Coeff Var	Root MSE	Common_p_cost Mean
0.928234	29.47099	44983.63	152637

Source	DF	Type I SS	Mean Square	F Value	Pr > F
MOTOR*Vessel_size	4	2.25E+12	5.63075E+11	278.26	<,0001
FISHERS*Vessel_size	3	38024476063	12674825354	6.26	0.0013

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MOTOR*Vessel_size	4	2.63244E+11	65810893589	32.52	<,0001
FISHERS*Vessel_size	3	38024476063	12674825354	6.26	0.0013

Parameter	Estimate	Standard Error	t Value	Pr > |t|
MOTOR*Vessel_size No 0-5 meters	5069.8598	42719.51079	0.12	0.9061
MOTOR*Vessel_size No 6-10 meter	-61296.6981	54527.50143	-1.12	0.2672
MOTOR*Vessel_size yes 6-10 meter	188835.3774	54352.17139	3.47	0.0012
MOTOR*Vessel_size yes >10 meter	676673.4835	88295.04405	7.66	<,0001

FISHERS*Vessel_size 0-5 meters	2903.972	10652.17369	0.27	0.7865
FISHERS*Vessel_size 6-10 meter	15252.3585	8460.91251	1.8	0.0784
FISHERS*Vessel_size >10 meter	-18777.1231	4774.44917	-3.93	0.0003