THE CONTRIBUTION OF LITTLE RUAHA RIVER TO THE INCOME OF THE ADJACENT HOUSEHOLDS, IRINGA, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL AND NATURAL RESOURCES ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE.

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ABSTRACT

This research for assessing the contribution of Little Ruaha River to the income of the adjacent households was conducted in four selected villages. The main focus was on assessing how individuals, households and communities depend on the river for their income. Specifically, the study aimed at examining the river regime changes for the past 47 years, assessing the main economic activities practiced by people in the elected villages, determining the contribution of the river to the households' income, evaluating the perception of people regarding river flow change over time and its linkage to household income. Both primary and secondary data were employed in answering these specific objectives. Questionnaires were administered to 200 randomly selected respondents in the four selected villages and supported by secondary data from Rufiji Water Basin Office and Agriculture department in the District Council Office. Simple linear regression model was used to examine the flow changes in little Ruaha river. To assess economic activities conducted by households, descriptive statistics was used to analyze data. Results show that, there is no significant changes in river flow for the period of 47 years. Findings reveal that, paddy production in the area is the main economic activity conducted by majority of the households. Results also indicate that, there is no relationship between river flow change and household income. Despite the insignificant changes in the river flow of Little Ruaha River, the household income tends to increase over time, plausibly because of the agricultural technology introduced to the communities. Increasing public knowledge on Little Ruaha River flow to the community is important, along with exploration of other economic activities which do not jeopardize the sustainability of the river. More research using robust methodologies to ascertain river flow changes and the factors influencing the change is of paramount importance.

DECLARATION

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

_____ _____

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(MSc. Candidate)

The above declaration is confirmed by:

_____ _____

Professor John F. Kessy Date

(Supervisor)

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DEDICATION

This work is dedicated to my family, especially my parents Professor Deogratias F. Rutatora and Imaculatha Nsiima. My brothers Danstan Rwetabura and Patience Rwemigira and my lovely sister Jacqueline Kemilembe. I really appreciate for their physical and emotional supports during the entire period of my study.

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ARI	Africa RISING
ASDP	Agricultural Sector Development Programme
ASF	Avocats sans Frontieres
CTA	Technical Centre for Agricultural and Rural Cooperation
DADPs	District Agricultural Development Plans
EC	European Commission
EPA	Environmental Protection Agency
HDI	Human Development Index
IFAD	International Fund for Agricultural Development
JICA	Japanese Internal Cooperation Agency
MATI	Ministry of Agriculture Training Institute
NEMC	National Environmental Management Council
NIC	National Irrigation Commission
OECD	Organization for Economic Co-operation and Development
PHRD	Planned Human Resource Development
RWBO	Rufiji Water Basin Office
SDG	Sustainable Development Goals
SNAL	Sokoine National Agricultural Library
SNV	Stichting Nederland's Vrijwilligers
SRI	System of Rice Intensification
TAGRODE	Tanzania Grass Roots Oriented Development
TZS	Tanzanian Shillings
UN	United Nations
UNDP	United Nations Development Programmes
USDA	United States Department of Agriculture

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Water is a natural resource which is an essential component as life supporting system on the earth (Pimental *et al.,* 2004). Globally, water plays a key role to many households in sustaining life and providing various social and economic needs (Noga and Wolbring, 2012). In addition, water is critical for supporting aquatic ecosystems to maintain its ecological integrity and other environmental benefits whether in water bodies, catchment areas or river flows (Randhir, 2012). In that regard, the benefits of water to both human life and ecosystems at large are well recognized and given priority in the internationally established Sustainable Development Goals (SDGs), specifically SDG 6 which emphasize on, access to clean water and sanitation and SDG 14 Life below water (Assembly, 2015).

Water can be affected in different ways in their sources either naturally or artificial. Artificial factors affecting water in their sources includes pollution which is mainly due to anthropogenic activities. On the other hands, natural factors such as erosion and climate change associated with increasing unpredictable rainfall and temperature also tend to affect water (Haseena *et al.,* 2017). All these factors affect water either by increasing or decreasing the water level content in the water sources. The decrease in the water level content in the water sources shrinks water supplies while the demand for water is high. These challenges water managers to simultaneously meet the needs of growing communities, sensitive ecosystems, farmers, ranchers, energy producers and manufacturers (Jachimowski, 2017). The decrease in the water level content might lead to complete drying of the water sources if precautions to enhance forestation to attract rainfall, protection of biodiversity and sustainable management of water resources are not taken into consideration (Yousefi *et al.,* 2018). The increase in the water level content in

the water sources may result into increase in runoff, flooding, or sea level rise. These effects can reduce the quality of water and damage important infrastructures used to transport and deliver goods and services (Yousefi *et al.*, 2018).

Little Ruaha River is one of the rivers found in the Southern Highlands of Tanzania. It is the main source of water especially during dry season to the surrounding communities providing fresh water for domestic uses and for irrigation activities. The little Ruaha is also important to the ecology of the Ruaha National Park. Little Ruaha River provides water to the Mtera Dam of which about 18% of the water helps in power generation. Although Little Ruaha River is a main source of water supply during dry season, communities along Little Ruaha River are still poor and face water related conflicts between farmers and livestock keepers and downstream and upstream users (Mbungu and Kashaigili, 2017). Based on this introduction, it is therefore important to assess the contribution of Little Ruaha to the income of the adjacent households and understand its water flow change in Little Ruaha River, how extreme is the change and the relationship between the change and the household income.

1.2 Problem Statement and Justification

Unlike Great Ruaha River that has been facing dryness since early 1990 (Walsh, 2012), Little Ruaha River has not been facing dryness and it is the one that supports livelihoods of the adjacent communities and the ecosystems during dry season (Mbungu and Kashaigili, 2017). Communities residing along Little Ruaha River are highly dependent on the river for their economic activities to boost their household income. However, these communities along Little Ruaha River are still poor and struggling to sustain their livelihoods. Different studies show that there is a link between river regime changes and the household income (Baleta *et al.*, 2016; Kauffman, 2016). According to Baleta *et al.*

(2016), as Mekong River flow decreased also the household income decreased. Kauffman (2016) also found similar results where the increased flow in Delaware River flow resulted into an increase of household income residing along the river increased. Several studies have been conducted along Ruaha River focusing on hydrology of a data-scarce tropical watershed using the soil and water assessing tool (Mbungu and Kashaigili, 2017), explaining climate change impacts, local knowledge and coping strategies in the Great Ruaha River (Kangalawe *et al*., 2011), causes of the river drying and strategies for preventing the river from completely drying (Kashaigili, 2010) and Rajabu, 2007) and on the impacts of climate change on water resources and agriculture and adaptation strategies (Pauline *et al*., 2016). However, most of these reviewed studies did not give attention to economic contribution of the little Ruaha River to the livelihoods especially income and fluctuations among households residing along the river. Therefore, this study aimed at finding out if there is river flow change in Little Ruaha River, how extreme is the river flow change, the knowledge level of people on water flow change and economic impact of river flow change in the household. It also aimed at pointing out the ecosystem changes and its impact on the income of the people that are dependent on the Little Ruaha River. Findings from this study are important to researchers, environmental management institutions such as National Environmental Management Council (NEMC) and water supply authorities to take evidenced based actions against water related problems originating from river regime changes along major rivers in the country. These rivers tend to confer multiple benefits to different stakeholders and water users, aquatic organisms and ecosystem at large.

1.3 Objectives

1.3.1 Overall objective

The overall objective of this study is to assess the contribution of the Little Ruaha River located in Iringa, Tanzania to the households of the adjacent local communities in the selected villages.

1.3.2 Specific objectives

Specifically, the study intends to:

i. Examine river regime change for the past 47 years in Little Ruaha River.
ii. Assess the main economic activities practiced by people in the selected villages.
iii. Determine the contribution of the river to the households' income
iv. Evaluate the perception of people regarding river flow change over time and its linkage to household income.

1.4 Research Questions

In order to address the stated specific objectives, the following questions were asked:

i. Is there any water flow change in Little Ruaha River for the past 47 years?
ii. What are the main economic activities conducted by river dependent households along Little Ruaha River?
iii. What is the contribution of the Little Ruaha River to the household income in the adjacent communities?
iv. Is there any linkage between river flow change and household income along Little Ruaha River?

CHAPTER TWO

2.0 LITERATURE REVIEW

There are various sources of water such as seas, oceans, lakes and rivers. Scarce water or no water at all in the sources brings effect to both livelihood and the ecosystems. Livelihood depends on water for various uses such as domestic activities, agricultural activities, industrial purposes, recreation and power generation (Cook *et al*., 2009). In addition, livelihood does not just depend on water for the above uses but water support the livelihoods of people in many different ways including both socially and economically. According to UN Water (2016), 95% of jobs in the agricultural sector, 30% of jobs in the industry sector, and 10% of jobs in the services sector are heavily dependent on water.

2.1 River Regime Change

A river regime can simply be defined as a difference in the discharge of the river throughout the year. While river discharge is the volume of water passing a measuring point or gauging station in a river in a given time (Leopold *et al.*, 1995). River regime describes two characteristics of a reach of an alluvial river: Firstly, it describes the variability in its discharge throughout the course of a year in response to precipitation, temperature, evapotranspiration and discharge basin characteristics; Secondly, it describes a series of characteristics power law relationships between discharge and width, depth and slope (Harris *et al.*, 2000). River regime changes might be due to climate change or anthropogenic activities. Literature indicate that, it is hard to differentiate if the changes are due to climate change or anthropogenic activities which is among the challenges encountered by this study. However, a lot of anthropogenic activities such as deforestation (Krasovskaia and Gottschalk, 2002) leads to climate change including

global warming. Climate change (climate parameters) might lead to river regime changes either by increasing or decreasing the volume of water. Although is challenging to differentiate the causes of river flow or regime changes but in most cases, generally most of the anthropogenic activities lead to the decrease of water volume. For example, overutilization of water from the river due to different agricultural activities such as rice plantation and deforestation which leads to removal of the blanket for absorbing heat from the sun light and exposure of the land into soil erosion and other land degradation issues tend to cause an increase in temperature leading to lack of rainfall due to climate change (Arnell and Gosling, 2013).

River flow regime studies are important for informing not only policy makers but also water users especially communities and other stakeholders along the water value chain. According to Herawati *et al.* (2017), the availability of water in Kapuas river in Indenosia is affected by river basin characteristics such as rainfall, vegetation and land cover type. Along with population and economy growth, there has been a change in land use that leads to changes in land cover types, thereby changing the river flow regime and affecting the availability of water in the river. Therefore, it is necessary to analyze water flow regime changes in the river to determine water availability for proper action plans in the future. The changes in the long-term hydrological regimes and human activities in the main Wei River in China showed a significant impact to the river flow regime (Zhang *et al.*, 2016). This study by Zhang *et al*. (2016), indicate that, the hydrological regime changes and potential human-induced impacts have been drawing increasing attention from local government and hydrologists. Under the combined influence of climate changes and human activities, the hydrological regime of the Wei River shows remarkable variations causing many issues such as lack of freshwater, water pollution, disastrous flooding and channel sedimentation. Therefore, it is evident that some river

regimes are changing in many parts of the world due to both climatic changes or anthropogenic activities.

2.1.1 Climate change

Climate change can be defined as a change in the statistical distribution of weather patterns when that change lasts for an extended period of time such as, decades to millions of years (National Research Council, 2012). It can also be referred to a change in average weather conditions, or in the time variation of weather within the context of longer- term average conditions (Bostrom and Lashof, 2007).

Climate change is caused by different factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Human activities have been identified as primary causes of ongoing climate change which is often referred to as global warming (Archer and Buffett, 2005). Other anthropogenic activities such as dust and increased emissions of greenhouse gases example from deforestation and use of vehicles might lead to climate change (Akbari *et al.*, 2009). However, climate change also affects anthropogenic activities such as agricultural and industrial activities. An increase in temperature in the globe may lead into dryness of water sources like rivers which may in turn affect agricultural activities which depend heavily on water. Physical evidences for climate change encompass a range of parameters such as artic sea ice decline, cloud cover and precipitation, vegetation, animals and historical and archaeological evidence (National Academy of Sciences, 2014).

Climate change affects not only livelihoods but also the ecosystem in general. The short- and long-term effects of climate change have awakened researchers to conduct different research works especially on what causes climate change, what are the effects of

climate change on the globe and how to prevent climate change and its impacts. Clifton *et al.* (2018), conducted a study on effects of climate change on hydrology and water resources in the Blue Mountains, Oregon, USA. This study explains the importance of water resource for both ecosystems and human uses in the semi-arid environment of the Blue Mountains, Oregon (USA). Water resources are among the mostly affected resources by climate change in both short and long-term basis. According to Dube and Phiri (2013), the reality of climate change is now a well-accepted reality and there is emerging evidence that climate change poses a massive threat for development especially in poor countries.

2.1.2 Detection of river regime changes due to climate change

Climate change leads to changes in river regime flow. According to Arnell and Reynard (1996), climate change is due to global warming and hence affects river flows and water resources. In this study by Arnell and Reynard, daily rainfall-runoff model and both equilibrium and transient climate change scenarios were used to investigate the potential changes in river flows in 21 catchments in Great Britain. Similarly, Doll and Schmied (2012) used the change in mean annual runoff (MAR) as one of the indicators for assessing the impact of climate change on freshwater resources. However, it is necessary to analyze changes of river flow regimes such as, changes in the temporal dynamics of river discharge, as these are important for the wellbeing of humans and freshwater dependent biota. Therefore, their study investigated the relation between climate-induced changes of MAR and changes of a number of river flow regime indicators, including mean river discharge, statistical low and high flows, and mean seasonal discharge in a global scale hydrological modeling.

2.1.3 Anthropogenic activities

These are activities caused or produced by human, and are mainly related to agricultural and industrial activities (Andrew, 2006). Human activities largely contribute to climate change by causing changes in the amounts of greenhouse gases, aerosols and cloudiness on the Earth's atmosphere. The largest known contribution of human activities to climate change is from burning of fossil fuels, which releases carbon dioxide gas to the atmosphere. Greenhouse gases and aerosols affect climate by altering incoming solar radiation and outgoing infrared radiation that are part of Earth's energy balance. Changing the atmospheric abundance or properties of these gases and particles can lead to a warming or cooling of the climate system. Since the start of the industrial era (about 1750), the overall effect of human activities on climate has been a warming influence. The human impact on climate during this era greatly exceeds that due to known changes in natural processes, such as solar changes and volcanic eruptions (Akbari *et al.*, 2009). Anthropogenic activities can directly lead to river regime changes due to overutilization of water resource such as in agricultural activities (rice plantation) and industrial purposes (Zhang *et al.*, 2016).

2.2 Water User Association

National Irrigation Commission (NIC) and Rufiji Water Basin Office (RWBO) control the associations in irrigation schemes including the Mbarali scheme under Ministry of water and Irrigation. The associations control water users, and make sure that every water user becomes a member. National Irrigation Commission and Rufiji Water Basin Office play different role in water use control. The main role of the National Irrigation Commission is to provide irrigation services to the agricultural sector. Through this National Irrigation Commission, water is made available to some industrial and commercial operations through some of its systems (Makoi, 2016). On the other hand,

the main role of Rufiji Water Basin Office is monitoring of water uses including the operations of Mtera and Kidatu dams (Lankford *et al*., 2004). However, these associations and organizations have both strengths and weaknesses which need to be considered when analyzing its effectiveness and efficiency.

2.3 Sustainable Livelihoods Framework

Sustainable Livelihoods Framework is a holistic, asset-based framework for understanding poverty and the work of poverty reduction. It can be applied at various levels of details such as a practical tool for designing programs and evaluation strategies. In addition, it provides a well-developed way of thinking about a complex issue in any community (Carney *et al*., 2000). A Livelihood comprises the capabilities, assets including both material and social resources and activities required for a means of living. According to Carney (1999), a livelihood is said to be sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the present and future generation. It contributes to the net benefits of other livelihoods at the local and global levels and in both long and short term (Chambers and Conway, 1992).

The concept of livelihood plays a role to the development sectors, providing important information, which in turn helps the development sectors to understand and analyze problems, demand and potentials with a household centered view, where it derives holistic approaches to address these issues. Different literatures have explained on sustainable livelihoods approach. According to Majale (2002), sustainable livelihoods approach is a holistic approach that tries to capture, and provide a means of understanding, the fundamental causes and dimensions of poverty without collapsing the focus onto just a few factors example economic issues and food security.

The main important principal assets or capital to livelihoods development are natural capital, social capital, physical capital, human capital and economic or financial capital (Morse *et al.,* 2009). These principals work together in order to attain sustainable livelihoods development. For livelihoods development to be achieved along the river, it is important to consider Natural capital since, river is categorized as a natural capital.

2.3.1 The concept of poverty

Water availability and consumption is directly linked to poverty. This study among other things, intended to address poverty issues for communities adjacent to little Ruaha River and to know the main causes and how to solve or alleviate it through enhancement of potential income generating activities such as irrigation schemes. Thus, the review addresses the concepts of poverty and poverty alleviation generally as the most promising strategy for household income generation and development in Pawaga division.

The term poverty has been defined differently by different scholars and due to different factors (Geoff and Kate, 2009) and differences in discipline's backgrounds, approaches and ideologies. The dominant western definition since World War II has defined poverty in monetary terms, using levels of income or consumption to measure poverty (Grusky and Kanbur, 2006 cited in Geoff and Kate, 2009) and defining the poor by head count of those who fall below a given income or consumption or "poverty line" (Lipton and Ravallon, 1993). However, this economic definition has been complemented in recent years by other approaches that define poverty in a more multidimensional way (Subramanian, 1997). These approaches include the basic needs approach (Shreeton, 1981), the capabilities approach (Sen, 1999) and the human development approach (UNDP, 1990). Their acceptance is reflected in the widespread use of the United Nations Development Programmes (UNDP) Human Development Index (HDI), which is the

composite measure of three dimensions of human development: (i) life expectancy, (ii) educational attainment and (iii) standard of living, measured by income in terms of its purchasing power parity (UNDP, 2006).

It is also reflected in the Organization for Economic Co-operation and Developments (OECD) conceptualization of multidimensional poverty, defined as interlinked forms of deprivation in the economic, human, political, social-cultural and protective spheres (OECD, 2006). This study adopted the definition by Narayan (2000) where poverty is defined as a sense of helplessness, dependence and lack of opportunities, self-confidence and self-respect on the part of the poor. The acknowledgement of the multidimensionality of poverty is reflected in the range of both quantitative and qualitative methodological approaches adopted to conceptualize and measure poverty.

2.3.2 Poverty alleviation

Poverty alleviation refers to lifting the poor out of poverty (Mundy and Gladbach, 1999). Two approaches have been discussed extensively in various literatures: alleviation through growth and alleviation through redistribution (Mundy and Gladbach, 1999). Alleviation through growth is fundamental to combating poverty and the main argument in this approach is based on the fact that the standards of living cannot rise without new wealth generated through economic activities. An anti-poverty strategy must seek ways to generate wealth by revising investment, wage structures, terms of trade and other factors.

International Fund for Agricultural Development (IFAD), (2007) revealed that more than one billion people in the world live on less than $ 1 a day, 2.7 billion struggles to survive on less than $ 2 per day, more than 800 million people go to bed hungry every day, including 300 million children. Every 3.6 seconds a person dies of starvation, and most of

those who die are children under age of 5. Every year 6 million children die from malnutrition before their fifth birthday. The European Commission (EC) and the Technical Centre for Agricultural and Rural Cooperation (CTA), show that poverty in Africa is pervasive, and predominantly rural (Mundy and Gladbach, 1999). About 40% of the population of Sub-Saharan Africa live below the international poverty line of $ 1 per day (in 1985 purchasing power dollars), and this figure has risen slightly since the mid-1980s. These figures may understate the vulnerability of many to the shocks of drought and war. The pattern of poverty is changing where the numbers of poor are rising in the cities, dry areas and areas with poor soils, war-affected regions, and among women, the landless and the elderly. These changes will call for a major rethinking of anti-poverty strategies. As poverty becomes more pronounced in the urban settings, policy makers will have to shift the directions of the policy strategies to ensure that policy design and approaches provide low-cost food at stable prices for the increasing urban communities. Therefore, policies facilitating these kind socio-economic changes are likely to differ from those currently being implemented.

2.4 Economic Activities Undertaken Along a River

The livelihoods of most of the people and communities adjacent to rivers depend on the river for different purposes such as food security, domestic uses, livestock development, hydropower production and fisheries (URT, 2002). Due to this dependence on the river, different economic activities are performed by people residing along the river in order to sustain their daily uses. Different studies have been conducted to point out the economic activities taking place along the rivers. In Rufiji river, among other economic activities taking place along the river it includes irrigation, ferries and boats navigation, hydropower generation (at Mtera-Kidatu system, and Kihansi hydropower station) and few mining and industries operations (UDSM, 2006). In Pangani river basin,

Turpie *et al*. (2007) identified agriculture, forestry, fisheries, mining, hydroelectric power supply, tourism and sisal processing industries as the main economic activities conducted along the river particularly in rural areas.

2.5 Household Activities and Income Generation

Household income is a measure of the combined incomes of all people sharing a particular household or place of residence. It includes every form of income such as salaries and wages, retirement income, cash government transfers like food stamps, and investment gains. Average household income can be used as an indicator for the monetary well-being of a country's citizens. Mean or median net household income, after taxes and mandatory contributions, are good indicators of standard of living because they include only disposable income and acknowledge people sharing accommodation benefit from pooling at least some of their living costs. Average household income is not necessarily a direct measure of an individual's earnings such as per capita income because the number of people per households and the number of income earners per household can vary significantly over time and between regions.

A household (HH) in this study is defined as a basic residential unit in which economic production, consumption, inheritance, child rearing and shelter are organized and carried out. In some cases, it has been used interchangeably with the term family. The household is the basic unit of analysis in many social, microeconomic and government models. It refers to all individuals who live in the same dwelling. In economics, a household is defined as a person or a group of people living in the same residence. Most economic models do not address whether the members of a household are a family in the traditional sense. Government and policy discussions often treat the terms household and family synonymously. The two terms are used interchangeably because of the influence of the

western societies where the nuclear family has become the most common family structure.

2.5.1 Contributions of various economic activities to household income

Economic activities taking place along the river, contributes directly or indirectly to the household income. Economic activities contributing directly to the household income includes fishing where those involved get direct income by selling fish, crabs and other products obtained from the river. Indirect income generating activities from the river includes all other domestic activities such water for cooking and food businesses to people involved in the fishing industry (Emmanuel, 2016). According to the National water policy of 2002 and other various researches conducted, a river makes appreciable contribution to community's livelihoods in terms of direct cash income and contribution to food security. Research show that, the livelihood of people residing along the Great Ruaha River in term of income and food security depends heavily on river (Lusekelo, 2016). Therefore, the decline of water volume in the river will have significant negative implications on the livelihood of people. The study also found that, recently farmers practicing irrigation systems in Mbarali district have been affected negatively by water limitation along the Usangu river basin.

A study by Mpemba (2016) investigated the contributions of fishing to the household income in Mafia District, Tanzania and the findings result revealed that several economic activities are conducted in the area. About 41.5% of the respondents indicated that fishing was the major economic activity for the households. The average household income from fishing alone was about 51 250 TZS where other fish related activities contributed about 15 000 TZS and other economic activities was 5000 TZS per day. Based on Ngurumwa (2016), the contribution of smallholder maize production in the household food security

in Babati District, Tanzania was significant. Majority (33.8%) of the households accrue an average income of between 100 001 and 200 000 TZS per month. About 32.5% of respondent households indicated that low income among maize producing households was the major constraint in maize production. According to Munishi *et al.* (2011), wetland based socio-economic activities carried out in valley bottoms contribute to about 15% of household food and about 55 - 95% of the annual household income equivalent to 3 234 721 TZS. The total use value of productive activities carried out in upland and valley bottom wetlands is 3 415 458 TZS per year per household.

2.6 The Relationship between River Regime change and Household Income

Depending on the careers and nature of the activities conducted by members of each household, the composition and total household income will be different. In some communities especially those in rural areas, majority of the members are conducting similar income generating activities particularly agriculture for boosting their household income. Baleta *et al.* (2016) found that, as Mekong River flow decreased the household income also decreased. Another study by Kauffman (2016) showed that, as Delaware River flow increased same trend was observed for household income. The increase of the average household income helped in improving the livelihoods and capabilities of the households to engage in other economic activities.

2.7 Conceptual Framework of the Study

The core question in this study is how the household's income is affected by river regime changes. The conceptual framework for this study (Figure 1), demonstrates the assumed inter-linkages between river regime changes, economic activities along the river and associated economic impact at household level.

The top box relates to the second specific objectives whereby, a researcher was interested to know the activities that are conducted by river dependent households along Little Ruaha River and how the economic activities contribute to household income. In addition, the researcher was interested on the main alternative economic activities performed by the household's members when the water flow changes in the river and what other economic activities help them maintain household's income. Therefore, a researcher collected data on the economic activities performed by the households dependent on the river and the income trend of the household. A researcher was able to know the most economic activities performed in the households and community at large, and the general trend of income in the households.

The left bottom box relates to the first specific objective. In this objective, a researcher was interested to understand the water flow change in Little Ruaha River and how extreme is the change and their impact on the household income. To address this objective, the researcher collected primary data on the existing knowledge on water flow change in the communities. The information collected were supported by the secondary data on average volume of water flow change for 47 years obtained from the Rufiji Water Basin Office.

Empirical evidence shows that, economic activities have impact on household welfare through provision of income, improvement of health status at household level and other social services. However, household welfare also has impact on economic activities. For instance, when income of the household change it might have positive or negative changes to the economic activities performed at a household. This is because, income change can have an impact on the amount of capital invested in the household's economic activities resulting into improvement or failure of the income generating activity.

On the other hand, the nature of the households' economic activities can have impact on water flow change in the river. For example, poor performance of economic activities leads to poor utilization of water which result to decrease of water flow in the river. However, water flow change can also affect economic activities because the increase or decrease of water flow might increase or decrease level of production and the production costs of the respective income generating activity such as agricultural activities. The water flow change in the river is also linked to household welfare because it provides water for various social services such as domestic water used in the household.

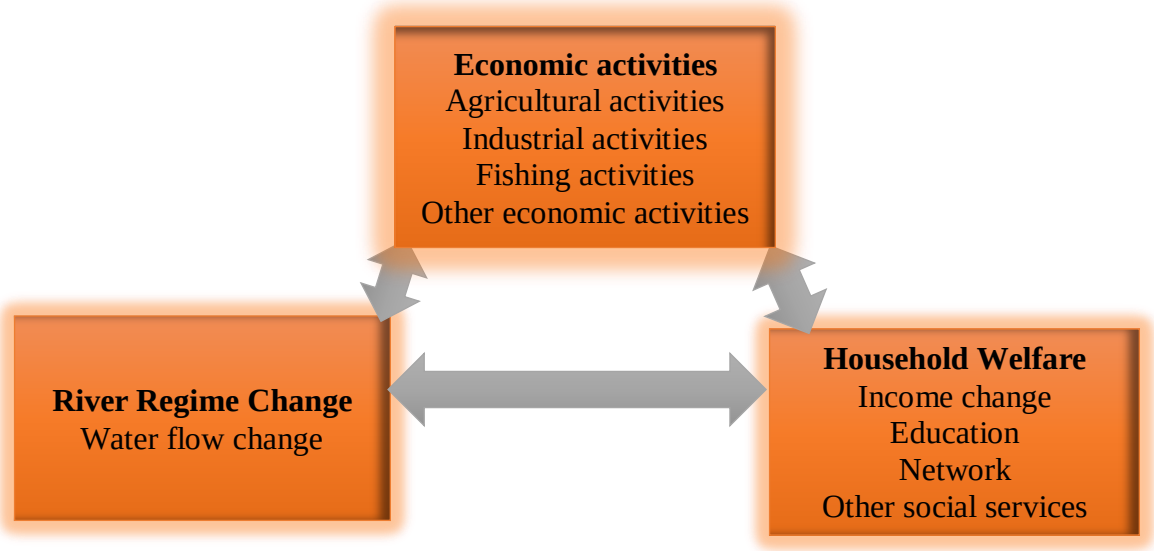

Figure 1: Conceptual framework of the study

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

The study was conducted in Itunundu, Kimande, Magozi and Luganga located in Pawaga division in Iringa District. Pawaga is one of the six administrative divisions in Iringa District, Iringa Region. Pawaga division was purposively selected out of six divisions because the livelihoods of about 80% of people in the division depends on Little Ruaha River. The division lies in the lowland zone within the Eastern arc of the Great Rift Valley.

The average annual temperature in Pawaga division is high over 25°C and the area is experiencing medium to low annual rainfall, ranging from 500 mm to 600 mm per annum (Mussei *et al.,* 2012). The main vegetation type in the area is thickets, offering the best grazing lands for livestock keepers. Due to low annual precipitation, the dryland farming is not practiced, hence the major economic activities are supplemental irrigation farming, livestock keeping and trading activities (Mkavidanda and Kaswamila, 2001; URT, 2005). The irrigation farming is practiced in irrigation schemes, and there are four irrigation schemes namely Luganga, Magozi, Mlenge and Mkombozi which are fed with the Little Ruaha River. The main users of Little Ruaha River include farmers who depend on water for irrigation and domestic water users found near or along the river; Wildlife from Ruaha National Park and Mtera hydropower dam.

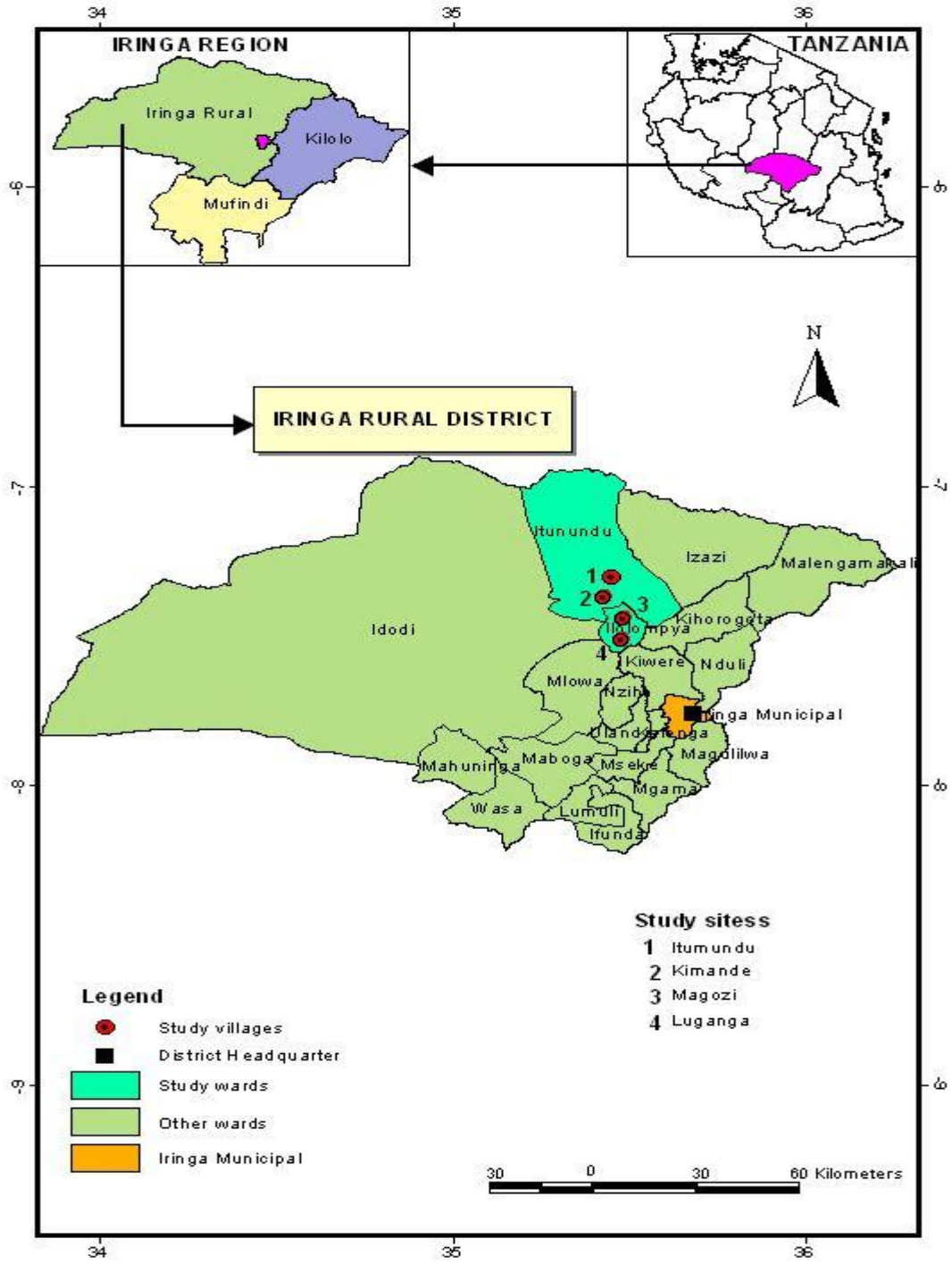

Figure 2: Map of the study area

3.2 Research Design

Cross-sectional research design was adopted in which data are collected at a single point in time from the selected respondents without repetition (Kothari, 2004). The collected primary data were supported with secondary data from the Rufiji Water Basin Office, Agriculture Department in Iringa District, ward and village offices which are collected over a long period of time in the study villages. Cross sectional design was used to solicit data from residents and key informant in the proximity of Little Ruaha River. The key informants included, district agricultural officers, village officers, irrigation officer, trade officers, agricultural extension officer and Rufiji Water Basin Officers. The rationale for the current design is primarily because it is less time consuming, flexible, economical and easy of handling and processing the collected information.

3.3 Sampling Procedure

A multistage purposive and random sampling procedure was opted in this study, because more than one steps were involved (Kothari, 2004). The technique was conducted in five stages: In the first stage, Iringa Rural District, which is along the river in Iringa region was purposively selected as the study area. The district was selected because Little Ruaha River passes through it and majority of its people depends on the river resources for their livelihoods. In the second stage, Pawaga division was also purposively selected. This was because a large percent (80%) of people in the division conduct agricultural activities that demand on water. In the third stage, two wards; Itunundu and Ilolompya were purposeful selected because the wards have higher population, and are located relatively closer towards the Little Ruaha River as compared to the other wards. In the fourth stage, two villages were randomly selected from each ward; the villages that were selected are Itunundu, Kimande, Magozi and Luganga. The fifth stage was random selection of respondents from households and key informants.

In each household, one respondent preferably the head of the household was selected. The sample household selection was done the same to all selected villages. The sampling frame for this study was obtained from village government offices.

3.4 Sample Size

According to Kothari (2004), sample size is the number of items to be selected from the population to constitute a sample. The sample of this study was selected to meet flexibility, efficiency and accuracy. The sample consisted of household respondents and key informants from the offices. Cochran's (1977) formula was supposed to be used in the study in order to acquire the exact sample of each village due to its household population. However, some villages (Magozi and Luganga) have small number of population making it to have very small sample size less than 30 hence, the formula was not used and instead in each village information was collected from 50 respondents in 50 households making a total of 200 respondents from the selected households. The study also involved 10 key informants for triangulating the information obtained by other technique.

3.5 Data Collection

3.5.1 Primary data

Primary data were collected using household questionnaires, checklist for key informants and direct observation. Household surveys were administered using structured questionnaires through structured interview while checklist for key informants were administered using structured open-ended questions. Both household questionnaires and key informants' checklist were written in English but translated in Swahili during data collection. During direct observation, non-participatory designed observation was used

where the researcher recorded everything on a notebook and was able to take pictures where necessary.

3.5.2 Secondary data

Secondary data were obtained from Sokoine National Agricultural Library (SNAL), Rufiji Water Basin Office (RWBO), and Agriculture Department in Iringa District, ward and village offices and various electronic sources to aid the meaningful analysis of this study.

3.6 Data Analysis

In this study, data were analyzed differently for addressing each of the stated specific objective. For the first specific objective in which river regime change for the past 47 years in Little Ruaha River was examined, linear regression and Pearson correlation analysis in Statistical Package for Social Science (SPSS) were used and inferential statistics used to present the results. Correlation analysis was also used to show the relationship between average water flow in over time. For the second specific objective of assessing economic activities and its contribution to household's income of communities adjacent to Little Ruaha River, statistical Package for Social Science (SPSS) was used and descriptive statistics in terms of percentage and frequencies of variables were used to summarize the results.

In addition, inferential statistics was also used to show the association between economic activities and households' income dependent from Little Ruaha River. The same programme were used for analyzing data for specific objective three in determining the link between river flow change and household income from commercial crops along Little Ruaha River. Descriptive statistics were used to show the percentage and

frequencies of variables. Inferential statistics (regression and Pearson correlation analysis) was also used to show the relationship between river flow change and household income from commercial crops along Little Ruaha River. Results were then summarized in tables, charts, figures and graphs.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents and discusses the key findings of this study. The study findings are laid out according to the questions and research objectives. It is organized into three sections. The first section discusses the Little Ruaha River flow changes for the past 47 years, the second section discusses the economic activities and the contribution of the river to the households' income and the third section discusses the perception of people regarding river flow change over time and its linkage to household income.

4.1 Social Demographic Characteristics of the Respondents

4.1.1 Age of the respondents

The scrutiny of respondent's age under this study simply aimed at finding out the age group that mostly responded to the questionnaire. This helped the researcher after the end of field work to know the most group that responded to the questions. The researcher's aim was to deal with each group but mostly the youth group (the working group) not too many young respondents or too old respondents.

Therefore, Table 1 presents the age group of the study which ranged from 18 and above. From Table 1, the majority of the respondents (53%) ranged from 31-50 which is suitable age for conducting any economic activities. On the other hands, 32% ranged from 18-30 and 10.5% ranged from 51-60 while 4.5% of the respondents ranged above 60.

Table 1: Age of the respondents

Age of respondents	Frequency	Percent
18-30	64	32.0
31-50	106	53.0
51-60	21	10.5
above 60	9	4.5
Total	**200**	**100.0**

4.1.2 Marital status of the respondents

Table 2 shows that 80% of the respondents were married, 9% were single, 7% were divorced and 4% were widows or widower. Hence, a large number of respondents were married which implies that, married people are mostly participating in economic activities which enable to earn more income. This is because of fulfilling family responsibilities such as family needs and other family obligations.

Table 2: Marital status of the respondents

Marital status of respondents	Frequency	Percent
Single	18	9.0
Married	160	80.0
Divorced	14	7.0
Widow/widower	8	4.0
Total	**200**	**100.0**

4.1.3 Household size of the respondents

In order to know the household size of the respondent, a question was asked to give out the total number of people who reside with the respondent. Figure 3 reveals that, higher number of the respondents live from 3 to 5 people while one respondent's household had 11 people.

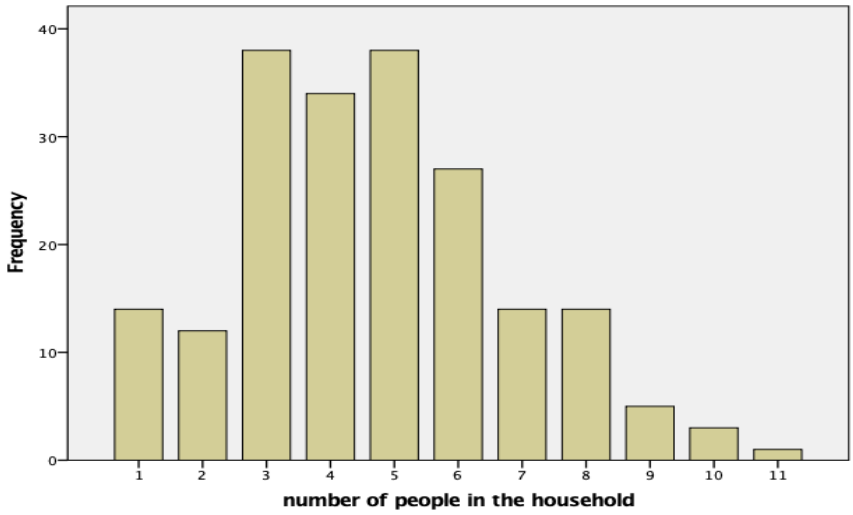

Figure 3: Household size of respondents

4.1.4 Occupation of the respondents

Figure 4 shows that 183 (91.5%) of the respondents were farmers. In most rural areas most people rely on agricultural activities to increase household income. In Pawaga division most of the households engage themselves in crop production mainly paddy production.

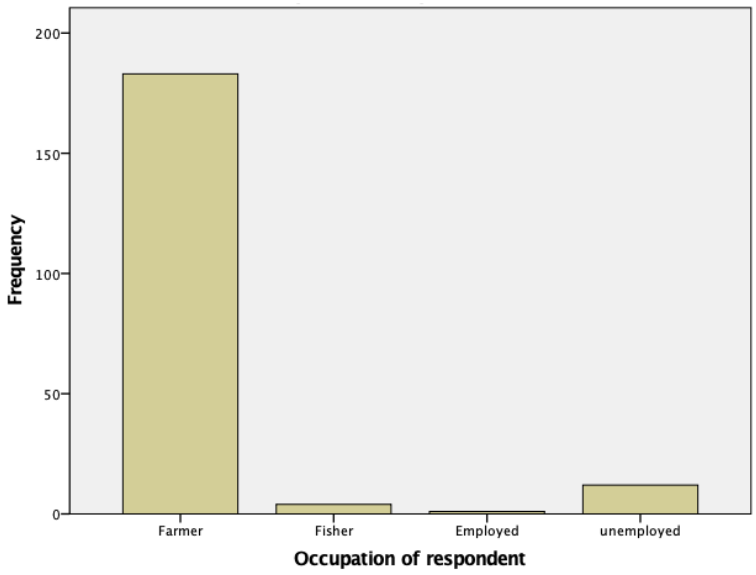

Figure 4: Occupation of the respondents

4.1.5 Education level of respondents

Table 3 shows that 79% of the respondents had primary education level, 8% had secondary education level, 0.5% had college level (certificate), 1% had higher level of education (bachelor degree) while, 11.5% had attained formal education from homecraft schools. Majority of the household respondents after completion of primary education, failed to continue with secondary studies and opted to engage themselves in agricultural activities and small business which can be held in rural villages.

Table 3: Education level of respondents

Education level of respondent	Frequency	Percent
Primary education	158	79.0
Secondary education	16	8.0
College	1	0.5
University	2	1.0
Others	23	11.5
Total	**200**	**100.0**

The aspect of education was considered as fundamental in this study since the absence of education is a bottleneck for social economic development. An individual's education level usually places a person where to earn his or her income. The level of education may determine individual's intellectual ability to fight against poverty (Stiftung, 2006).

This situation attributed by the fact that most respondents had primary education level, which could not enable them to obtain jobs in formal sector because level of education determines where to work. On top of that most of the respondents argued that, they engaged themselves in crop production because of their level of education.

4.2 River Flow Change for the past 47 years in the Little Ruaha River

Findings indicate that about 0.042% of the variability in average river flow change was counted for by its regression on time (years). As observed from figure 5, by average, year

1977 has the lowest river flow compared to other years while in year 1998 has the highest river flow. The annual average river flow change has unpredictable random trend with rise and falls making it difficult to predict. In this case the model is not best fitted because there is no much variation of river flow across the years as shown in Figure 5 rather across months as shown in figure 6. In Figure 6, results show that there is high river flow in March, then it decreases from April to November and it increases again from December. This is so because March is the rainy season which last up to April and comes back during October up December.

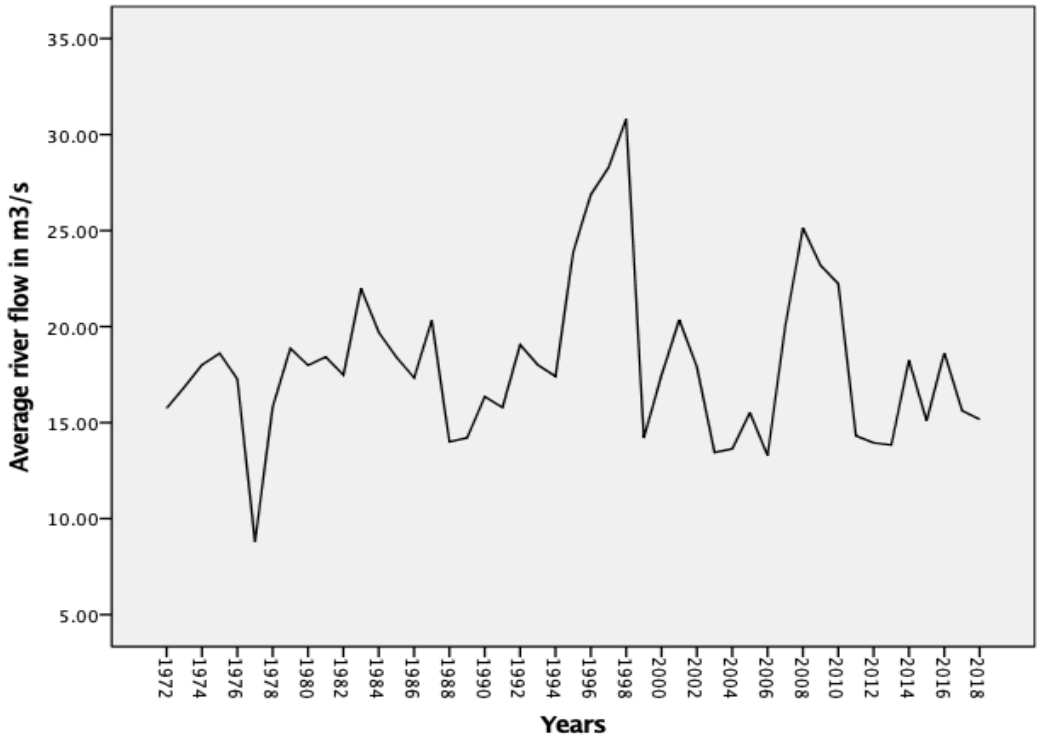

Figure 5 : Average river flow change from 1972 to 2018

Source: RWBO (2018)

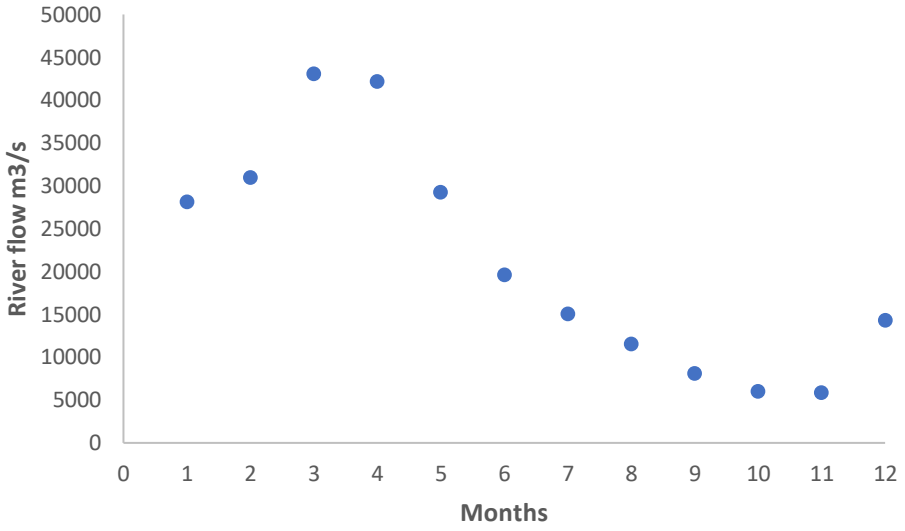

Figure 6: Monthly river flow change from 1972 to 2018

Source: RWBO (2018)

This insignificant of these two variables are evidenced in Table 4 with a P-value of 0.891 (above 0.05) and a correlation of 0.021 meaning the variables are not statistically significant related. This basically implies that the water flow trend does not vary across years rather across seasons of year.

Table 4: Correlation between years and average flow

		Year	Average Flow
Year	Pearson Correlation	1	0.021
	Sig. (2-tailed)		0.891
	N	47	47
Average flow	Pearson Correlation	0.021	1
	Sig. (2-tailed)	0.891	
	N	47	47

Source: RWBO (2018)

The results show that there is no significant change in the Little Ruaha River for the past 47 years. These results are from experienced people along with the responsible authorities like Rufiji Basin Water Office and District Office. The same results were observed by Mbungu and Kashaigili (2017) and Kassian *et al.* (2016). There are some reasons that signifies these results. The Little Ruaha River originates from the highland parts of Mufindi and Kilolo Districts (Mbungu and Kashaigili, 2017). These areas receive high amount of rainfall, over 1600 mm per annum. Likewise, due to high amount of rain which is well distributed, the areas do not depend on Little Ruaha River for crop production, it is mainly used for domestic water use. The use of Little Ruaha River for domestic water is also very low, as on these areas, there are many water sources which are used for domestic purposes. These areas of Mufindi and Kilolo Districts on which Little Ruaha River flow, there is massive tree plantations, along with intensive conservation measures, including Eastern Arc Mountains Conservation Project. This to a large extent stabilizes the flow of the Little Ruaha River.

4.3 Economic Activities and the Contribution of the river to the households' income

4.3.1 Main economic activities conducted in the study area

Table 5 shows the economic activities conducted by households. Majority (63%) of the respondents were engaged in crop production while 33% were engaged in multiple economic activities to sustain their livelihoods. For example, one respondent is engaged in crop production and entrepreneurship. Only 3% and 1% were engaged in entrepreneurship and fishing activities respectively. Therefore, on average for the overall sample from all the villages, crop production was the main economic activity conducted by households. These findings are similar to Katega and Lifuliro (2014) where it was observed that about 97% of the households were engaged in agricultural activities.

Table 5: Main economic activities conducted by households

Economic activities	Frequency	Percent
crop production	126	63.0
Fishing	2	1.0
Entrepreneurship	6	3.0
Multiple economic activities	66	33.0
Total	**200**	**100**

4.3.1.1 Main household economic activities depending on little Ruaha River

Table 6 shows the main economic activities conducted by households that depend on Little Ruaha River. Table 6 indicates that majority (86.5%) of the respondents are engaged in crop production while 8% are engaged in multiple economic activities such as crop production and livestock keeping. About 4.5% of the respondents revealed that their economic activities do not depend directly on the existence of Little Ruaha River. Results also indicated that only 1% of the interviewee were engaged in fishing.

Table 6: Economic activities that depend on Little Ruaha River

Economic activities	Frequency	Percent
crop production	173	86.5
Fishing	2	1.0
None	9	4.5
more than one	16	8.0
Total	**200**	**100**

We find that, crop production is the main economic activity in the four selected villages. The high reliance on crop production which in turn depend on availability of water indicates the importance of Little Ruaha River for residences at Pawaga. Similar results were obtained in the study conducted by Mwaruvanda (1996) where agriculture was the

main economic activity taking place along Great Ruaha catchment. Baleta *et al.*, 2016, also found that rice production is the main economic activity that take place along Mekong River. However, according to the study by Okumagba and Ozabar (2014) recreation is the main economic activity taking place along River Ethiope in Nigeria.

4.3.2 Household responses on commercial crops grown that solely depend on irrigation from Little Ruaha River

Table 7 shows that 77% of the interviewed households are growing rice (paddy) as a main commercial crop, 6% growing both rice and vegetables, 2% growing rice and cassava while 1% are not growing any commercial crops. Further, 1% are growing rice and onions, 1% growing both rice and beans, 1% growing rice, cassava and vegetables, 0.5% growing cassava only, 0.5% growing rice, beans and watermelon, 0.5% growing rice, cassava and tomatoes, 0.5% growing rice, potatoes and cassava and 0.5% growing vegetables only.

Table 7: Commercial crops that solely depend on irrigation from Little Ruaha River

Commercial crops that solely depend on irrigation from Little Ruaha	Frequency	Percent
Cassava	1	0.5
None	2	1.0
Rice	154	77
Rice, beans	2	1.0
Rice, beans, watermelon	1	0.5
Rice, cassava	4	2.0
Rice, cassava, tomatoes	1	0.5
Rice, cassava, green vegetables	2	1.0
Rice, onions	2	1.0
Rice, green vegetables	12	6.0
N/A	17	8.5
Total	**200**	**100**

These findings indicate that, paddy is the main crop produced in Pawaga division. About 77% of the interviewed households are engaged in paddy production while 6.5% are practicing multiple crops production. Paddy production was therefore used as a main commercial crop for assessing the income trend in the selected villages. According to Bont *et al*. (2019), maize was reported to be the major crop produced by resident farmers.

4.3.3 Paddy production in Pawaga Division

Results show that, from 1992 to 2018 total paddy production, productivity per acre and price per bag has been increasing each. Razmy and Ahmed (2005) found that the paddy production trend fluctuated and it was due to changes in extent sown, extend harvested and average yield. Information from the Agriculture Department show that, the size of the area used for paddy production in Pawaga has doubled from 7243 ha in 1998 to 14 588 ha in 2018. Likewise, the crop harvest increased from 17 271 tons in 1998 to 89 416 tons in 2018. Productivity per unit area has also increased from 1.5-2 tons /ha in 1998 to 4.5-7 tons/ha in 2018. The main reason for this increase is the nature of the irrigation practiced and the improvement of the Irrigation schemes that took place during 2004 to date.

In Pawaga, the dryland farming is less practiced due to poor distribution of rainfall, so most of farmers are engaged on irrigation farming. The type of irrigation practiced is supplemental irrigation, it does not strictly depend on Little Ruaha River as it depends also on rainfall. This type of irrigation reduces the dependence of the Little Ruaha River for farming activities, and less water is used as compared if it would strictly depend on the water from the Little Ruaha River.

Table 8: Paddy production and price from 1992- 2018

Year	Average Quantity Produced (Bags/Acre)	Average Price per Bag (TZS)
1992	6.0	8 000
1993	7.0	8 000
1994	7.0	8 000
1995	7.0	8 000
1996	7.0	8 500
1997	7.0	8 500
1998	7.0	12 000
1999	7.0	13 500
2000	10.5	12 000
2001	10.5	15 000
2002	10.5	15 500
2003	9.5	15 500
2004	10.5	16 000
2005	11.0	16 000
2006	10.5	18 000
2007	11.5	22 000
2008	9.0	25 000
2009	10.5	25 000
2010	14.5	25 000
2011	15.0	35 000
2012	16.5	35 000
2013	17.0	37 500
2014	19.0	60 000
2015	19.0	57 500
2016	19.0	67 500
2017	19.0	80 000
2018	19.0	72 500

Source: Village office, 2018

Through ASDP-DADPs programmes, there has been improvement of irrigation infrastructures in order to reduce water loss and increase the area of production. During implementation of these programmes, four irrigation schemes of Luganga, Ukwega, Magozi and Mlenge were improved by constructing the modern water heads and gates, construction and lining of primary canals and parts of secondary canals. During the construction of the waterheads, the main gates were strictly constructed to allow only the

amount of water permitted by the RBWO passes through the gates, hence no excess water can pass through the gates. The lining of primary and secondary canals reduces water loss through seepage hence allows more water for irrigation.

The improvement of infrastructures was were also accompanied with a continuous training to farmers and introduction of new technologies on paddy production. Studies indicate that since early 2010s, there have been intensive farmer's trainings on good agronomic practices to farmers. There has been several government and non-government institutions and programmes, including the Ministry of Agriculture, JICA, SNV, PHRD, MATI Igurusi, ARI Dakawa, TAGRODE and ASF. There was an introduction of the System of Rice intensification (SRI), all these institutions were training farmers on this methodology, and it uses less water in paddy production while increasing productivity. There was also an introduction of high yielding variety, SARO 5 TXD 306. The introduction of water efficient technologies along with the use of High yielding varieties has boosted the paddy production to a large extent, and increases the income of the farmers.

The improvement of infrastructures, provision of continuous trainings to farmers and introduction of new technologies on paddy production stimulated trading activities in Pawaga division over time. In the past 20 years, the economic status of Pawaga's residents was very low, and it was among the poorest area in the District, with a very low economy, and was mainly occupied by nomads. Currently, there are various economic activities rather than paddy cultivation, and is among the area with fast growing economy in the District due to increased trading activities. The contribution to the District revenue accounts for 12% in 2018, from 2.8% in 1998. The household economy has also increased for 36% within past 20 years.

According to District Trade Office and District Planning department, the average household income has increased by 36%, and contribution of Pawaga Division to the total District revenue has increased by 12% during the past twenty years. Various factors have contributed to the growth of Pawaga's economy including the improvement of irrigation infrastructures, through ASDP-DADPS as mentioned above but also the construction of storage facilities and provision of farm and processing machineries.

The farmer groups were facilitated with machinery loans, where they provided with power tillers. Also, were provided with milling machines so as to process their paddy to add value. There was construction of warehouses for paddy storage and the irrigation schemes organizations were facilitated with combine harvesters. This stimulate the growth of trading activities as it created direct and indirect employments. There is an increase of service providers for these power tillers and other machinery, opening up of spare parts shops, introduction of servicing workshops and increased of other services such as shops, lodges and hotels. All these creates other economic activities and reduces the dependence of the Little Ruaha river as a major source of economic activity.

In addition, according to village agricultural and trade officers, in the past years' farmers in Pawaga used to sell only paddy but from 2016 farmers started selling rice. In 2016 they sold 1 Kg of rice for 1200 TZS and obtained average amount of 1 692 200 TZS, in 2017 they sold 1Kg of rice for 1350 TZS and obtained average amount of 1 921 450 TZS and in 2018 they sold 1Kg of rice for 1 400 TZS and obtain average about of 2 046 000 TZS. Hence this shows that since they started selling rice the income is increasing.

4.3.4 Annual household's income from rice production

Figure 7 shows that 46% of the respondents earn more than one million per year while 22% earn about 600 000 - 990 000 TZS per year. On the other hand, 22% of the respondents also indicated that they are earning about 200 000 - 590 000 TZS per year. The remaining 10% of the respondents reported that they do not earn their income from rice production.

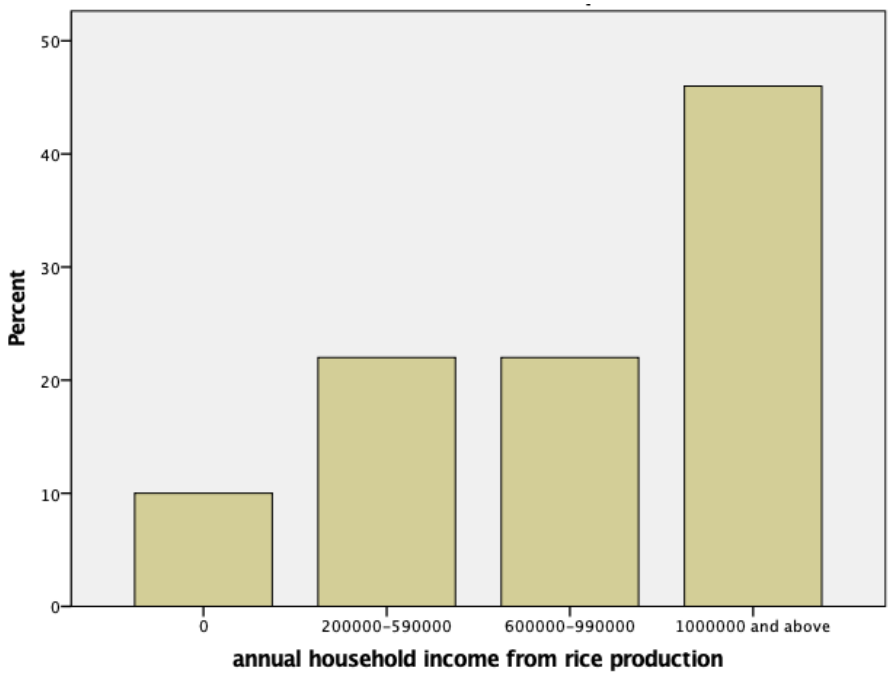

Figure 7: Household annual earnings from rice production (TZS)

Findings indicate that, majority (46%) of the interviewed households earn more than one million per year implying that the economic status of Pawaga division is not so poor as people can earn a certain amount of money per month for sustaining their families. Based on the information from village officers, Pawaga division is growing faster as compared to other divisions in the area.

Most of the people have started to engage themselves in other non-agricultural economic activities. The population and economic growth in the division have resulted into development of many social and public services. Similar results were obtained by Mlelwa (2013) and Baliyan and Baliyan (2014). According to Mlelwa (2013), about 49% of respondents reported to be earning more than 800 000 TZS per year from vegetable production while Baliyan and Baliyan (2014) reported an average household income of 7 679 489 TZS and 8 372 737 TZS in Muzaffarnagar and Baghpat district respectively.

4.3.5 Annual Household's Income from other crop production

In Pawaga division, rice is the major crop grown however, there are other crops grown by the households such as cassava, tomato, onions, green vegetables, beans and watermelon. However, these other crops are mainly grown by the households found in Luganga village compare to other villages because Luganga village are allowed to use water from Little Ruaha River to irrigate crops in two seasons while other villages are allowed to use water only one season.

Table 8 shows that, 4.5% of the respondents earn 300 000-500 000 TZS per year. This implies that household income is mainly contributed from rice production compare to other crops. About 86.5% of the respondents do not grow other crops such as cassava because, pawaga division experiences very high temperature and little rain, therefore they mainly depend on Little Ruaha River to irrigate crops. However, they are not allowed to irrigate anytime they want instead they use the water from Little Ruaha River when they are allowed to, therefore it becomes hard for them to grow a lot of crops, that is why they mainly depend on paddy production.

Table 9: Household annual income from other crops production (TZS)

Income from other crops	Frequency	Percent
50 000-200 000	8	4.0
300 000-500 000	9	4.5
600 000-900 000	4	2.0
1 000 000 and above	6	3.0
N/A	173	86.5
Total	**200**	**100.0**

4.3.6 Annual Household's Income from other economic activities

There are other economic activities performed by households, that help boost the household income. Example of these activities are fishing, wood and charcoal selling. Not all respondents engaged themselves in other economic activities, others just engaged themselves in only crop production for generating household income.

Figure 8 show that 22.5% of the respondents earn about 300 000 – 500 000 TZS per year, 11% earn about 600 000 – 900 000 TZS per year, 9% earn about 50 000 – 200 000 TZS per year while, 4.5% earn more than one million per year. 53% of the respondents reported that they do not engage themselves in other economic activities other than crop production in their households.

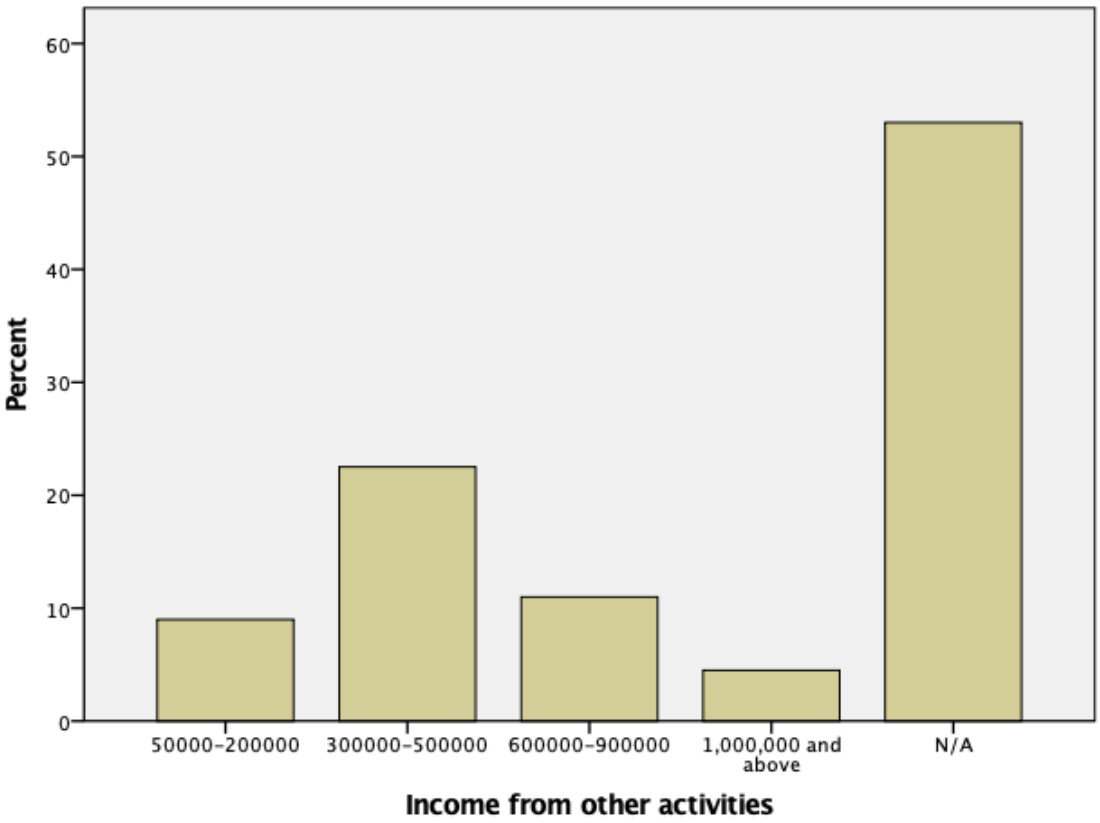

Figure 8: Household annual earnings from other economic activities (TZS)

Findings indicate that income from other economic activities is not as much as is earned from rice production. Similar results were obtained by Mlelwa 2013 whereby, it was also found that household income from other economic activities was less gained compare with income obtained from maize production.

4.3.7 Household income from commercial crops and economic activities depending on Little Ruaha River

Household respondents were asked to narrate their income trend of commercial crops over the past five years. Respondents responded differently some responded it is increasing, some decreasing while others responded the income trend is stable. Table 10 shows that 35.5% of the households who depends on Little Ruaha River, indicated the

income trend of commercial crops is increasing especially in crops production as evidenced in the Figure 9. Some respondents were not aware of the trend of their incomes from commercial crops may be due to lack of proper records and memories.

Table 10: Cross tabulation between Economic activities dependent on Little Ruaha River and income trend of commercial crops

			Income trend of commercial crops					
			Increasing	**Decreasing**	**Stable**	**I don't know**	**N/A**	**Total**
Economic activities dependent on the Little Ruaha River	Crop production	Count	69	48	51	3	2	173
		% within economic activities dependent on the Little Ruaha River	39.9	27.7	29.5	1.7	1.2	100.0
	Fishing	Count	0	0	0	0	2	2
		% within economic activities dependent on the Little Ruaha River	0.0	0.0	0.0	0.0	100.0	100.0
	None	Count	0	0	0	0	9	9
		% within economic activities dependent on the Little Ruaha River	0.0	0.0	0.0	0.0	100.0	100.0
	More than one	Count	2	2	7	0	5	16
		% within economic activities dependent on the Little Ruaha River	12.5	12.5	43.8	0.0	31.3	100.0
Total		Count	71	50	58	3	18	200
		% within economic activities dependent on the Little Ruaha River	35.5	25.0	29.0	1.5	9.0	100.0

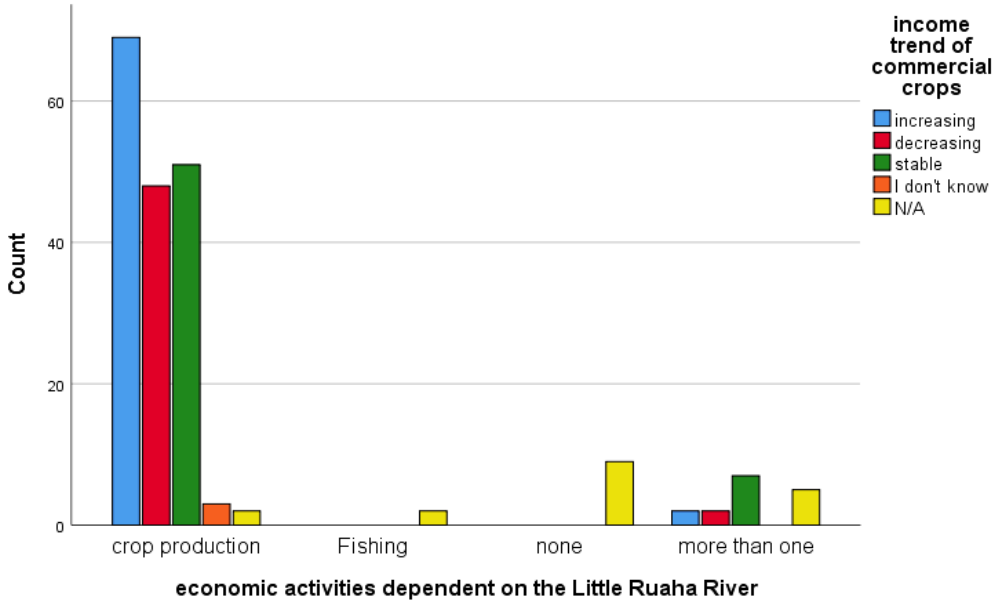

Figure 9: Relationship between economic activities dependent on Little Ruaha River and income trend of commercial crops

The income trend of crop production is increasing in Pawaga division compared to the past years. Due to the increase of income, households can engage themselves in other economic activities such as selling goods in the village that help them to boost the household income. In addition, due to increase in income, they sell not only paddy but also rice. Similar results were obtained by USDA (2019) and Parton *et al.* (2007).

According to chi-square test of association, there is significant association (P-value 0.00) between income trend of commercial crops and both economic activities dependent on the Little Ruaha River and economic activities of households. This means income trend of commercial crops depend on the economic activities performed in the households. This is because 80% of the household respondents participate in crop production as the main economic activity.

4.3.8 Factors Influencing income trend change of the main economic activity

Figure 10 shows that, this question was not applicable to about 39.5% of the respondents while 27.5% responded that market is the factor resulting to income trend change. About 10% of the interviewed people responded that decreased water flow in Little Ruaha River is the factor for income trend change, 7.5% responded that increased water flow in Little Ruaha River is the factor for income trend change, 6.0% responded that poor pesticides is the factor for income trend change. 5.0% responded that improved pesticides are the factor for income trend change and 4.5% of the respondents did not know the factor for income trend change.

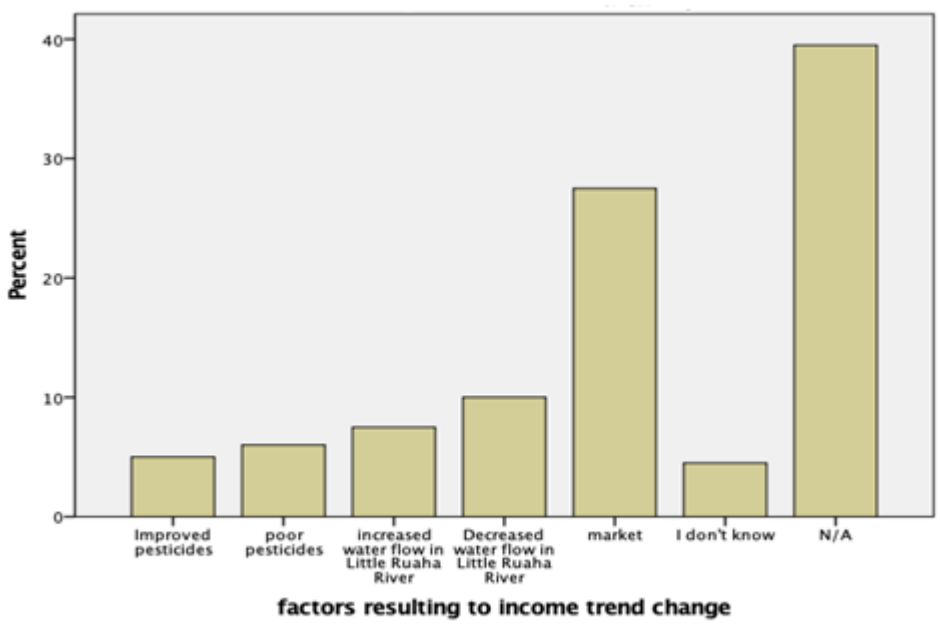

Figure 10: Factors influencing to income trend change

Findings show that, 27.5% of the respondents said that, market is the main factor for the income trend change. The presence of reliable market helps to increase sustainability of the household income, because all what is produced will be brought to the existing market. On the other hand, if the market for the produced goods will not be reliable, the households income will also be unstable. Therefore, existence of the reliable and robust market for the produced good is an important factor for economic growth and development in Pawaga division. Other respondents reported that, water in the Little Ruaha River has less effect on their household income since they use the same amount of water supplied to them by the water user authority (RWBO). According to the study conducted by Parton *et al.* (2007), the increase for crop income resulted from large increases in crop yields.

4.4 The Link between River Flow Change and Household Income from Commercial Crops along Little Ruaha River

4.4.1 Change on amount of water flow in Little Ruaha River and income trend of commercial crops

Results show that, about 35.5% of the interviewed households indicated some increasing trend of the income from commercial crops due to any change on amount of water flow in Little Ruaha River (Table 11). Some respondents however, were not aware of any change in water flow in Little Ruaha River.

Table 11: Cross tabulation between change on amount of water in Little Ruaha River and income trend of commercial crops

			Income trend of commercial crops					
			Increasing	Decreasing	Stable	I don't know	N/A	Total
Is there any change on amount of water flow in Little Ruaha River	Increased	Count	12	11	9	0	2	34
		% within Is there any change on amount of water flow in Little Ruaha River	35.3	32.4	26.5	0.0	5.9	100.0
	Decreased	Count	50	30	39	3	9	131
		% within Is there any change on amount of water flow in Little Ruaha River	38.2	22.9	29.8	2.3	6.9	100.0
	Both	Count	7	4	3	0	2	16
		% within Is there any change on amount of water flow in Little Ruaha River	43.8	25.0	18.8	0.0	12.5	100.0
	I don't know	Count	1	0	0	0	5	6
		% within Is there any change on amount of water flow in Little Ruaha River	16.7	0.0	0.0	0.0	83.3	100.0
	No change	Count	1	5	7	0	0	13
		% within Is there any change on amount of water flow in Little Ruaha River	7.7	38.5	53.8	0.0	0.0	100.0
Total		Count	71	50	58	3	18	200
		% within Is there any change on amount of water flow in Little Ruaha River	35.5	25.0	29.0	1.5	9.0	100.0

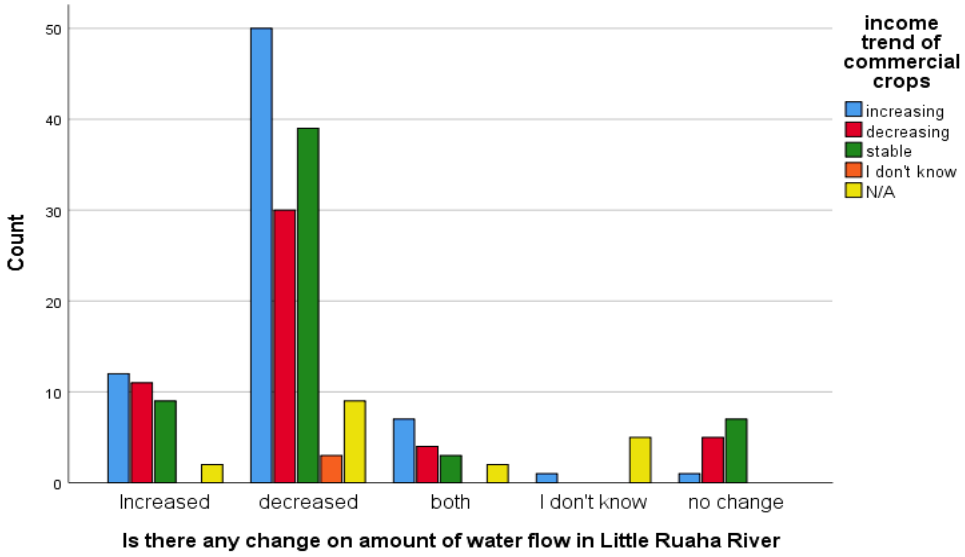

Figure 11: **Relationship between income trend of commercial crops and change on amount of water flow in Little Ruaha River**

Despite the slight insignificant changes of the Little Ruaha River flow, the average household income is growing over time. Baleta *et al.* 2016, obtained different results in their study where there is a link between river flow and income of the household. As Mekong river flow decreases also the household income decreases. According to Kauffam (2016), as Delaware River flow increases also the income at household level and community at large also increases. People are able to engage themselves in different economic activity such as agriculture and fishing. The chi-square test of association indicated that there is significant association (P-value 0.00) between income trend of commercial crops and change on amount of water flow in Little Ruaha River. On the other hand, there is also a significant association (P- value 0.00) between change on amount of water flow in Little Ruaha River and both economic activities dependent on the Little Ruaha River and economic activities of households at a significance level of 0.05.

4.4.2 Correlation between average flow of Little Ruaha River and Paddy production

Results in Table 12 show that, the P value of 0.942 meaning that there is no significant relationship between average flow of little Ruaha river and rice production. This implies that river flow is not a determinant or does not influence rice production. The obtained small negative value of Pearson correlation -0.021 indicates that rice production does not depend on river flow. Therefore, river flow of Little Ruaha can not necessarily affect the rice production as there are other strong determinants of production.

A downhill pattern of fit line in Figure 12 indicates there is no significant relationship between Rice production and average river flow of Little Ruaha with R-square of 0.042%. Variation of rice production cannot be explained in relation to average flow of little Ruaha river.

Table 12: Correlation between average flow of Little Ruaha River and Paddy production

		Average flow of Little Ruaha River (m3/s)	Paddy production (tons)
Average flow of Little Ruaha River (m3/s)	Pearson Correlation	1	-0.021
	Sig. (2-tailed)		0.942
	N	15	15
Paddy production (tons)	Pearson Correlation	-0.021	1
	Sig. (2-tailed)	0.942	
	N	15	15

Source: RWBO (2018) and Agriculture Department in District Office (2018)

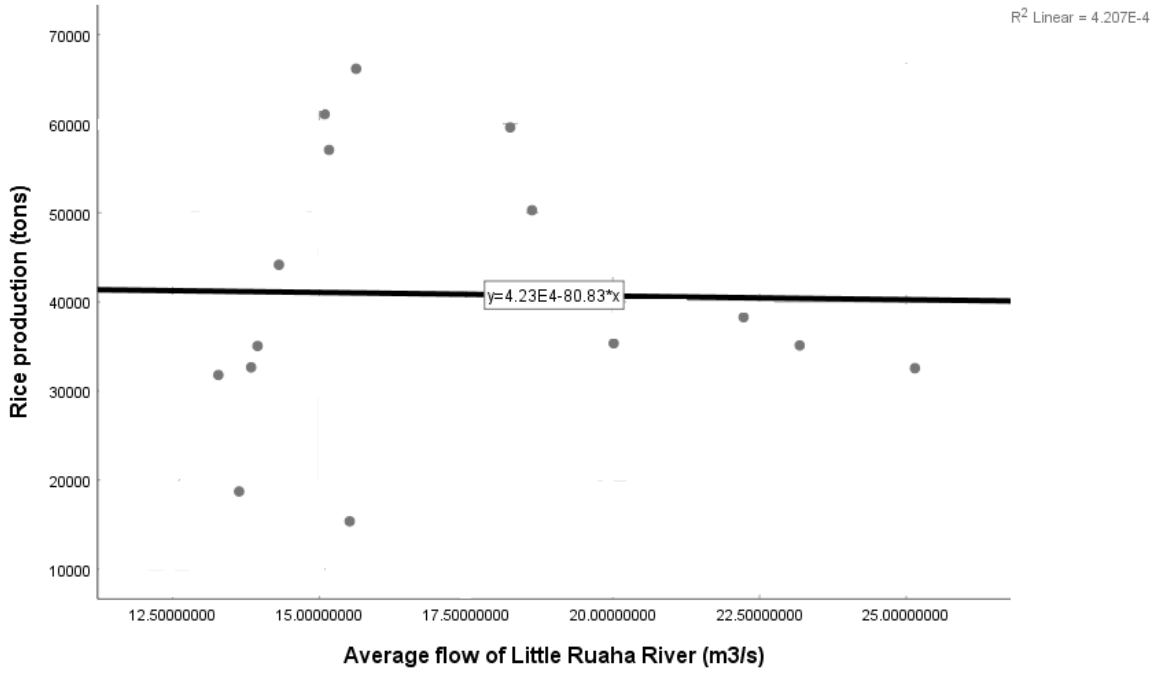

Figure 12: Relationship between average flow of Little Ruaha River and Paddy production from 2004 to 2018

Source: RWBO, 2018 and Agriculture Department in District Office, 2018

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The purpose of the study was to assess the contribution of Little Ruaha River and its water flow changes to the livelihoods of people who depend on the river. The study intended to find out if there is river flow change in Little Ruaha River, how extreme is the river flow change, what are the factors that lead to the change, the knowledge of people on water flow change and economic contribution of river flow change to the households in the selected villages.

There is no significant change on the average river flow volume in the Little Ruaha River for the past 47 years (1972 to 2018). This may imply that there has been too slight change to be easily realized by the residents along the river. Crop production is the major economic activities taking place in Pawaga division and the household income of people living adjacent to Little Ruaha River are significantly associated with the type of economic activities taking place in those villages. The income of people from crop production is increasing over time which in turn helps the households to invest in other diversified economic activities.

There is a slight change of the Little Ruaha River flow which does not have significant impact on the household income at Pawaga. This may be due to the reason that, most of the people in the villages practice supplemental irrigation which does not affect their income directly. Similarly, the paddy production does not have significant impacts on the river flow, as it is practiced at the tail end users of the Little Ruaha River, while the flow depends much on the upper course of the river, where irrigation farming is not practiced.

Other activities in the study area carried out directly on the river, particularly fishing, are not major economic activities, and contribute less than 0.5% on the household income. Therefore, there is generally no strong link between average river flow change in Little Ruaha River and the household income from commercial crops such as rice.

5.2 Recommendation

Based on the presented findings, it is therefore, recommended that:

i. Little Ruaha River is a potential resource for producing various agricultural crops. Therefore, there is a need to increase public knowledge on the use of the river to the community informing them about how water is utilized and the major factors that can contribute to water flow change and how can the community help to preserve water in the river. This will increase their awareness and minimize the conflicts among them at the same time ensuring sustainable management of the river resources. The knowledge about the Little Ruaha River will also assist the communities in efficient utilization and sustainable management of water resources.

ii. The Rufiji Water Basin Office should be responsible for educating the community on how water is distributed in the villages. Awareness creation to local communities is essential for helping them understand how water is utilized and distributed to different users in order to avoid conflicts between them.

iii. The government should focus on empowering the communities around Little Ruaha River through provision of loans and other financial supports for them to diversify economic activities rather than focusing on paddy production only. This will help other household members to conduct other activities that will contribute to the

household income more than when all household members conduct the same economic activity.

iv. More research should be conducted using robust methodologies to ascertain river flow changes and the factors influence the change. This is particularly important for ensuring sustainability of water use and controlling water losses. Research should also focus on developing efficient irrigations schemes and water storage facilities. Efficient utilization of Little Ruaha River will also reduce dependence on rainfall for agriculture. This is because, rainfall is becoming unpredictable in many places due to climate change.

v. The Agricultural Department and other Government Authorities or Offices should make sure that information is well recorded and well stored each year. Proper record keeping will allow the possibilities of undertaking different policy analyses and projections hence ensuring sustainability of resource use. The well recorded and stored information may also be used by researchers for providing advises to planners and decision makers.

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APPENDICES

Appendix 1: **Household survey questionnaire**

My name is Irene Rutatora. I am a student from Sokoine University of Agriculture, Morogoro. The aim of my study is to assess the relationship between changing river regime and the economy of people in your village. Therefore, I wish to get some information from you. I hope you will help me.

Questionnaire No…….....Date of interview.....

Village.....Ward.....Division .....

District.....Region.....

1. Basic information (circle the appropriate answer**)**

1.1 Sex

a) Male b) Female

1.2 Age

a) 18-30 b) 31-50 c) 51–60 d) above 60

1.3 Marital status

a) Single b) Married c) Divorced d) Widow/widower e) Separated

1.4 Education level attained

(i) Primary (ii) Secondary (iii) College (iv) University

(iv) Others (Please specify)

1.5 Occupation: (i) Farmer (ii) Fisher (iii) employed (iv) Unemployed

(v) Others (please specify) ……

1.6 Number of Children …….

1.7 Total number of people in the household……..

2 Economic activities conducted by communities along Great Ruaha River

2.1 What are the major economic activities conducted by your household (please list)

i. ……. ii……. iii…….

iv …… v ……

2.2 Which one(s) mentioned above depend on the Little Ruaha River existence? (please list) i…….ii……. iii……

iv ……..v …….

2.3 Do you grow any crops?

(i) Yes (ii) No

2.4 What type of crops do you grow? (please list them)

i……ii…… iii…… iv……..

2.5 Which crops you grow are for subsistence purposes? (rank them in terms of importance)

i……ii……iii…… iv……..

2.6 Which crops you grow are for commercial purposes? (Rank them in terms of importance)i……ii……iii…… iv……..

2.7 From the commercial crops; mention those that solely depend on irrigation from Little Ruaha River? i……ii……iii…… iv……..

2.8 How much do you earn from crops that are dependent on Little Ruaha River per annum?

Types of crops grown	Number of bags harvested	Amount sold	Tanzanian Shillings

2.9 How much do you get from crops grown elsewhere?

……

2.10 How do you use money obtained from activities related to Little Ruaha River?

Activity	How much earned annually	How money obtained is used
Crop farming		
Fishing		
Tourism		
Transportation		
Brick making		
Other		

2.11What is the income trend of commercial crops in your place?

(i) Increasing (ii) Decreasing (iii) Stable (iv) Not sure

2.12 If increasing; what are the key reasons?

(i) Improved pesticides (ii) increased water flow in the Little Ruaha River (iii) Increased size of the farm (iv) Any other (please specify)

2.13 If decreasing; what are the key reasons?

(i) Poor pesticides (ii) Decreased water flow in the Little Ruaha River (iii) Decreased size of the farm (iv) Any other (please specify)

2.14 From the above-mentioned trend; how does it affect your income?

……

3 River regime change and its implication to water availability for irrigation and economy

3.1 Where do you get your domestic water?

(i) Little Ruaha river (ii) Boreholes (iii) Water authority in the area (iv) Any other please specify

3.2 Do you irrigate your crops from Little Ruaha River?

(i) Yes (ii) No

3.3 If yes; do you get enough water for irrigating your crops?

(i) Yes (ii) No

3.4 If no; where do you get your water?

(i) Boreholes (ii) Rainfall (iii) Others (please specify)

3.5 Is there any change of amount of water flow in Little Ruaha River in the past 10 to 20 years?

(i) Yes (ii) No

3.6 If yes, what kind of change?

(i) Increased water flow, (ii) Decreased water flow

3.7 What are the factors for the decreased/increased water flow in the Little Ruaha River

i……. ii…… iii……

3.8 What are the indicators that you see/use to tell the change? (Increased/Decreased) (Please list)

i……. ii…… iii……

3.9 If Increased, how does it affect the amount of water-needed for irrigation?

i……. ii…… iii……

3.10 If decreased, how does it affect the amount of water-needed irrigation?

i……. ii…… iii……

3.11 Are there any water use conflicts among users in this area?

(i) Yes (ii) No

3.12 If yes; what are the reasons

(i) Decreased water flow (ii) Poor management of water (iii) Increased number of farmers (iv) Increased size of the farms (v) Others (please specify)

4 Coping strategies of households to stabilize their incomes (if the water is decreasing)

If economic activity is affected because of decreased water in the Ruaha River;

4.1 What are the alternative activities that you do to ensure you boost your income? (list them in terms of priority)

i……. ii…… iii……

4.2 While doing those alternative activities, what measures are you taking (as individual) to reduce the stress of water flow in Little Ruaha River?

i……. ii…… iii……

4.3 Are there any local government initiatives to ensure water is available for irrigation and other domestic uses in your place?

(i) Yes (ii) No

4.4 If yes, what are those initiatives

i……. ii…… iii……

4.5 If no, why do you think they are not doing anything?

i……. ii…… iii……

4.6 What do you recommend to the government to do to solve the problem of water stress in your area?

i……. ii…… iii……

"THANK YOU FOR YOUR COOPERATION"

Appendix 2: **Checklist for Key Informants**

My name is Irene Rutatora. I am a student from Sokoine University of Agriculture, Morogoro. The aim of my study is to assess the relationship between changing river regime and the economy of people, that are dependent in Little Ruaha River. Therefore, I wish to get some information from you. I hope you will help me.

1.1 Background Information

Date……

Respondent No. ---------- ---------

Full Name----------

Age----------

Sex---------- (1, Male 2, Female)

Education level----------

Position----------

1.2 Official Information

1. What is the relationship between river regime change and economy of the people around this area?
2. What economic activities do the people in this area depend on for living?
3. What are the economic activities affecting the Little Ruaha River?
4. What type of crops are grown around this area?
5. What is the yield trend of crops grown around this area? What do you think is the reason for the situation?
6. Are there any water use conflict among users in the area? If yes, what are the reasons?
7. Is it true that river regime is changing in the last 10 years?

8. If yes, how does it affect the income of the people who are dependent on Little Ruaha River economically?
9. Do you educate people on proper use of water in Little Ruaha River, so that they cannot lead to changing river regime
10. If yes, what are the method used to educate people on proper use of water in Little Ruaha River?

THANK YOU FOR YOUR COOPERATION

Appendix 3: **Guideline for direct observation**

- Living standard of the people in the villages at the time of data collection.
- Economic activities conducted by communities along Little Ruaha River.
- The types of crops grown in the area (in all villages).
- The size of the farms found in the villages.
- Water level in Little Ruaha River during data collection.