SPATIO-TEMPORAL DIVERSITY AND ABUNDANCE OF FISH AND ITS CONTRIBUTION TO HOUSEHOLD INCOME IN THE LITTLE RUAHA RIVER CATCHMENTS IRINGA TANZANIA

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ABSTRACT

Fish is an important component of aquatic biodiversity in Tanzania and plays an important role in the national economy. However, the spatial-temporal distribution of fish in the Little Ruaha River Catchments and its contribution to household income have not been given sufficient evaluation. This study determined the spatiotemporal diversity and abundance of fish, generated the information spatial distribution of fish across the catchments and determine the contribution of fish to household income. Fish samples were collected during dry and rain season using gillnets of 76.2 mm mesh size in three sampling sites (in the upper reach, middle reach, and lower reach). Structured household questionnaire and field observation were used to collect information on the contribution of fisheries to household income. The Shannon diversity index was used to compute the diversity of fish in the different habitats and seasons. Kruskal-Wallis and Mann Whitney tests were used to determine the difference in fish diversity and abundance between habitats and seasons. The contribution of fisheries to household income was assessed as the mean proportion of household income obtained from fishing activities. A total of 250 fish individuals belonging to five species were captured. The fish species diversity and relative abundance was higher in the lower reach compared to the upper reach. The relative abundance of fish was statistically different ($p<0.05$) between habitat and seasons. However, there was no significant ($p>0.05$) difference in fish diversity between habitats and seasons. *Oreochromis* and *Clarias* were the common species across all habitats. Fisheries contributes to an individual monthly income of up to 500 000 TSA (US$ 220) and supplies about 51% of protein to community households. Sustainable fisheries management in river basins contributes significantly to community livelihoods. Management of river basins should integrate fisheries activities as among the options for integrated river basin management.

DECLARATION

I, FARIDA MAYOWELA, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor is being concurrently submitted to any other institution.

_____ _____

Farida Abdalla Mayowela Date

(MSc. Candidate)

The above declaration is confirmed

_____ _____

Prof. Munishi P.K.T Date

(Supervisor)

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DEDICATION

This dissertation is dedicated to my beloved parents, Abdalla Mayowela and Honorina Mbilinyi, who laid the foundation of my education and for their affectionate love.

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LIST OF ABBREVIATIONS AND ACRONYMS

DFID	Department for International Development
DS	Dry Seasons
DSC	Down Stream Catchment
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Global Positioning System
GRRC	Great Ruaha River Catchments
Kg	Kilogram
MNRT	Ministry of Natural Resources and Tourism
MSC	Midstream Catchment
M.s.l	Meters above sea level
NACE	National Classification of Economic Activities
RCA	Ruaha Catchment Areas
RS	Rain Seasons
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SPSS	Statistical Package for the Social Sciences
URT	United Republic of Tanzania
USC	Upstream Catchment

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Fish are important source of food in that they contribute as much as 17% of the world's animal protein (FAO, 2018). The World Bank, FAO and World Fish Center, reported an estimated annual production of 48 million tons of fish by small-scale fisheries which increase the food supply to the world's population (De Graaf *et al*., 2014). Fisheries also play an important role in the world economy, as millions of people around the world find a source of income and livelihood in the fisheries and aquaculture sector (FAO, 2014). The most recent official statistics indicate that 59.6 million people were engaged in the primary sector of capture fisheries and aquaculture in 2016, with 19.3 million people engaged in aquaculture and 40.3 million people engaged in fisheries (FAO, 2018).

Almost 95 percent of the world's inland fisheries catch is in developing countries (Bartley *et al*., 2015), and 90 percent of inland capture production is consumed in the developing world and approximately 43 percent of global inland catch occurs in low-income food deficit countries (World Bank, 2012). Tanzania is among the countries in Africa endowed with numerous water resources that are important sources of biodiversity including fish (Sobo, 2012). The country ranks the top 10 worldwide as a producer of inland water capture (FAO, 2014) and was amongst the top 10 countries in Africa in terms of total capture fisheries production. The fisheries sector also plays an important role in people's livelihoods and the economy of the country. Fisheries contribute around 10% of the national Gross Domestic Product (GDP) (MNRT, 2005) and it is an important source of economy and livelihoods for many Tanzanians providing food security, employment opportunities and income generation activities.

In Iringa region fisheries activities seem to be one of the important economic activities that contribute to the economy of the local communities and district revenues in general. This is so especially to villages adjacent to the Ruaha River Catchment. While statistics on annual total catch are scarce, available, anecdotal reports suggest increased trend in fishing and the number of fishermen, especially in areas around the Little Ruaha River and Mtera Dam (Mjema and Kulindwa, 2001). Therefore this study aim to provide an assessment of the spatial and temporal distribution of fishes along the Little Ruaha River catchments and its contribution to the livelihoods and economy of local communities adjacent to Little Ruaha River.

As an important component of biodiversity, fish need to be conserved, and aquatic systems are crucial for the conservation of both local and global biodiversity of fish (Dee *et al*., 2016).There is a great diversity in the form and function of aquatic systems, presenting a wide range of fish habitats (Vallès and Oxenford, 2015). Understanding the spatial and temporal patterns and processes that influence the functional organization of species assemblages is an essential step in understanding ecosystem structure and function (Boersma *et al.,* 2016). The clarification of distributions of fish can help inform the monitoring and management of biodiversity, and inform policy related to the fish on management of river catchments for conservation of biodiversity including fish (Shechonge *et al.,* 2019). The species richness and biomass are important to consider in spatio-temporal changes in species diversity and abundance (Loiseau and Gaertner, 2015). Diversity in the ecological roles of fish communities may be a more important indicator of change for monitoring programs to track when implementing an ecosystem-based management approach (Micheli *et al*., 2014).

1.2 Problem statement

Tanzania is rich in aquatic resources making the fisheries sector important in the economy (Sobo, 2012). Fishing activities from aquatic resources are also amongst important economic activities that contribute into provision of food and nutrition, employment, income, livelihoods, recreation, foreign earnings and revenue from local perspectives to the national level (Sobo, 2012). The little Ruaha River is among the water sources in Tanzania with both ecological and economic value. Fishing is one of the major economic activities that contribute to the local economy and livelihoods of communities adjacent to the Little Ruaha River catchments though its contribution remains little understood.

Aquatic resources including Little Ruaha River are under high degradation pressure due to increasing demand for aquatic resources for income generation and improvement of livelihoods to the community (MNRT, 2005). The loss of biodiversity in Ruaha River Catchment Areas is driven by strong local dependence on natural resources particularly for financial needs. Loss of biodiversity is associated with the declining levels of water due to expansion of human activities like fishing and agriculture (Sosovele *et al.*, 2002).

While numerous studies have been carried out in the Ruaha Catchment especially in the Little Ruaha River (Sosovele *et al.*, 2002) and (Munishi *et al*., 2016), the data on the variation of fish diversity and abundance in space and time and the way this influences the livelihoods that depend on these resources is scanty or non-existent. The spatiotemporal distribution of fish in river ecosystems and its influence on household income have not been given sufficient coverage in literature and may constrain fisheries management to deliver adequately community livelihood benefits.

1.3 Justification for the study

This study contributes to the body of knowledge on fish community ecology and establishes baseline information on the spatio-temporal patterns in species diversity and community composition, which better inform fisheries management and conservation objectives in the Little Ruaha River Catchments and beyond. Furthermore the study provides information on the contribution of fisheries activities to household income in the Little Ruaha River catchments. The findings will help policy makers and the government on resources and policy adjustments for sustainability fisheries resources management, utilization. It will further enhance sustainable utilization of river systems for improved contribution to local economy and livelihoods as well as maintenance of ecological integrity of river systems.

1.4 Objectives

1.4.1 Overall objective

The general objective of the study was to assess the spatio-temporal variation of fish and its contribution to household income in the Little Ruaha River Catchment Iringa Tanzania.

1.4.2 Specific objectives

The specific objectives of the study are to:

1. Determine the spatial and temporal diversity and abundance of fish species along the little Ruaha river cathments.
2. To generate information on the spatial distribution of fish species across the little Ruaha river catchment.
3. Determine contribution of fisheries activities to household income around little Ruaha river catchments.

1.5 Research questions

i. How does the diversity and abundance of fish vary spatially and temporary in the little Ruaha River Catchments?

ii. How does fish distribution vary spatially across the little Ruaha river catchments?

iii. To what extent does fishing contribute to household income for communities adjacent to little Ruaha river catchments?

1.6 Conceptual framework

The conceptual framework summarized in Figure 1 shows the relationship between the distribution of fish across the habitats and seasons, and its contribution to household income through fishing. The diversity and abundance of fish, depends on seasonal fluctuation of fish across the habitats and the proper fisheries management. The results of such management and fluctuations to diversity and abundance of fish, has the influence to the household income and community livelihoods hence sustainable development to the community.

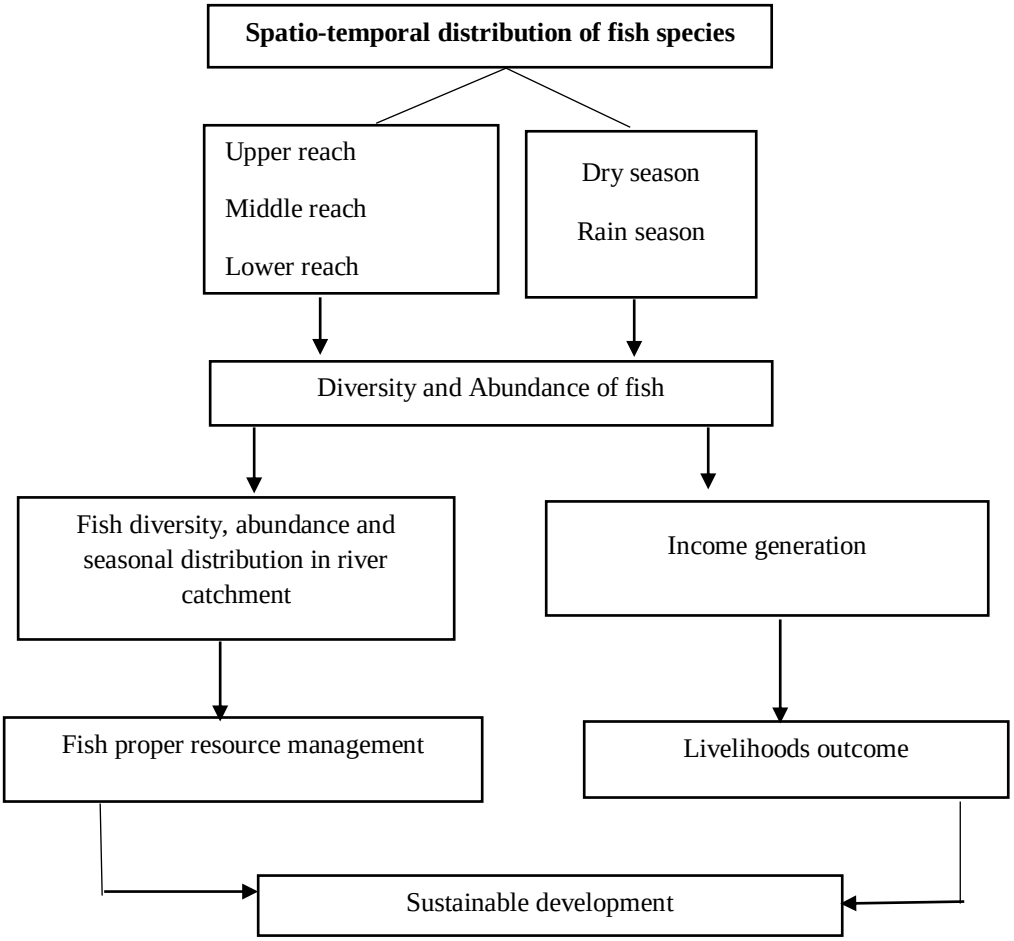

Figure 1: Conceptual Framework of the study

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Ruaha Catchments Ecosytems

Ecosystem services are the direct and indirect contributions of ecosystems to human well-being that support directly or indirectly our survival and quality of life (BISE, 2010). According to Millennium Ecosystem Assessment (2005), ecosystem services categorized into four main groups, which are;

- Provisioning services; are the products obtained from ecosystems such as food, fresh water, wood, fiber, genetic resources and medicines.
- Regulating services; the benefits obtained from the regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification and waste management, pollination or pest control.
- Supporting services; highlight the importance of ecosystems to provide and to maintain the three other categories of ecosystem services such as water cycle, nutrient cycling, production of atmospheric oxygen and soil formation.
- Cultural services; include non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation and aesthetic values.

The RCA is one among the ecosystems which is important for agriculture, livestock keeping forestry, fishing, mining and tourism/wildlife activities that are important for the welfare of the people in the region and in Tanzania in general (Sosovele *et al.,* 2002), it is also important in providing refuge for many species and becomes more apparent during the peak of the dry season in which there would definitely be higher species richness for

both flora and fauna in the catchments because of the wetter and favorable conditions compared to the other more terrestrial habitats (Munishi *et al.*, 2016). Fishing is one among the important economic activities provided by Ruaha river catchments (Sosovele *et al.*, 2002). According to the fisheries officer at Mtera, about 90% of residents there depend on fishing activities for their livelihood.

2.2 General overview of fisheries

According to Panayotou (1982) a fishery is typically defined in terms of the "people involved, species or type of fish, area of water or seabed, method of fishing, class of boats, purpose of the activities or a combination of the foregoing features". Fisheries are activities leading to harvesting fish; it may involve capture of wild fish or raised fish through aquaculture. Fisheries is the important sector in the world as it is estimated that 56.6 million people were engaged in the primary sector of capture fisheries and aquaculture in 2014, of whom 36 percent were engaged full time, 23 percent part time, and the remainder were either occasional fishers or of unspecified status (FAO, 2016). In Africa, extensive inland water habitats and inland fisheries provide significant food and livelihoods to riparian and wetland communities (FAO, 2015). Tanzania also is among of the Countries in Africa which is endowed with numerous water resources which are important sources of biodiversity including fisheries (Sobo, 2012). The country has potential to produce over 730 000 metric tons of fish from both captured and aquaculture. Fresh water fisheries accounts for 80% of the landed catch of about 280 000 to 320 000 tons annually that make fisheries sector to contribute around 10% of the national Gross Domestic Product (GDP) (MNRT, 2005).

2.3 River catchments

River basins or river catchments (the land area between the source and the mouth of a river, including all of the lands that drain into the river) and coastal and marine systems influenced by catchment discharges are important geographical units for considering the management of wetlands and water resources (Ramsar, 2010). Wetlands play critical roles in river basin management and, conversely, land and water-related human activities within river basins can have very significant influences on the ecological character of wetlands in those basins (Ramsar, 2010). The Little Ruaha River Catchments located in the Southern Highlands of Tanzania, is one of major sources of water for the Ihemi Cluster, which is one of the six clusters identified by the Southern Agricultural Growth Corridor (SAGCOT) for agricultural intensification with significant investments in irrigation planned (SAGCOT, 2011). Wetlands in the Little Ruaha apart from being highly productive agricultural lands also provide natural habitats to many species of invertebrates and aquatic organisms (Mbungu and Kashaigiri, 2017).

2.4 Fishing and livelihoods

Livelihood implies a means of living (set of activities a human being apply to earn everyday life) (Hornby, 1992). The concept of 'livelihoods' has moved analysis away from narrow parameters of production, employment and income to a much more holistic view which embraces social and economic dimensions, reduced vulnerability and environmental sustainability, all within the context of building on local strengths and priorities. This recognizes that humans pursue a range of livelihood strategies based on the assets (natural, financial, social, human and physical capital) they have to draw on and the livelihood outcomes they wish to achieve (Shackleton and Cousins, 2000). The livelihoods related to fisheries through the concept of poverty reduction where the wealth or rent generated by the fisheries (or fish related activities such as fish trade) is

sufficient large to lift households above the poverty line. In the large majority of cases, however, the contribution of small-scale fisheries to the household economy is much more modest and the income generated may just be sufficient to maintain the household at their current standard of living (Carney, 1999). This case usually corresponds to situations where the households have limited or not access to land and/or other factors of production (e.g. access to financial capital) and where open access or common pool resources (such as fisheries) may then play an important role in supplementing alternative low per capita food production options and provide additional cash income (Beck and Nesmith 2001). In this sense fisheries play an important welfare function in many rural areas of the developing world (FAO, 2014). This welfare function is mainly conditioned to the existence of an open, or common (regulated or non-regulated) access to the resources, which allows household members to engage in the activity at low, or no, entry costs (Chambers and Conway, 1992). These activities can take various forms, be associated with different levels of time and capital investments, and be undertaken by various members of the households (Bene, 2006).

2.5 Brief overview of fishing in the Little Ruaha River Catchment

Fishing in the Little Ruaha River Catchments, is most clearly seasonal with peak catches occurring in the early rains and dwindling with the river level (Sosovele *et al.*, 2002). The most common fish during this early season is catfish (*Clarias*) followed by tiger fish (*Hydrocynus*) and Kitoga (*Bagrusorientalis*) (Kulindwa *et al.*, 2001). Therefore fishing seems to be common in this season because the river is raising and fish are migrating so it easier to catch them in migration pathways. More than 38 species have been recorded in the Ruaha basin (Payne, 1995). With respect to biodiversity, a high proportion of the 38 species (that is about 40%) are endemic and found nowhere in the world, including some of the most commercially important species (Mgaya, 1998). The most important species

in the river is the endemic tilapia, *Oreochromis urolepis* Johansson, (1997) and Chale, (2004). This sustains the enormous fishery that has developed in the Mtera reservoir as well as those of Great and Little Ruaha rivers (Payne, 1995).

2.6 Case study fisheries and community livelihoods in the Ruaha catchments areas

Fish is an important element in the local diet as well as an important source of income to the local communities and the District Councils (URT, 1997). Fishing is an important activity for many of the villages in the RCA particularly those of Pawaga Division and areas surrounding the Mtera reservoir (Sosovele *et al.,* 2002). Most fish catch is used for domestic consumption, usually fresh. Other stock is smoked and sold to different parts in and outside the region like Tabora, Iringa, Singida, Mbeya, Songea, Dar es Salaam, Dodoma, Morogoro, Tunduma, and Njombe and possibly exported to Zambia and Malawi.

2.7 Spatial and temporal diversity and abundance of fish

Fish is one among the best known aquatic organism which are the source of food harvested from natural populations (Oberdorff *et al.,* 1995). The diversity of fish comprises species richness (number of species in a defined area), species abundance (relative number of species) and phylogenetic diversity (relationships between different groups of species) (Herder and Freyhof, 2006). The patterns in species diversity and abundance are highly influenced by both spatial and temporal factors (Konan *et al.,* 2006), (Suvarnaraksha *et al.,* 2012), and (Felix *et al.,* 2013). In freshwater fishes both biological and physical factors cause differences within and among communities (Myers *et al.,* 2000). On local scale biological factors such as competition, predation and highly food availability especially during the rains seasons but also physical factors such as habitat diversity, flow regime, temperature and channel morphology interact to

influence species diversity and abundance (Vieira *et al*., 2013) and (Worischka *et al.*, 2014). The latitudinal gradient of the upper part also can inhibit temperature variability which is necessary for growth and production of fish and make the diversity and abundance of fish to be low in the particular habitat (Knouft, and Anthony, 2016). The catchments can experience large variations in water level during a short time period and extreme low water during the dry season which can reduce fish abundance (Winemiller and Leslie, 1992).

Also the differences in numbers of fish species can be attributed by different sampling techniques, area covered, elusive and cryptic behavior of fish (Quirino *et al.*, 2015). These factors can be brought by seasonal change of climatic conditions as well as longitudinal change along the river system network (Flinders *et al.*, 2009) and (Melles *et al.*, 2012).

2.8 Factors affecting diversity, abundance and distribution of aquatic resources including fish

The diversity of life on Earth is rapidly declining under the current biodiversity crisis (Olson *et al.*, 2002). Extinction rates are 100–1000 times higher in many different taxonomic groups and across a wide range of environments (Pimm *et al.*, 1995). However, habitat degradation and invasive species are the most commonly cited causes of decreasing in diversity and abundance of fish (Didham *et al.*, 2007). There is a general agreement on the urgent need for management actions focused on conserving biodiversity (Olson *et al.*, 2002), but such actions require an understanding of the mechanisms driving biodiversity loss.

2.9 Contribution of fisheries to household income

Fishing is responsible for approximately 90% of all fishing jobs worldwide and it provided critical income for millions of families (Batista *et al.*, 2014). In any fishing communities, fisheries have a direct link to household incomes (Ninnes 2004). This household income explains the levels of income in which at the end indicates whether a given fishing household is benefiting or not (Hill, 2005) and (Bilame, 2012). Global Fisheries Alliance (2009) reported that fisheries contribute to African development by stimulating the growth of a cash based economy and fish caught were sold on a daily basis. Fish production from the capture fisheries in Tanzania increased from 348 000 metric tonnes worth Tshs 76.76 billion in 1998 to 365 974 metric tonnes worth Tshs 1.49 trillion in 2014 (URT, 2015).

2.10 Contribution of fisheries to employment

Inland capture fisheries are important as a source of direct employment and income to an estimated 16.8 million to 20.7 million people globally, particularly in developing countries (FAO, 2018). It has been conjectured that more than twice as many people may be involved along the supply chain, including women (HLPE, 2014; Funge-Smith, 2018). Most inland fisheries are small in scale (NACE, 2008). Small-scale fisheries create employment several times greater than large scale fishing, as the lesser mechanization of the fishing operations typically requires greater human input (World Bank, 2012).

2.11 Contribution of fisheries to household food security

Fish and fish products have a crucial role in nutrition and global food security, as they represent a valuable source of nutrients and micronutrients of fundamental importance for diversified and healthy diets (FAO, 2018). Fish constitutes among the most important sources of animal protein and it provides macro-nutrients such as protein, lipids,

carbohydrates and wide range of essential amino and fatty acids. The sector contributes to about 30 percent of total national animal protein consumption that control nutritional disorders such as Marasmus and Kwashiorkor (URT, 2015). The United Nations General Assembly proclamation of the UN Decade of Action on Nutrition for 2016–2025 provides an opportunity to raise awareness about the role of fish and to ensure that it is mainstreamed in food security and nutrition policy (FAO, 2018).

2.12 Challenges facing fisheries in developing countries

Inland fisheries are open access (new entrants are permitted), but as the increase in capacity takes up all the resource rent, fishing has ceased to be a profitable business (URT, 2016). Any recovery in the fisheries industry is negated by the arrival of new entrants, rather than improved livelihoods for existing operators. The population increase in fisheries has been the critical challenge in an erosion of biodiversity which affect the function of ecosystem (FAO, 2018). Effective fisheries monitoring, control and surveillance is hindered by a lack of funding, slow legal processes and inadequate fines. Market forces, poverty, falling incomes and weak enforcement continue to provide the environment for illegal fishing and trade, presenting serious challenges to the long term sustainability of the inland fisheries (Lorenzen *et al*., 2016). However, fisheries Officers do their best to apply the controls, and regularly seize illegal fishing gears and unlicensed vessels (URT, 2016).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the study site

The Little Ruaha River, one of the three tributaries forming the Great Ruaha River Catchment (GRRC). Geographically, the watershed lies within longitudes 35˚2'E and 35˚36'E and, latitudes 7˚11'S and 8˚36'S. The Little Ruaha River watershed has been estimated to cover 6210 km^2 and drains parts of Iringa Municipality, Iringa, Kilolo and Mufindi Districts in Iringa Region. The average annual rainfall ranges from 500 mm in the lowlands (e.g. rainfall measured at Mtera Met station) to 700 mm in the highlands at Iringa based on average rainfall from 1979 to 2012. The mean annual temperature varies from about 18˚C at higher altitudes to about 28˚C. Elevation ranges from 698 to over 2300 m, above sea level (m.s.l) (Mbungu and Kashaigili, 2017).

Three wards were selected for social economic study that was Igowole, Kalenga and Migoli in Iringa and Mufindi Districts. The population density varies per districts, and currently there are 254 032 in Iringa district, and 265 829 in Mufindi District, according to 2012 census. Agriculture and fishing are the major source of income for the majority (40%) of Iringa residents, followed by casual and piece work (21%). Other dominant income-generating activities include trade of non-agricultural products (11%), salaries (6%), service provision (4%) and trade of agricultural products (3%). The dominance of agriculture and fishing is due to geographic factors and positioning of the region. Iringa has favourable geographic and climatic conditions for a range of food and cash crops (Andrew *at al.*, 2018).

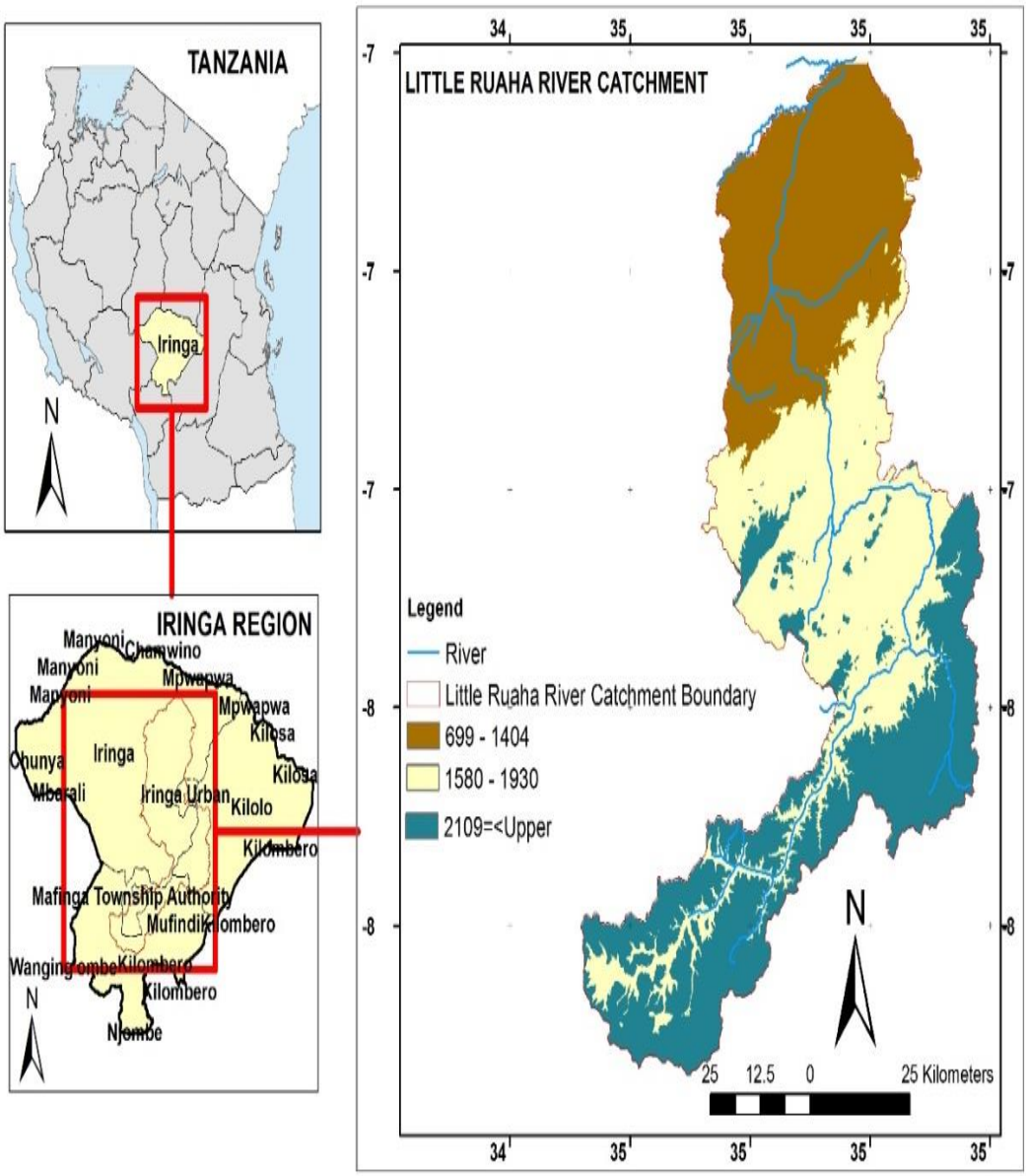

Figure 2: Map of the Little Ruaha catchments showing the different reaches of the river (down 699-1304m; middle reach 1580 – 1930m and upper reach > 2109m)

3.2 Sampling procedures and data collection

3.2.1 Spatial and temporal diversity and abundance of fish along the Little Ruaha River Catchments

The study was carried out during March and May 2019 to cover the dry and rain seasons. The area was purposively stratified into three gradients - upstream, midstream and lower stream Catchments that cover Mufindi and Iringa District in Iringa Region. The gradients were categorized into specific elevation bands: 1546-2293 m.s.l for upstream, 946-1545 m.s.l for midstream, 699-945 m.s.l for downstream. In band one catchment where there is prominence of fisheries activities was purposively selected. Lake Ngwasi in Mufindi District and Igowole village were selected for upstream Catchment, Kibebe Catchment in Iringa district and Kibebe village were selected for midstream catchment and Mtera reservoir in Iringa district and Migoli village were selected for downstream catchment. Fish sampling was carried out in all three sites during early morning and evening. Fish were captured by fisherman using legal fishing gear, which is gillnet of 76.2 mm mesh size. The captured fish were counted and identified using field guide book.

3.2.2 Spatial distribution of fish in little Ruaha river catchments

The distribution of species was recorded as presence or absence of a given species in a particular habitat. Global Positioning System (GPS), was used for the documentation of the coordinates of the sites where the fish sample were recorded. A GIS tool was used to develop the spatial map which shows the spatial distribution of fish species in the study sites.

3.2.3 Determination of the contribution of fishing to community livelihoods

The sampling frame for this study was all people registered to engage in fisheries activities around the Little Ruaha River Catchments. Purposive sampling adopted in the

selection of four villages based on the proximity to Little Ruaha River Catchments. About 50 respondents were randomly selected from each village to make a total of 200 respondents. According to Yurdugul (2008) the minimum number of respondents recommended to represent a population is 30. The greater the precision of estimate and confidence in the results, the larger the sample size needed (Zhang and Yuan, 2016). Another factor, which is equally important, in determining the sample size is the amount of resources (time, money, and personnel) available for the study (Atilgan, 2013). Data (qualitative and quantitative) were collected through field observations and questionnaire survey. Secondary data were collected through relevant literature reviews. Relevant sources such as District fisheries office were used. Supplementary information was collected through personal observation in the field for the purposes of cross checking some of the information obtained through questionnaire survey especially on the type of fishing activities and other economic activities conducted along the Little Ruaha River Catchments.

3.3 Data analysis

3.3.1 Spatial and temporal diversity and abundance of fish along little Ruaha river catchments

3.3.1.1 Species diversity

Shannon's diversity index (Shannon and Weaver, 1963) and equitability index (Piélou, 1969), were used to make a comparative study of the spatial and temporal variations of the diversity of fish along the Little Ruaha River Catchments:

$H' = -\sum (P_i \ln P_i)$; where H' is the index of species diversity, P*i* is the proportion of individual in the species and ln is the natural logarithm; $E = H' / \text{Log2}(Rs)$; where H' is the Shannon's diversity index and Rs is the total number of species. The differences in species richness (number of species, Shannon diversity and equitability) in habitats and

seasons were evaluated using the Kruskal-Wallis test, a non-parametric analysis of variance, followed by Mann-Whitney. Shannon's diversity index, equitability index and all statistical analyses were carried out by the software PAleotological STatistic (PAST) version 2.17 (Hammer *et al.,* 2001).

3.3.1.2 Abundance of fish species

A relative abundance of fish species in various habitats was calculated as the ratio of the number of species found in each habitat and the total number of species recorded in all study habitats.

3.3.1.3 Spatial distribution of fish

GIS based spatial analysis technique was used to establish the spatial distribution of fish in the different catchments of the Little Ruaha River.

3.3.2 Determination of the contribution of fisheries activities to community livelihoods around little Ruaha river catchments

Both qualitative and quantitative data analysis was used. Qualitative information were analyzed using content analysis. This method, allow the information collected through verbal discussions with key informants and focused group discussion to be analyzed. The method enables the researcher to include large amount of information and systematically identify its properties (Mihas, 2019). Data collected through questionnaires were analyzed by using Statistical Package for Social Science (SPSS) computer software version 16.0. Microsoft Excel was used to draw figures and tables. Information on contribution of fisheries activities to local economy and livelihoods of communities in Little Ruaha River were analyzed descriptively and summarized into frequencies, percentages and mean and presented in tables and graphs.

CHAPTER FOUR

4.0 RESULTS

4.1 Spatial and temporal diversity and abundance of fish in the little Ruaha river catchments

4.1.1 Fish species richness by habitats and seasons

A total 250 individuals belonging to 5 fish species five genera and five families were captured in the Little Ruaha River Catchments in the dry and the rain season (Table 1). The highest species richness was recorded in downstream (lower reach) catchments (n=4), followed by upstream (upper reach) catchment (n=3) and the lowest richness was recorded in midstream (middle reach) catchment (n=2). All five identified families, genera and species were present in both dry and rain seasons.

Table 1: Families, Fish species composition and richness in the little Ruaha catchments

			Number of individuals				
Family	**Genera**	**Species**	**USC**	**MSC**	**DSC**	**RS**	**DS**
Cichlidae	*Oreochromis*	*Oreochromis urolepis*	20	32	12	110	63
Clariidae	*Clarias*	*Clarias gariepinus*	2	3	11	12	4
Mochokidae	*Synodonts*	*Synodonts spp*	0	0	18	12	6
Alastidae	*Hydrocynus*	*Hydroynus vittatus*	0	0	29	21	8
Cyprinidae	*Labeobarbus*	*Barbus macrolepis*	14	0	0	6	8

Note: USC=Upper stream Catchment, MSC=Midstream Catchment, DSC=Downstream Catchment, RS=Rain season, DS=Dry season

4.1.2 Fish species diversity by habitats and seasons

Fish diversity varied across spatial gradients (Table 2). The highest species diversity was recorded in the downstream (lower reach) catchments (*H'* = 0.962), followed by upstream (upper reach) catchment (*H'* = 0.8544), and the lowest species diversity was recorded at the midstream (middle reach) catchment (*H'*= 0.2925). Kruskal-Wallis test, shows no significant difference (DF = 2; P > 0.05) in species diversity between habitats. Fish species diversity was higher during the rainy season (*H'*= 1.036) compared to dry season (*H'* = 0.9989). Mann-Whitney test also suggest no significant difference (P >0.05) in species diversity between seasons.

Table 2: Fish species richness, abundance and diversity in the Little Ruaha river catchment by habitat and season

	USC	MSC	DSC	RS	DS
Species Richness	3	2	4	5	5
Individual	36	35	179	161	89
Shannon-Weiner diversity (H')	0.8544	0.2925	0.962	1.036	0.9989
Evenness	0.7833	0.6699	0.6542	0.5634	0.5431

Note: USC=Upper stream Catchment, MSC-=Midstream Catchment, DSC=Downstream Catchment, RS=Rain season, DS=Dry season

4.1.3 Relative abundance of fish species by habitats and seasons

A total of 250 of individual fish were recorded during the study (Table 3). The most abundant species was *Orechromis urolepis* (69%), followed by *Hydrocynus vittatus* (11.6%), Synodonts *spp* (7.2%), *Clarias gariepinus* (6.4%) and *Barbus macrolepis* (5.6%) (Table3).

Table 3: Relative abundance of fish species in the little Ruaha river catchment southern Tanzania

		Habitat			Total
Species	**N**	**USC**	**MSC**	**DSC**	**%**
Oreochromis urolepis	173	20	32	121	69.2
Hydrocynus vittatus	29	0	0	29	11.6
Synodonts spp	18	0	0	18	7.2
Clarias gariepinus	16	2	3	11	6.4
Barbus macrolepis	14	14	0	0	5.6
Total	**250**	**36**	**35**	**179**	100

Note: N= Number of individuals, USC= Uppstream Catchment, DSC= Midstream Catchment, DSC= Downstream Catchment

Habitat wise, the fish species were most abundant in the lower reach habitat than other habitats. Also the species were most abundant in the rain seasons than dry season (Table 4). Statistical test also show that there is significance difference ($p<0.05$) of fish abundance between habitats and seasons.

Table 4: Relative abundance of fish by habitats and seasons in the little Ruaha river catchments sothern Tanzania

	Total number	**Percentage**
Downstream Catchment	179	71.6
Upstream Catchment	36	14.4
Midstream Catchment	35	14.0
Rain season	161	64.4
Dry season	89	35.6

4.2 Spatial Distribution of fish in the Little Ruaha River Catchments

The most abundant species was *Oreochromis urolepis* compared to other species. However, spatially *Oreochromis urolepis* and *Clarias gariepinus* were present in all catchments though with considerable variation in their abundances among the different river catchments (Figure 3). *Hydrocynus vittatus* and *Synodonts* species were collected

only from the downstream catchments and their abundances varied. *Barbus macrolepis* was found in the upper catchment only.

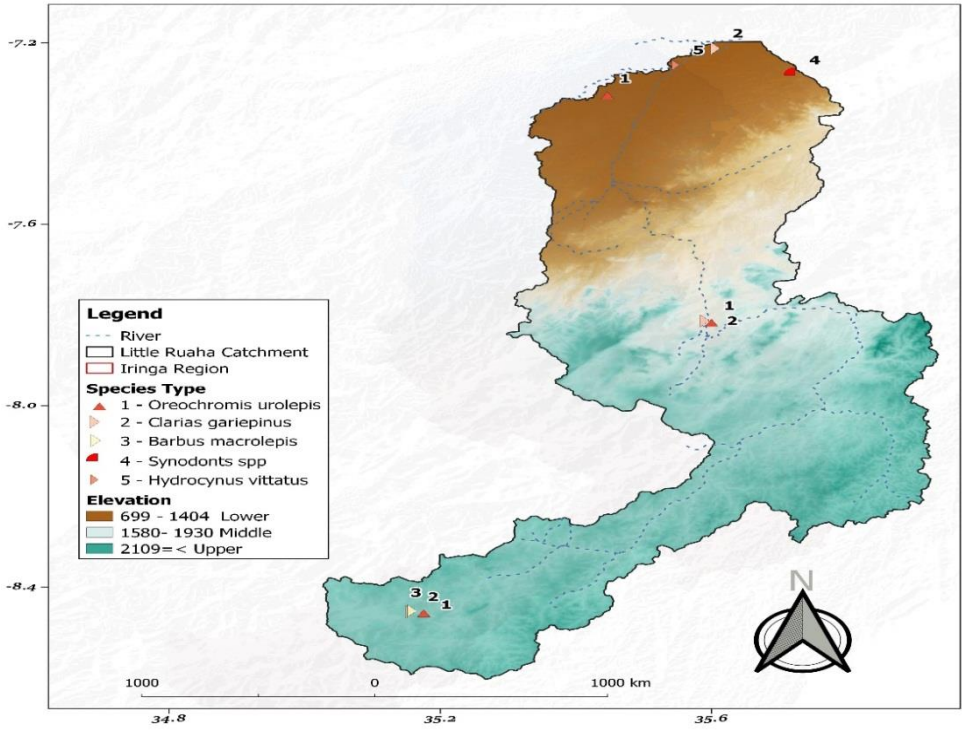

Figure 3: Spatial distribution of fish species along the Little Ruaha river catchments

4.3 Contribution of Fisheries Activities to household income

4.3.1 Socio-economic characteristics of households

The socio-economic characteristics of respondents included in the study were age, education level, marital status, duration of residence and size of household members. The results (Table 5) show that, about 75.5% of respondents were married, 16.5% were single, and 4% were widowed and 4% were divorced. Also the majority of these respondents lies between the age of 19 and 54, where by 52% of respondents were aged between 18-35 years, 44% were aged between 36-53 years, and 4% were aged above 53 years.

Most of the respondents (70.5%) had primary education, 15% secondary education, 11.5% had no formal education, and 3% had college education. About 55.5% of households had an average household size of less than 5 people, 37.5% had an average family size between 6-10 people, and 7% had household size of more than 10 members.

Table 5: Social economic characteristics of respondents (n=200)

		Villages %				
Social attributes		**Makatapora**	**Migoli**	**Igowole**	**Kibebe**	**Total %**
Marital status	Single	10	14	18	24	16.5
	Married	88	72	78	64	75.5
	Divorced	2	4	4	6	4.0
	Widowed	0	10	0	6	4.0
Age (years)	18-35	44	50	42	72	52
	36-53	54	44	50	28	44
	Above 53	2	6	8	0	4.0
Education level	No formal education	8	10	18	10	11.5
	Primary education	74	62	72	74	70.5
	Secondary education	14	20	10	16	15.0
	Others	4	8	0	0	3.0
Household size	1-5 members	66	30	60	66	55.5
	6-10 members	24	60	36	30	37.5
	Above 10 members	10	10	4	4	7.0

4.3.2 Contributions of fisheries to household income in the villages of Migoli, Kibebe and Makutapora

4.3.2.1 Economic activities

Table 6 shows the main economic activities in villages adjacent to the Little Ruaha River Catchment. The main economic activities included fishing, agriculture, livestock, fish related business, groceries and motorcycle operations. (Fishing and agriculture was one of the daily activity undertaken by majority of households accounting for 29.5% fishing only and 32.5% combined fishing and crop production, A combination of fishing, livestock production and other economic activities accounted for 15% while fishing and other activities accounted for 13%. Combined fishing, crop production, livestock production and others accounted for the lowest proportion.

Table 6: Economic Activities in Migoli, Makatapora, Igowole and Kibebe villages (n=200)

Activities	Frequency	Percentage
Fishing and agriculture	65	32.5
Fishing	59	29.5
Fishing, agriculture and others	30	15.0
Fishing and others	26	13.0
Fishing, agriculture, livestock prod and others	19	9.5
Fishing agriculture and others	1	0.5
Total	**200**	**100**

4.3.2.2 Income generation

The results show that percentage of production and income earning differed between the villages (Figure 4 & 5). Production of fish can range from 50kg up to 100kg or above per month (Figure 4), whereby according to fisheries officers one kilogram of fish range 5 000-10 000 TZS. The village which earn the highest range of income from

fish production is Makatapora where by 72% of respondents earn the income from fisheries activities that range above 500 000 per month, 16% of respondents earn between 400 000-500 000, 12% of respondents earn between 300 000-400 000 and no respondents earns below 300 000. In Migoli village, 62% of the respondents earn above 500 000, 26% of the respondents earn between 400 000-500 000, 12% of the respondents earn between 300 000-400 000 and none of the respondents earn below 300 000. Study finding show that, in Igowole village 4% of them earn between 400 000 - 500 000, 28% of the respondents earn between 300 000 - 400 000, 58% of the respondents earn between 200 000-300 000 and 10% of the respondents earn between 100 000-200 000. Therefore majority of respondents in Igowole village earn 200 000-300 000, and none of the respondents earn above 500 000 per month. The last village is Kibebe where by 6% of the respondents earn 300 000-400 000, 54% of respondents earn 200 000-300 000, 40% of the respondents earn 100 000-200 000 and none of the respondents earn above 400 000 per month.

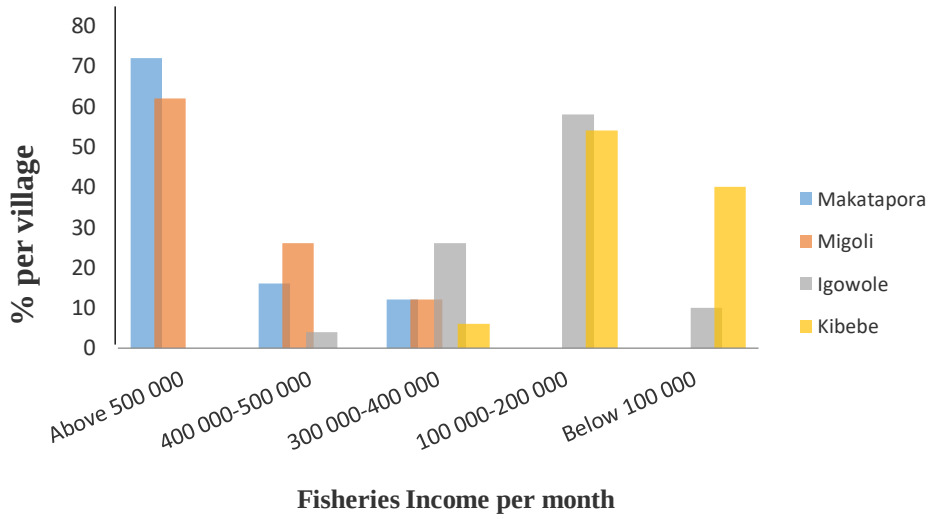

Figure 4: Income generated by fishing in study sites

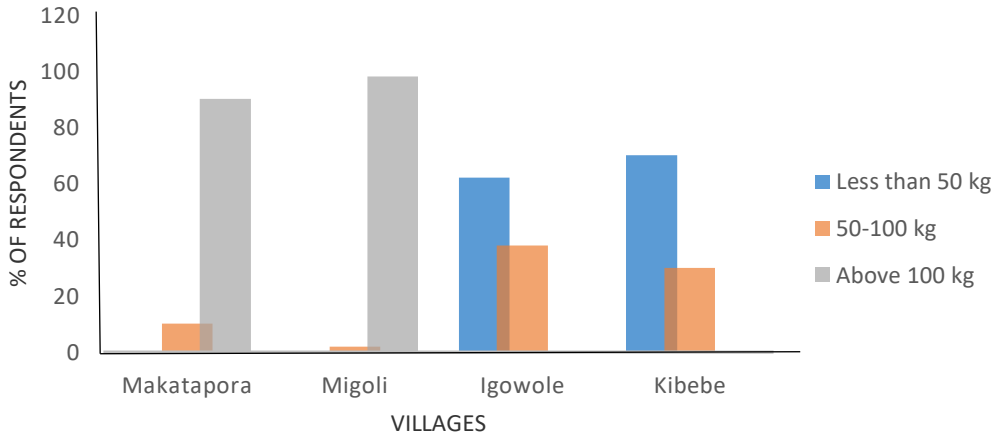

Figure 5: Total production of fish per month in the study sites

4.3.2.3 Source of protein (household food)

The study show that of the different sources of protein, fish is among the most important sources of protein. About 24-78% of protein in the villages of Makatapora, Migoli, Kibebe and Igowole are from fish catch. These villages are located adjacent to the river catchment, where they can easily accessthe commodity (Figure 6).

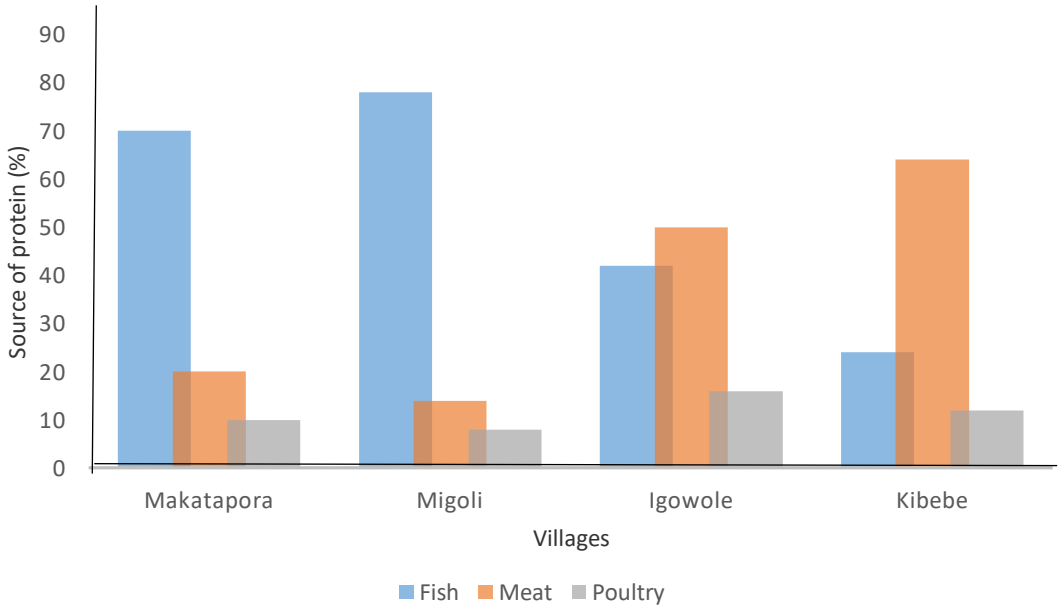

Figure 6: Source of protein in Makatapora, Migoli, Igowole and Kibebe villages

4.3.2.4 Fish marketing and value chain

The study found that fishers have three options of selling fish. First they sell within Iringa region, second outside the region and third they do sell both within and outside of Iringa region. Fish are used both for domestic consumption and trade in the local or external markets. About 65% of fishes are sold within the study area possibly inter household trade or in local markets, 14.5% outside of the study area 20.5% in both within and outside Iringa region (Figure 7).

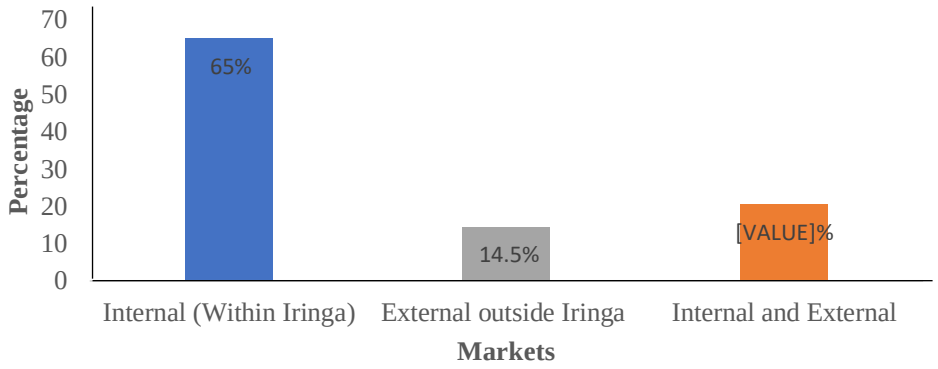

Figure 7: Fish market in Makatapora, Migoli, Igowole and Kibebe villages

4.3.2.6 Household use of fish income

The results show that 49% of money obtained from fish sales are used for household activities including paying school fees and health care for children and family members, procurement of other household requisites like food, clothing and fishing equipment, furthermore about 25% of money used for buying food and 26% for paying taxes and licenses as the means of contributing the development of social services to the area including building of schools, hospitals and other development (Figure 8).

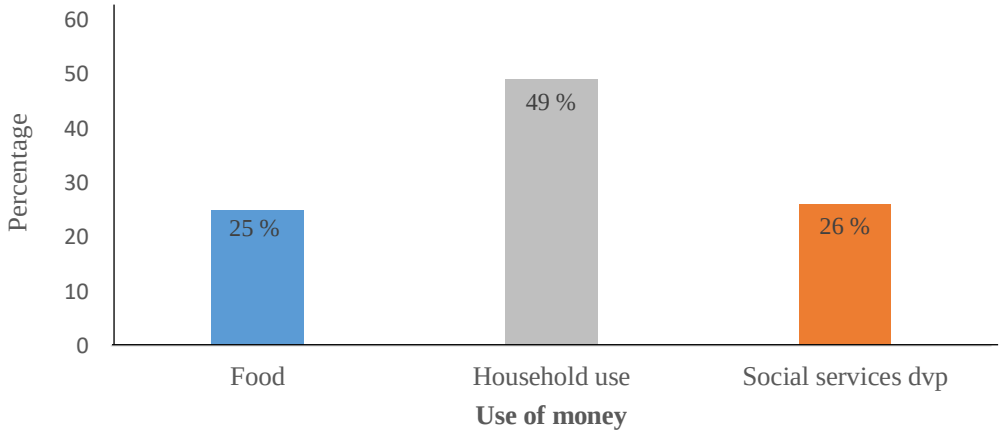

Figure 8: Usage of money obtained from fish sale in Migoli, Makatapora, Igowole and Kibebe villages

CHAPTER FIVE

5.0 DISCUSSION

5.1 Spatial and temporal diversity and abundance of fish in little Ruaha river catchments

Understanding the diversity, abundance, and distribution of fish species in river ecosystems are among the central goals in tropical ecological research (Herder and Freyhof, 2006). In this study, the total of 250 individuals, belonging to 5 fish species, five genera and five families were captured in Little Ruaha River Catchments in dry and rain seasons. According to Payne (1995), more than 38 species have been recorded in the Ruaha basin With respect to biodiversity, a high proportion of the 38 species (that is about 40%) are endemic and found nowhere in the world, including some of the most commercially important species (Mgaya, 1998). The most important species in the river is the endemic tilapia *Oreochromis urolepis*. This sustains the enormous fishery that has developed in the Mtera reservoir as well as those of the Great and Little Ruaha rivers (Payne, 1995). The differences in numbers of fish species between the previous and currently study was probably attributed to different sampling techniques, area covered, elusive and cryptic behavior of fish (Quirino *et al.,* 2015). For instance, Payne (1995) employed gillnets of various mesh size to allow catch ability of variety of fish and most of the studies included Ruaha River Catchments in general. Also according to Iringa District Fisheries Officer, the use of illegal fishing gears, such as beach seines and fish nets with illegal mesh size (undersize), have been increasing that destroy the environment and decrease fish production and biodiversity in general.

No significant seasonal differences were seen in fish diversity between the sampling habitats. Species richness, Shannon diversity did not change significantly from one season

to another in the river catchments as also observed by Konan et al. (2006) and Felix *et al.* (2013). In other tropical regions, Flinders *et al.* (2009) suggested that the assemblage structure is determined more by average or persistent differences in environmental conditions among sites, than by seasonal variation in environmental conditions. Also the homogeneity in fish species composition among the habitats, may result from connectivity between one catchments to another by the Little Ruaha River, because fish can migrate more easily between them.

Oreochromis urolepis was the most abundant specie due to their high reproduction rate and their feeding behavior in variety of food. Chale (2004) reported that O. urolepis is very fecund species compared to other species in Mtera. Also Johansson (1997) reported that *O. urolepis* are omnivorous, feeding on aquatic plants, worms and insects which makes endemic tilapia being an important specie in the Little Ruaha River Catchments. However spatially *Oreochromis urolepis* and *Clarias gariepinus* were present in all catchments.

Also among three habitat, the downstream habitat was the most abundant in species. This is due to environmental variability and stability at Mtera cachments because the catchment is not only fed by Little Ruaha River, but it also receive water from the Great Ruaha and Kisigo River that cause the catchment to have high fish species biomass and supporting important artisanal fisheries (Chale, 2004).

Fish abundance was lowest at the upper and middle catchments, because of the altitudinal gradient of the upper part that inhibit temperature variability which is necessary for growth and production of fish (Knouft, and Anthony, 2016). Also the catchments can experience large variations in water level during a short time period and extreme low

water during the dry season which can reduce fish abundance (Winemiller and Leslie, 1992). The abundance of fish was seasonal with high abundance in rain season compared to dry season because during the wet season there is water input into the catchments which results into migrations of fishes from the river to the catchments therefore it is easier to catch fish into migrations pathways (Sosovele *at el.*, 2002). The fisheries activities are closely linked to cycles of the moon and tides, seasonal changes in the climate and the breeding patterns of the fish and other species on which they depend. Therefore there is a close relationship between weather and fishing operation (Vieira *et al*., 2013).

5.2 Contribution of Fisheries Activities to Household Income

This part discusses the various information obtained from the study area on the contribution of fishing to household income. Social and economic factors play an important function in utilization of various resources with the aim of improving economic status. If done without consideration of the environmental impact can lead to unhinged natural resource utilization resulting into depletion. The socio-economic characteristics of the population that were included are age, education level marital status, duration of residence and size of household members. For example, the majority of the respondents are aged between 19-54 years, which implies that, most of the people in the study were in economically productive age group, as the age above 54 years is considered less economically active because the members are too old though they might be important in guiding the young generation in regard to resource management. Mayetta (2004) reported that older people have indigenous knowledge with regard to natural resources management and values after using them for decades. Thus they can be resourceful in guiding the young generations on the cultural practices to protect and manage natural resources. The results also suggest that that majority of the respondent attained primary

education as the highest level of education. With this level of education it further implies that majority of respondents are able to read and write, therefore this means that they can be trained and acquire the knowledge on sustainable utilization of fisheries resources. The increase in education level, increases the awareness and thereby creating positive attitudes, values and thereby motivating people to manage natural resources sustainably (Katani, 1999); URT (2012) reported that large household size has an implication in resource utilization because large household size means high consumption units within the household and this can lead to more extraction of the resources where by in the results, most of the households, had the household size of less than 5 people which is within the national average household. The fishing activities also have several benefits which contribute direct or indirect to community livelihoods adjacent Little Ruaha River Catchments as follows.

5.2.1 Economic activities (fisheries as source of employment opportunities)

Findings show that, the main economic activities in the study area are fishing, agriculture, livestock and others like different kinds of business such as fish related business, groceries and motorcycle operations. Almost all people mentioned fishing and agriculture as one of the daily activity conducted in the areas adjacent Little Ruaha River Catchments Fisheries is common economic activities to the villages of Migoli and Makatapora around Mtera dam. The economic activities in the society include how goods and services are produced, distributed and consumed at all levels which can be assessed currently and forecasted to measure the significance impact of a particular activities (NACE, 2008). These economic activities can be taken as employment that assures food security for people and it should be emphasized that in a significant number of cases, small-scale fisheries activities take place in rural areas, where alternative employment opportunities may be scarce or even non-existent (FAO, 2018) reported that, an estimated forty-one

million people worked as fishers and fish farmers as a full-time, or part-time, occupation in 2004, up from about thirty-nine million in 2000. The majority of fishers are small-scale, artisanal fishers, earning a living from coastal and inland fishery resources.

5.2.2 Income generation

Fishing activities in Iringa region generated direct benefits to the community where by income generation is the one among those benefits. Therefore this study confirm that fisheries has contribution to household cash income because the results show that the fish catch can be up to above 100kg, and a household can earn more than 500 000 TZS per month. In these circumstances, access to harvesting of fishery resources, may represent the only option available to make a living and maintain food purchasing power, where fisheries is their main source of employment. Increasing revenue has also been observed alongside the growth of fishing communities along the RCA and increased pressure on these resources. For example, income from fishing sector for Iringa Rural District has been increasing from Tsh. 4 million in 1995 to Tsh. 17 million by October 2001 (Sosovele *et al.,* 2002). Béné (2006) state that, in the developing world more than one hundred million people are thought to currently depend directly upon small scale fishing and postharvest activities (fish processing and fish trading) for at least part of their income. Small scale fisheries also employs millions of fishery associated workers including fish processors, carpenters, transporters and traders of goods critical to the sector (ice, salt, petrol food; and non-food goods) as well as fish. Also Ninnes (2004) indicate that in fishing communities where fishing is usually the main activity- the degree of dependence on fisheries for cash income can be extremely high. But they also show that it may not necessarily be 100 percent for instance as it observed in this study 29% of households depends an income from fisheries.

5.2.3 Fish as a source of protein

The results reveal that fish is among the most important sources of protein in the study area among the various sources. Villages in the study area, bordered the river catchments, hence easily access the commodity. Worldwide, more than 1 billion people rely on fish as an important source of animal protein especially where other sources of animal protein are scarce or expensive (Béné, 2006). According to (FAO, 2014), fish provide 19 percent of the protein intake of the developing countries. However this share can exceed 25 percent in the poorest countries and is up to 90 percent in isolated parts of coastal or inland areas, where river, floodplain, or lake-related fishing activities play a crucial role in food supply. Therefore, even a small amount of fish caught every day can be an important dietary supplement for the poor people who cannot always afford a variety of different sources of food (Béné, 2006). In the Ruaha Catchments Areas fish is an important element in the local diet as well as an important source of income to the local communities and the District Councils, and most of fish are used for domestic consumptions and are usually fresh (Sosovele *et al*., 2002).

5.2.4 Fish marketing and value chain

The study found that fishers have three options when it comes to selling fish. First, they sell within Iringa region, second outside the region and the third they do sell both within and outside of Iringa region. Sosovele *et al*. (2002), reported that fishing is an important economic activity that has been expanding significantly in Iringa region particularly in the villages adjacent to the Little Ruaha River catchments, as a result of available markets and good prices found in the urban areas. Most fish catch of Ruaha Catchment Areas are used for domestic consumption and are usually fresh and others are smoked and sold to different parts in and outside the country like Tabora, Iringa, Singida, Mbeya, Songea, Dar es Salaam, Dodoma, Morogoro, Tunduma, and Njombe and possibly exported to

Zambia and Malawi. Fish traders (mongers) usually visit different fish landing sites daily to buy fish and transport to markets in different areas. Also Béné (2006) reported that, it is clear that the local fish processors and traders are benefiting from the external fish trading, through adding values and increasing price for external market.

5.2.5 Household use of income from fisheries

The results show that money obtained from fish sales used for household activities including paying school fees and health care for their children and extended family members, procurement of other household requisites such as food, clothing and fishing equipment, buying food and paying taxes and licenses as the means of contributing to the development of social services to the area including building of schools, hospitals and other infrastructure development. According to the fisheries officer of Iringa district, the fish sector contributes up to 300 million per annum in the district from fish licenses and taxes. Global Fisheries Alliance (2009) reported that fisheries contribute to African development by stimulating the growth of a cash based economy and fish caught were sold on a daily basis. Also the theory that economic substitution will reduce pressure on fishing resources assumes that fishing provides the primary source of income for poor households, and that when another source of income replaces this, they will have less need for the fishery (Hill, 2005).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Understanding the dynamic nature of spatiotemporal variation and distribution patterns of fish as well as its contribution to the livelihoods of the community, is necessary to inform fisheries monitoring, management and conservation programmes. The longitudinal gradient of the Little Ruaha river system alters fish assemblage structure, which are modulated by seasonal rainfall changes. The seasonal flow of the river influences fish assemblage structure, with greater abundance and biomass of fish in the river catchments, although no differences in species richness and diversity between habitats and seasons. Sustainable fisheries management in river basins contributes significantly to community livelihoods through income generation, protein availability and employment opportunities.

6.2 Recommendation

Based on the findings, discussion and the conclusion above, the following recommendations were drawn:-

i. Management of river basins should integrate fisheries activities as among the options for integrated river basin management. Also, there is the need for the authorities in taking considerations to these catchments so as to ensure the conservation of biodiversity including fish in Little Ruaha River catchments.

ii. It is also recommended that future studies should include other sampling techniques that will sample the whole size range of fishes.

iii. The great contribution of fisheries to livelihoods improvement, calls for a greater need of involving rural communities in conservation activities so as to ensure that fisheries resources are utilized sustainable level.

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APPENDICES

Appendix 1: Household questionnaire in assessing the contribution of fisheries activities to community livelihoods

Division……..

Ward……

Village…….

Village registration number…….

Date of interview……..

Name of enumerator…….

A. General Information Questions

Household characteristics:

1. Name of respondent …….

2. Tribe…….

3. Age……

4. Sex……Male 1 Female 2

5. Marital status (Tick appropriate answer)

S/n	Marital status	Code
i.	Single	1
ii.	Married	2
iii.	Divorced	3
iv.	Widowed	4

6. Duration of residence in the village in years…….

7. Education level (Tick appropriate answer).

S/n	**Education level**	**Years of schooling**	**Code**
i.	No formal education		1
ii.	Primary education		2
iii.	Secondary education		3
iv.	Others (Specify)		4

8. Number of household members……

9. Household composition (Tick appropriate answer).

Age(years)	Female	Male	Total	Code
<18				1
18-60				2
>60				3

B. Fisheries and other economic activities

1. What are the major sources of household income?

S/n	Source of household income	Tick	Income (year/month)	Code
i.	Fishing			1
ii.	Crop production			2
iii.	Livestock production			3
iv.	Both livestock and crop production			4
v.	Tourism			5
vi.	Others (Specify)			6

2. Do you participate in any kind of fisheries activities? Yes ( ) No ( )

3. What are these activities?

…….

……

…….

4. Explain how you conduct these activities

…….

……

C. Fisheries benefits and loses

1. Which benefits do you get from fisheries activities? (Tick appropriate answer).

S/n	Activity	Tick	Code
i.	Food and nutrition		1
ii.	Employment		2
iii.	Development of social services		3
iv.	Others		4

2. Explain Where and how

Food and nutrition……

……..

…….

Employment……..……..

……

…….……..

Development of social services……..…….

…….……..

……

Others…….

……

3. What are the quantities, uses and values of fish you have harvested for the past 12 months?

Fish type	Season[1]	Frequency of fishing[2]	Labour[3]	Unit of production	Total production	Uses		Frequency of consumption at household[4]	Price per unit	Type of market[5]	Total value
						Own use	Sold				

1 Codes: 1= Dry season (June-November), 2= Rain season (Dec-May),

2 Codes: 1= everyday, 2= once in a week, 3= once in a month, 4= i cannot tell

3 Codes: 1=one, 2= two, 3= three, 4=four, 5= more than 4

4 Codes: 1= everyday, 2= once in a week, 3= thrice in a week, 4= once in a month

5 Codes: 1= internal within Iringa region in local markets, 2= external outside Iringa region

Appendix 2: Questions for village leaders

1. Name of the village

2. Name of the leaders

3. Oral history of the area about fisheries activities.

4. Which groups of people engaged in fisheries activities?

5. What are the benefits obtained from fisheries activities?

6. Is there any financial support that facilitates fishing?

7. Are there any people coming from outside the district to perform fishing, why?

8. What was the situation in the past days, current and what are the expectations?

9. Awareness on the importance of fishing in a respective area

10. What are your general recommendations?

Appendix 3: Questions for District Fisheries Officer

1. What are the factors that influence fishing activities in your area?
2. Is there any relationship between fishing activities and the improvement of local livelihood?
3. What are the activities performed in relation to fishing?
4. Who supports the fishing activities financially (both fishing and its related activities)?
5. How does the government benefit from fisheries activities?
6. What is the condition of fishing in your area?