RECESSION FARMING PRACTICES AND THEIR LINKAGES TO HYDRO-CLIMATIC RISKS IN THE KILOMBERO VALLEY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA

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ABSTRACT

The Kilombero valley has national, regional and international importance due to its proximity to water supplies, fertile soils and flat landscape. About 80% of its population engages in agricultural production to fight poverty and food insecurity. Besides population expansion, Kilombero Valley is vulnerable to drought and flood risks due to climate variability and change. The current study assessed recession farming practices in relation to hydro-climatic risks reduction. Specifically the study focused on characteristics of recession farming practices, its contribution to mean annual household income, variation of water in the valley and farmers' perception on climatic risks associated with water. Primary data were collected through interview and Focus Group Discussion. Hydrological data were obtained from RBWB. The quantitative data were analysed by using descriptive analysis, independent t-test and trend analysis while content analysis was used to deduce theme from data obtained by Focus Group Discussion. The study revealed that recession farming has crucial role in hydro-climatic risk reduction especially in the dry season. It ensures the availability of 1322.02 Kg/ha of maize and rice when food from rain-fed agriculture becomes limited. Recession farming ranked as the second contributor of mean annual household income (556 316.66 TZS) after rain-fed agriculture (686 366.67 TZS). The valley experiences downward trend of water flow with spatial-temporal variation. Farmers are aware on hydro-climatic risks and be able to develop copping strategies. The study recommends the government to monitor the implementation of Agricultural Sector Development Strategy – II that aims to facilitate the accessibility of agricultural inputs and market infrastructure by smallholders.

DECLARATION

I, **Neshafati Fwaya**, do 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 being concurrently submitted in any other institution.

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DEDICATION

I dedicate this work to my parents, Adamson Fwaya and Rhozina Ndavile and my brother, Fred Maganga who laid the foundation for my education.

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LIST OF ACRONYMS AND SYMBOLS

ASDS-II	Agriculture Sector Development Programme-II
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LSIA	Large-Scale Agricultural Investment
KV	Kilombero Valley
UNDRR	United Nations Disaster Risk Reduction
RBWB	Rufiji Basin Water Board
SAGCOT	Southern Agriculture Growth Corridor of Tanzania
TZS	Tanzania Shillings

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Floodplains have national, regional and international importance due to their proximity to water supplies, fertile soils and flat landscape (Gebrekidan *et al*., 2020) making them attractive for settlement establishment. Despite its values, floodplains are highly vulnerable to hydro-climatic risks and land use change (Bosongo, 2011; Wilson *et al*., 2017). Modification of floodplains due to climate change and land use change interfere the function of floodplains.

Small-scale farmers with low adaptive capacity are thought to be more vulnerable (Balama *et al*., 2013). Water resources are becoming increasingly scarce in the dry season (Näschen *et al*., 2019) and contested due to climate change and growing water demand for consumption, agriculture and industries in rural and urban (IPCC, 2007; Lalika *et al*., 2011; Lalika *et al*., 2015). Water demands by different sectors/uses in some cases compete directly with one another in that the water used by one sector is no longer available for other uses (IPCC, 2007). For example, the water consumed by upstream irrigation farming affects the yearly inundation of the floodplain and reduce stream water flow for hydropower generators and aquatic life downstream. This interferes with traditional patterns of land and resource use on the floodplains.

In view of this situation, adaptation of water use efficiency strategies is crucial in relation to seasonal rise and fall of water level imposed by climate change and land use changes in floodplains in order to reduce hydro-climatic risks and uncertainties to the community (Näschen *et al*., 2019; Lalika *et al*., 2015). Recession farming is a common practice in floodplains, used to meet food requirements when other food sources are limited (Everard, 2016). It is practiced in the dry season after the floods have receded (Munodawafa, 2013; Sidibé *et al.,* 2016). Recession farming relies on residual moisture left by receding floods to grow crops and based on natural fertilization of floodplain (Kashe *et al*., 2015).

There is a huge potential for flood based farming systems considering the areas that experience annual flooding (Nederveen, 2012). For instance Ghana government adopted sustainable management of water, land and environment strategy to reduce rural poverty through agricultural and rural development (Sidibé *et al.,* 2016). The strategy encompasses recession farming. There is evidence that recession farming tends to have a lower environmental impact and less cost than large-scale irrigation systems (Sidibé *et al.,* 2016; IUCN, 2000; Oyebande, 2001). It is compatible with the protection of African floodplain ecosystems (Kilombero floodplain inclusive), many of which are presently being modified with negative consequences for the ecosystem services provided by wetlands as a result of land use change and climate change (Alavaisha, 2020; Sidibé *et al.,* 2016; Näschen *et al*., 2019; Balama *et al*., 2013).

1.2 Problem Statement and Justification

1.2.1 Problem statement

Despite its values, Kilombero Valley (KV) is under intense pressure, which is imposed by human interventions. Conversion to cropland and excessive exploitation by improperly planned development activities in the valley is having, and will continue to have, severe, adverse, and irreversible impacts on its capacity to provide services in the future (Wilson *et al*., 2017; Alavaisha, 2020; Näschen *et al*., 2019). Furthermore, the Population density has been increasing steadily. As a result, productive agricultural land is becoming scarce (Gebrekidan *et al*., 2020).

In additional to land use change, KV is vulnerable to drought (in the dry season) and flood risks (in the wet season) due to variability and climate change (Näschen *et al*., 2019; Balama *et al*., 2013). Prolonged droughts cause reduced land-based food production consequently, causing countries to be net importers (Bosongo, 2011). On other hand Näschen *et al*. (2019), reported that due to climate change, flooding intensity is likely to increase in KV. Floods are the most taxing type of hydro-climatic risks to humans, assets, as well as to cultural and ecological resources (Bosongo, 2011).

The government of Tanzania in collaboration with private companies and international donors recognized the need for increasing smallholder welfare and the achievement of economic growth and poverty reduction through sustainable intensification pathways (Jenkins, 2012; Schnitzer and Azzarri, 2014). Efforts are made to reduce critical constraints facing small-scale farmers (Gebrekidan *et al*., 2020). However, most of efforts favour rain-fed and irrigation agriculture. For example, Agriculture Sector Development Programme-II (ASDS-II) and Southern Agriculture Growth Corridor of Tanzania (SAGCOT) both as agricultural programmes promote intensive irrigation agriculture in the KV in order to improve agricultural production and reduction of rural poverty in Tanzania (Gebrekidan *et al*., 2020). There is inadequate information on recession farming practices in relation to hydro-climatic risk reduction in KV. This is making farmers and the government to be in position of not realizing the full potential of recession farming in KV. Several studies reported the contribution of recession farming to livelihood (Munodawafa, 2013; Kashe *et al*., 2015; Everard, 2016; Sidibé *et al*., 2016; Bosongo, 2011; Nederveen, 2012). Gebrekidan *et al*. (2020), characterized farmers and farming systems in KV. Höllermann *et al.* (2021), investigated the differences between farmers from rain-fed and irrigated agriculture. Then the current study looked on recession farming practices and their linkages to hydro-climatic risks in the KV.

1.2.2 Problem justification

Information on whether recession farming system is suitable in relation to hydro-climatic risk reduction is crucial in planning and policy making for resource management of the KV and lower Rufiji Basin. In KV, generic policies and interventions (large-scale agricultural investment (LSAI) scheme) are implemented (Gebrekidan *et al*., 2020). However, the expected outcomes have not been fully met, indicating the need of urgent actions. The results of this study will help policy makers to formulate targeted policy rather than generic one for KV management.

1.3 Research Objectives

1.3.1 General objective

To analyse recession farming practices and their linkages to hydro-climatic risks and uncertainties in the KV

1.3.2 Specific objectives

i. To characterize recession farming practices along KV.
ii. To assess the contribution of recession farming to household income.
iii. To explore water sources, availability and variation in KV.
iv. To examine occurrence of hydro-climatic risks and uncertainties in the KV.

1.3.3 Research questions

i. Is recession cropping a suitable farming practice for the KV in relation to hydro-climatic risk reduction?
ii. What is the contribution of recession farming on mean annual household income?

iii. What is the situation of the present-day water flow in KV?

iv. How do people perceive hydro-climatic risks and uncertainties?

4.4 Conceptual Framework

In this study, flooding was considered as an opportunity for recession farming in KV. On other hand, stability of local farmers was determined by their response at the onset of drought. Drought affects crop production thereby reduces local farmers' food consumption and agriculture derived income (Deverux, 2007). Occurrence of floods improves floodplain soil fertility and ensures availability of soil moisture in early months of the dry season (May – June). Recession farming practiced in the dry season, utilizing soil moisture left by floods. Recession farming yield helps to buffer rain-fed agricultural yield in the dry season to reduce drought risks until the following rainy season (Figure 1).

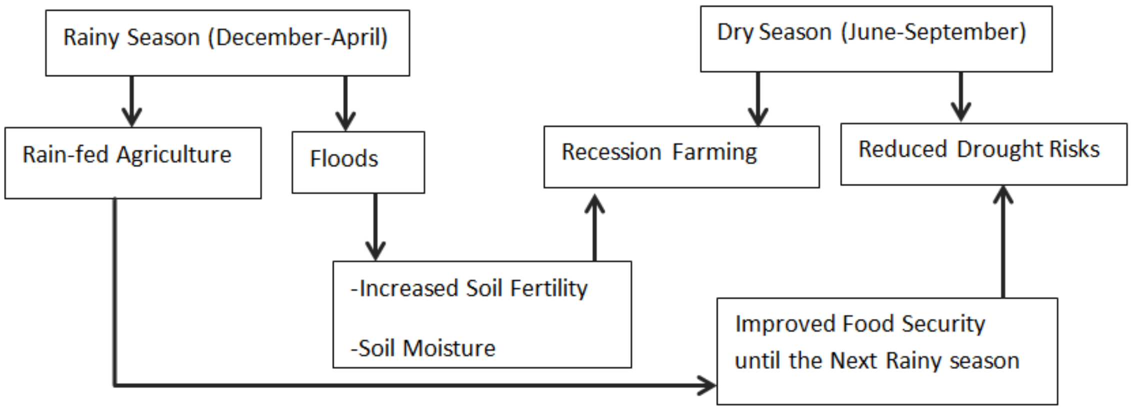


Figure 1: Conceptual framework analysing the linkage of recession farming and hydro-climatic risks

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Characterization of Flood Recession Farming

Flood recession farming is a common practice in many regions of the world on river floodplains, lake margins, and other wetlands where water level rise and fall predictably (Everard, 2016). It is based on residual moisture and natural fertilization of the floodplain as flood water recede (Kashe *et al*., 2015; Everard, 2016). While the frequency of flood events is expected to be increasing in floodplains in the rain season (Näschen *et al*., 2019), it is possible to take advantage of soil moisture left by floods and increase overall annual production of recession farming once the flood water recede (Sidibé *et al.*, 2016). This is a result of an unevenly distributed annual rainfall pattern (Nederveen, 2012; Näschen *et al*., 2019). In Africa several countries have been practicing recession farming including Senegal, Zimbabwe, Zambia, Kenya and Tanzania (Rufiji River Basin) (Nederveen, 2012).

There are some general features that are typical for flood recession farming. In recession farming, farmers have no control over water flow to the recession fields (Everard, 2016; Sidibé *et al.,* 2016). The annual flood that comes in the rainy season brings fertile sediment from the upper catchment (Sidibé *et al.,* 2016; Nederveen, 2012). The flooded areas are often gently sloped floodplains or margins of lakes or wetlands where these sediments can settle. Organic material in the sediment acts as a natural fertilizer (Kashe *et al*., 2015). The recession farmers do not have to add fertilizers and plots are suitable for continuous cropping without fallowing (Nederveen, 2012).

2.2 Contribution of Recession Farming to Household Income

In areas dominated by flood-prone lands, flood recession farming can potentially be an effective solution to meet the food requirements of rural populations and increase their incomes (Bosongo, 2011; Sidibé *et al*., 2016). Nevertheless, even where irrigated farming took place, flood recession farming remained important at the household level for subsistence needs, supporting household subsistence during months where other contributions to the household income were limited (Everard, 2016). Income generated from recession farming is influenced by the number of crops intercropped in the same land (Munodawafa, 2013).

2.3 Climate change, Land Use Change and Water Variation in Floodplain

Floodplains provide many benefits to humans. Water resources and fertile soils for plant production are among of the ecosystem services from floodplain (Gebrekidan *et al*., 2020). For centuries, humans have intensively modified and used rivers and floodplains, often leading to a decreased ecological status and a loss of the floodplain character (Lena *et al*., 2019).

Population increases and demand for food (and food security) has led to agro-innovation and targeted development throughout the world (Alavaisha, 2020). An example of such targeted development can be found in Tanzania. Recently, under the policy of Kilimo Kwanza (Agriculture First), Tanzania implements an initiative known as the SAGCOT, which aims at rapidly developing agricultural potential through large and small-scale irrigation schemes, in a sustainable way (Lugangira, 2018). The initiative in combination with climate change is expected to decrease water flow, increases water demand among competing water users if not well planned (Wilson *et al*., 2017).

Recent studies in KV reported significant impact of land use change and climate change on water resources (Näschen *et al*., 2019; Alavaisha, 2020; Wilson *et al*., 2017; Balama *et al*., 2013). For example, low streamflow and poor water quality due to land use change and climate change detected in KV (Näschen *et al*., 2019; Alavaisha, 2020).

2.4 Terminology Related to Disaster Risk Reduction

2.4.1 Disaster

Disaster defined as a serious disruption of the functioning of a community or a society at any scale due to hazardous event interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts (UNDRR, 2017; Kiwango, 2015).

2.4.2 Disaster risk

The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity (UNDRR, 2017; Mikellidou *et al*., 2018).

2.4.3 Hazard

Hazard can be defined as a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation (UNDRR, 2017; Kiwango, 2015). It may be natural, anthropogenic or socio-natural origin (combination of natural and anthropogenic factors, including climate change) (Sahani *et al*., 2019; UNDRR, 2017).

2.4.4 Exposure and vulnerability

The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas is termed as exposure (UNDRR, 2017; Sahani *et al*., 2019). The condition determined by physical, social, economic and environmental factors, or process which increase the susceptibility of an individual, a community assets or systems to the impacts of hazard (UNDRR, 2017). Thus, hazard poses risk to society, assets and ecosystemin a given period, based on the extent of exposure to that hazard, the vulnerability of affected people, property or surroundings and their resilience, or adaptation in response to the hazard (Sahani *et al*., 2019).

2.4.5 Disaster risk reduction

Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risks, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development (UNDRR, 2017).

A global, agreed policy of disaster risk reduction is set out in the United Nations endorsed Sendai Framework for Disaster Risk Reduction 2015-2030, adopted in march 2015. The expected outcome of the policy from 2015 to 2030 is: The substantial reduction of disaster risk and losses in lives, livelihood and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries (UNDRR, 2017).

2.5 Hydro-climatic Risks

Hydro-climatic risks originate from hydrological hazards (floods, drought, heatwaves and cold spells) related to uncertainties and climate change (UNDRR, 2017; Balama *et al*., 2013). IPCC (2001, 2007) reported that water hazards are likely to get worse, as there is a confidence that the magnitude and frequency of floods and droughts increase due to changes in mean or variability of climate change. Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitude (IPCC, 2007). Bosongo (2011) reported that during floods and droughts household income is severely affected since the quantity of crops sold is little due to crop failure. Furthermore, during flood or drought the price of grain in the local market increases (Bosongo, 2011). Adaptations such as altered cultivars and planting times allow low and mid to high latitude cereal yields to be maintained at or above baseline yields for modest warming (IPCC, 2007).

Tanzania is among of developing countries which are vulnerable to hydro-climatic risks. According to available data, the country has been hit by drought more than 18 times since its independence (Kiwango, 2015). The recent one occurred in 2007/2008 whereby Arusha, Dodoma, Kilimanjaro, Manyara, Shinyanga, Lindi, Singida, Tabora and Mwanza regions were affected. Floods in Tanzania are exacerbated due to unsustainable land use planning (Kiwango, 2015). KV in Morogoro region is among of the floodplains that are vulnerable to unpredictable floods and prolonged dry spells (Balama *et al*., 2013).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Study Area

3.1.1 Location of study area

The study was carried out in selected villages along the Kilombero Valley. This valley is located in Ulanga and Kilombero Districts in Morogoro region, Tanzania and it lies between longitudes 34.563° and 37.797°E and latitudes 7.654° and 10.023°S (Wilson *et al*., 2017). It covers an area of about 11,600 km^2, with a total length of 250 km and a width of up to 65 km (Gebrekidan *et al*., 2020). In 2002 the KV was designated as a Ramsar site due to its international importance (Gebrekidan *et al*., 2020). The floodplain is surrounded by the Udzungwa Mountains in the northwest and the Mbarika Mountains and Mahenge Highlands in the southwestern parts. The peak elevation drops from an altitude of more than 1800 m amsl to about 300 m amsl in a few kilometres (Wilson *et al*., 2017).

3.1.2 Climate of KV

Generally, the floodplain is humid with high temperatures ranging from 26℃ to 32℃ (Gebrekidan *et al*., 2020). While the relative humidity in the mountains is between 70–87%, the lowlands experience 58–85% humidity with average potential evaporation of 1800 mm (Wilson *et al*., 2017). The Kilombero plains experience annual rainfall of between 1200 – 1400 mm (Wilson *et al*., 2017). The rainy season is between December and April while the dry season is between June and September.

3.1.3 Vegetation and soil

The dominant natural vegetation in Kilombero is miombo woodland, grassland and bushland (Alavaisha, 2020). Miombo are common in the more elevated parts, while grassland is dominant in the floodplain. KV is a typical fertile alluvial floodplain with loamy, clay, clay loamy and sandy soils and is an essential source of nutrients and sediment for the downstream area (Nindi *et al*., 2014).

3.1.4 Drainage pattern

The KV used to have 38 permanent rivers which provided high potential for hydroelectric power and large irrigation schemes for sugarcane plantations (Nindi *et al*., 2014). Many of these tributaries flow into the floodplain from the Mahenge Highlands located in the south of the valley. The plain becomes inundated during the wet season, while it dries up during the dry season, except for the rivers and river margins, as well as for areas with permanent swamps and water bodies (Gebrekidan *et al*., 2020). The Kilombero Valley forms one of the four principal sub-basins of the Rufiji River and discharge 62% of Rufiji basin run off (Wilson *et al*., 2017).

3.1.5 Socio-economic activities

The main economic activity in Kilombero Valley is farming. About 80% of the population is engaged in agricultural production associated with the floodplain (Mombo *et al*., 2011; Nindi *et al*., 2014). Fishing, Forestry, urbanization and transport and Livestock keeping are another prominent economic activities (Gebrekidan *et al*., 2020; Wilson *et al*., 2017). Conflicts between pastoralists and farmers over land use are a chronic and widespread problem, which has resulted in injury and litigation disputes (Gebrekidan *et al*., 2020).

3.2 Methods of Data Collection

3.2.1 Study design

Study design states the conceptual structure within which research is conducted. This study used cross sectional design; data were collected once at a time in the field. The design was adopted because allow the collection of maximum information with minimum expenditure of effort, time and finance.

3.2.2 Sampling procedure

The data used in the current study were collected using a household survey in 4 villages (Mbingu, Idete, Mkula and Minepa) in KV. In total, 120 farm households were interviewed. Purposive selection of study villages was adopted based on water availability in dry season. Presence of irrigation scheme was used as indicator of water availability. Then target population involved two villages with irrigation schemes and other two villages without irrigation schemes. Only 30 households from each village registration list were randomly selected for the interview. The sample size is supported by Nkonoki (2015) who reported that, a sample of at least 30 units is sufficient irrespective of the population size. Furthermore, McClanahan *et al*. (2005), reported that investigations on socio-economic studies in Sub-Saharan Africa require a sample size between 80 to 120 household respondents.

3.2.3 Data collection

Triangulation technique was used to collect data whereby several data collection methods were used. Primary data were collected through interview and Focus Group Discussion. Hydrological and precipitation data were obtained from Rufiji Basin Water Board. Triangulation technique helps to increase the validity and reliability of the results.

3.2.3.1 Interview

Respondents were interviewed using questionnaire to collect information on socio-economic factors, contribution of recession farming to household income, characterization of recession farming practices with time, source of water for farmers and water variability, relevance and perception of hydro-climatic risks and new developments on farming practices. Likert scale statements were included in the questionnaire to measure farmer perceptions on hydro-climatic risks.

3.2.3.2 Focus group discussion (FGD)

A checklist focusing on qualitative data was designed for the focus group discussions. One group of 4-6 people (gender and age sensitive) was gathered per each study village at a given time for the discussion. Several topics were discussed in FGD including the way farmers perform recession farming, linkage of recession farming and hydro-climatic risks and constraints facing recession farming.

3.2.3.3 Data on water variation

Hydrological flow and precipitation data were obtained from Rufiji Basin Water Board (RBWB). These data were used to show water variability and helped to discuss perception of farmers on hydro-climatic risks in KV.

3.3 Data Analysis

Descriptive analysis was used to analyze quantitative data such as farming systems, cultivated crops and crop yields from recession farming, contribution of recession farming to household income, perception on hydro-climatic risks and uncertainties, source of water in dry season and water availability. Independent t-test was used to compare household income from recession farming in KV between villages with and without irrigation scheme since the two village groups are independent of each other in term of water availability in the dry season. Trend analysis was used to analyse variation of water in KV. Content analysis was used analyse challenges facing recession farming in KV.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Characterization of Recession Farming Practices along KV

4.1.1 Farming system and cultivated crops in recession farming

Recession farming allows growth of more crop types and varieties including maize, rice, sorghum, beans, pumpkin, watermelons and vegetables (Everard, 2016, Kashe *et al.*, 2015; Sidibé *et al.*, 2016). The majority of farmers in KV cultivate maize (64.2%), paddy rice (44.2%), vegetable (24.2%), groundnuts (11.7%) and water melon (5.8%) in recession farming (Table 1). Duvail and Hamerlynck (2007) reported similar findings along the Rufiji River. Farmers in KV prefer more to grow maize in recession farming because it can withstand limited soil moisture. Other crops grown in recession farming are beans, cassava, sweet potatoes, yams, tomatoes, sorghum, African eggplant, okra, legumes and mung beans (Table 1).

Table 1: Crops cultivated in recession farming in the study village

Crops	**Percentage (%)**				
	1*	**2***	**3***	**4***	**Average**
Maize	93.3	100.0	36.7	26.7	64.2
Rice	6.7	0.0	88.7	86.7	44.2
Vegetables	43.3	26.7	20.0	6.7	24.2
Groundnuts	13.3	30.0	3.3	0.0	11.7
Water melon	6.7	3.3	3.3	10.0	5.8
Beans	6.7	0.0	3.3	3.3	3.3

Cassava	3.3	6.7	3.3	0.0	3.3
Sweet potatoes	0.0	0.0	6.7	3.3	2.5
Yams	0.0	6.7	0.0	3.3	2.5
Others (Tomatoes, Sorghum, African eggplant, Okra, legumes, and Mung beans)	6.7	6.7	10.0	3.3	6.7

*****Village → 1 = Idete, 2 = Mbingu, 3 = Mkula, 4 = Minepa

Source: Field data, 2021.

Table 2: Cropping system in recession farming

Cropping system	**Percentage (%)**				
	1*	**2***	**3***	**4***	**Average**
Monocropping	53.3	40	83.3	93.3	67.5
Intercropping	46.7	60	16.7	6.7	32.5
Total	**100**	**100**	**100**	**100**	**100**

*Village → 1 = Idete, 2 = Mbingu, 3 = Mkula, 4 = Minepa

Source: Field data, 2021.

About 67.5% of farmers practice mono-cropping system in recession farming (Table 2). This is in line with another study on characterizing farmers and farming system in KV (Gebrekidan *et al*., 2020). On other hand, land scarcity in KV influenced 32.5% of farmers to practice intercropping system in recession farming to meet their demands. Farmers intercrop maize with other crops such as groundnuts, vegetables, legumes and okra.

4.1.2 Crops yield from recession farming and rain-fed agriculture

The study quantified only the yield of major crops (maize and rice grain) grown in recession farming and rain-fed agriculture due to poor data records of harvest by farmers in KV. The average yields of maize and rice grain in recession farming and rain-fed agriculture are uneven in four study villages (Table 3). The total yield (maize and rice) in recession farming (1322.02 Kg/ha) is less than the total yield (maize and rice) in rain-fed agriculture (1816.39 Kg/ha). In the dry season not all farms are used for recession farming due to variation of soil moisture. The low lying area and river banks are common used for recession farming because they retain soil moisture while both low and high lying are used for rain-fed agriculture. Moreover, maize yields are significantly higher in recession farming compared to rain-fed agriculture (Table 3). This is similar to findings reported in Zimbabwe, where farmers harvest more maize grains in recession farming than in rain-fed agriculture (Munodawafa, 2013). Seasonal water variation has influence on agriculture productivity (Kashe *et al*., 2015; Everard, 2016; Gebrekidan *et al*., 2020). This contributes the difference in productivity between the two agriculture systems. For example in KV, there are few rain events during the dry season; farmers cultivate more maize crop in recession farming since it withstands more water stress than paddy farming.

Table 3: Maize and rice means yield in study villages

Village	**Crop**	**Recession farming Yield, Kg/ha, (Mean ± SD)**	**Rain-fed agriculture Yield, Kg/ha, (Mean ± SD)**
Mbingu	Maize	1045.5 ± 896.546	70.839 ± 240.502
	Rice	0.0000 ± 0.0000	1926.67 ±1966.08
Idete	Maize	835.839 ± 667.4574	175.661 ± 500.1
	Rice	40.0000 ± 184.951	1496.67 ± 1391.72
Minepa	Maize	306.0000 ± 743.563	147.339 ± 486.465
	Rice	1913.33 ± 2124.039	2416.67 ± 3567.292
Mkula	Maize	320.739 ± 605.234	88.4 ± 465.295
	Rice	826.67 ± 519.903	943.33 ± 485.431

Source: Field data, 2021.

Although the total yield in recession farming is lower compared to rain-fed agriculture, it ensures food supply when food from rain-fed agriculture becomes limited. The results imply that recession farming has crucial role on food security during the dry season. Also the results imply that farmers have knowledge on crop selection with respect to spatial and temporal water variation to maintain food security around the year.

4.1.3 Tools/equipment used for land preparation

Farmers use different tools/equipment to prepare land for recession farming and rain-fed agriculture in KV, depending on household economic status. The majority of farmers (68.1%) use hand hoe for land preparation (Table 4). However technology development has led farmers to use labour-saving technologies and innovations such as power tillers and plough drawn by oxen and tractors (Table 4). Farmers also use herbicide, fire and billhook to remove weeds in farm, making land ready for tillage. Government of Tanzania (2016) reported the same level of mechanization in Tanzania.

Table 4: Tools/equipment used for land preparation

Tools/Equipment	**Percentage (%)**				
	1*	**2***	**3***	**4***	**Average**
Hoe	63.3	72.4	96.7	40.0	68.1
Oxen	20.0	75.9	0.0	56.7	38.2
Power Tiller	3.3	3.4	40.0	70.0	29.2
Tractor	60.0	6.9	3.3	13.3	20.9
Others (Fire, Herbicides, billhook)	26.7	27.6	40.0	53.3	36.0

*Village → 1 = Idete, 2 = Mbingu, 3 = Mkula, 4 = Minepa

Source: Field data, 2021

4.1.4 Fertilizer and pesticide use in recession farming

Besides land and labour, farmers practicing recession farming apply other agricultural inputs to enhance and protect their crops in the KV. Majority of farmers (49%) apply pesticides (Figure 2). Farmers use pesticides to protect their crops from resistant pests or harmful worms hosted in the soil (Munodawafa, 2013; Nederveen, 2012). There are two types of pesticides that are mostly used in the study area, namely, Duduba and Karate. Of the interviewed farmers, only 43.9% use inorganic fertilizer while 7.1% use organic fertilizer to enhance growth of their crops (Figure 2).

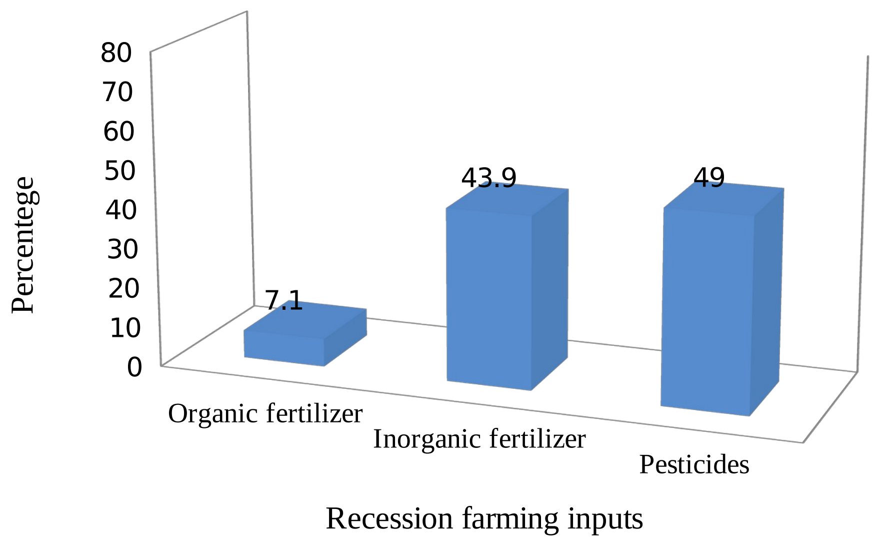


Figure 2: Agricultural inputs applied in recession farming apart from land and labour

Source: Field data, 2021.

"Over utilization of land in the study villages to meet increased demands has led farmers to depend on inorganic fertilizers in order to increase the yield" (Elder farmer from Idete village). Recession farming practiced in other area such as Ghana, Botswana, Senegal and other countries in West Africa only depend on natural soil fertility brought by floods (Everard, 2016, Kashe *et al*., 2015; Nederveen, 2012; Sidibé *et al.*, 2016). This implies that, there is an additional cost of practicing recession farming in KV. Also the receiving environment is being affected from the use of pesticides and inorganic fertilizers.

These inputs are also used during rain-fed agriculture. Farmers reported that, accessibility of agricultural inputs is quite difficult in the dry season (for recession farming) than in the rain season. Many agricultural input shops operate in the rain season because it is the season when intensive agricultural activities take place.

4.1.5 Challenges facing recession farming

Recession farming practices in KV face several challenges that severely undermine its productivity: High cost of agricultural inputs, farmers reported that they must sell more than one bag of maize (65 000 TZS) in order to afford one bag of inorganic fertilizer. Lack of market and seasonal variation of water hamper farmers to practice recession farming. Farmers sometimes need to rent a water pump in order to abstract river water since soil moisture after rain season dry up before harvest period (Sangari, 1991). Furthermore farmers reported that their crops are highly attacked by pests (Box 1).

Box 1: Effect of pests in recession farming production

"Our crops are highly affected by pests. The harvest from recession farming and irrigation scheme is reduced. In previously, 1500 Kg up to 2000 kg were harvested per hectare from paddy farming, but now the harvests are reduced (400 Kg up to 700 Kg). Sometime you can even harvest 200 Kg, it is worse".

(Focus Group Discussion, April, 2021)

Source: Field data, 2021.

Also the study by Munodawafa (2013) on benefit of floodplain recession farming reported pests as among the major contributor to reduction in yield of recession farming.

4.2 Contribution of Recession Farming to Household Income

A comparison was carried out to establish how much recession farming and other economic activities contribute to annual household income. The results show that 82% (1 242 683.33 TZS) of mean annual household income is contributed by agricultural activities (recession and rain-fed agriculture) in KV (Figure 3). Rain-fed agriculture is the dominant one, contributing 45% (686 366.67 TZS) of the household income.

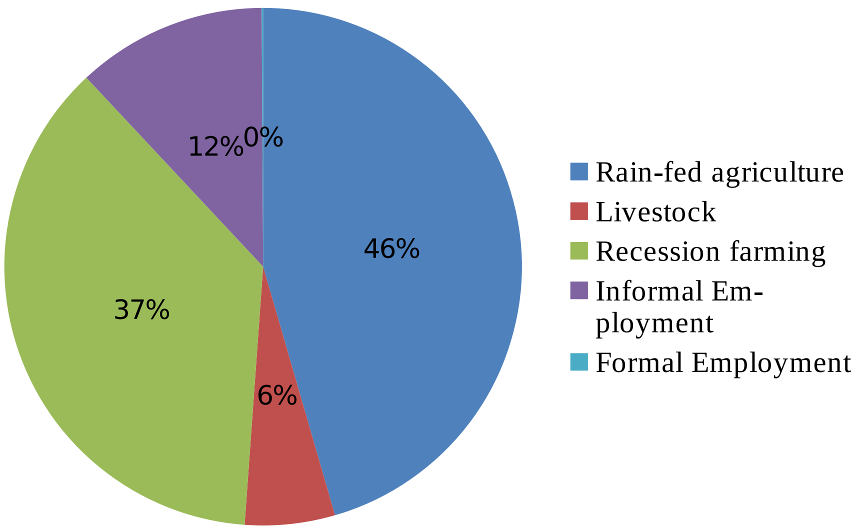


Figure 3: Source of household income per annual

Source: Field data, 2021.

Recession farming contributed only 37% (556 316.66 TZS) of the household income, less than rain-fed agriculture (Figure 3). This is in line with another study on benefit of floodplain recession farming (Munodawafa, 2013). Crops from recession farming are largely cultivated for subsistence. Unavailability of market discourages farmers to sell their crops. They only sell their crops for emergency such as paying for school fees and their treatment. Sometimes farmers only practice recession farming to supplement food supply when rain-fed crops are destroyed by floods (Bosongo, 2011; Sidibé *et al.*, 2016; Everard, 2016). Other sources of income are livestock (6%), informal employment (12%) and formal employment (0%).

4.3 Household Income from Recession Farming of Villages with and without Irrigation Scheme

Independent-samples t-test was applied to test household income difference from recession farming of villages with and without irrigation scheme. Results from t-test are displayed in Table 5.

Table 5: Independent sample t-test of household income difference from recession farming between villages with and without irrigation scheme

household income	t	df	Sig. (2-tailed)	Mean Difference
Recession farming	5.805	118	.000	640200

Source: Field data, 2021.

It was revealed that $p = 0.000$. Therefore, $p < 0.05$ implying that there is significant difference in household income from recession farming between villages with and without irrigation scheme. Minepa and Mkula villages benefit more (876 416.7 TZS) than Mbingu and Idete villages (236 216.67 TZS) from recession farming. This can be attributed to difference in water availability across the study villages in dry season (Kashe *et al.*, 2015). Farmers practicing recession agriculture use flowing river water and wells to supplement the depleted soil moisture (Nederveen, 2012; Sangari, 1991), making sure their crops reach harvest stage. This improves the total harvest since farmers are able to cultivate both maize and rice crops in recession farming. The result implies that farmers who are able to diversify their crops earn higher income than the one relying on one crop.

4.4 Water sources, availability and variation in KV

4.4.1 Water sources and availability in KV

During the dry season, when the rain stops completely (around May) households have to look for other water sources for agricultural activities. Majority of farmers (63%) use river for watering their crops when soil moisture dries up (Figure 4). They use water pump to abstract water from the river to stream bank where their farms are located. Other farmers (37%) use borehole as source of water when the soil moisture dries up before harvest period (Figure 4). This is possible because floodplains are characterized with shallow groundwater between two and four meters deep (Nederveen, 2012).

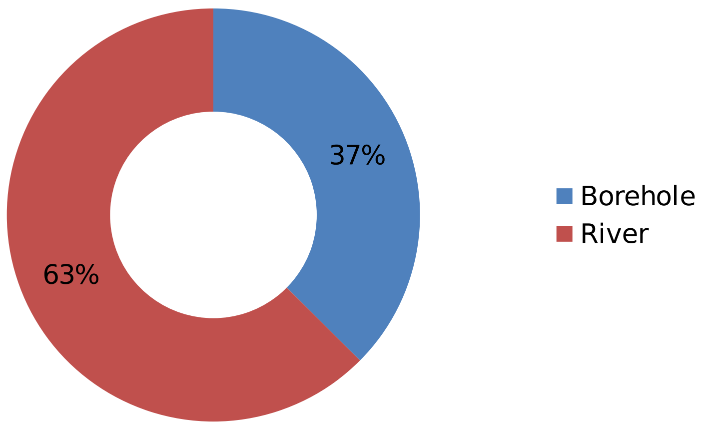


Figure 4: Water sources during dry season in KV

Source: Field data, 2021.

Table 6: Accessibility of water to farmers in KV

Accessibility of water	Percentage (%)				
	1*	**2***	**3***	**4***	**Average**
Free	93.3	100	30.0	16.7	60
You have to pay	6.7	0.0	70.0	83.3	40
Total	**100**	**100**	**100**	**100**	**100**

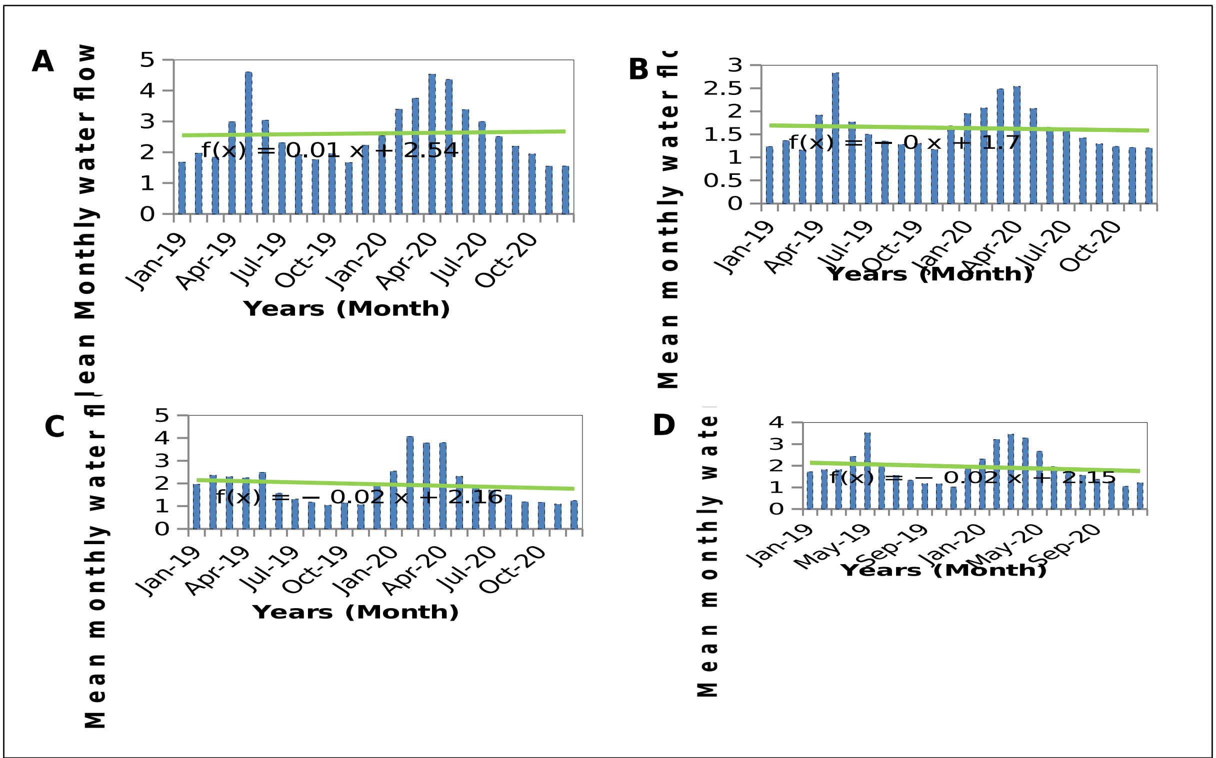
*Village → 1 = Idete, 2 = Mbingu, 3 = Mkula, 4 = Minepa

Source: Field data, 2021.

About 60% of interviewed farmers pay no fee to access water for their agricultural activities during dry season. They only need to have a water pump or borehole in order to use available water. Other farmers (40%) have to pay water fee in order to access water for agricultural activities. They use water from established irrigation schemes for irrigation agriculture (paddy farming). Availability of water in schemes does not guarantee free access. Individual farmers who are economically stable enjoy these large scale agriculture investment schemes. The accumulated fee is used to maintain irrigation scheme facilities. The responses imply that the cost attached in irrigation scheme is high (47 000 TZS at Minepa village). Apparently, farmers go for recession farming in order to secure food and income in the dry season.

4.4.2 Water variation in KV

Trend analyses for mean monthly water flow at four river reaches gagging stations in KV are presented in Figure 5. The water flows for both stations (except Lwipa station) show a slight downward trend.



Source: RBWB, 2021.

Furthermore, the results show spatio-temporal variation of water flow on the subcatchment in KV (Figure 5). The peak flow occurs during the long rains (March and April) while low flows are experienced during the dry period, July to November (Figure 6).

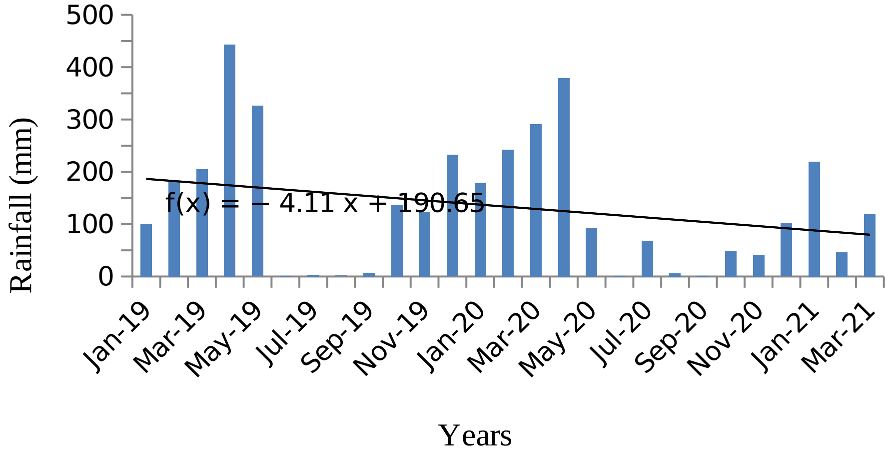


Figure 6: Recorded rainfall from one of weather station in the study area

Source: RBWB, 2021.

CDM (2016) reported the same general flow pattern of Kilombero Valley with minimal impact from limited large-scale water abstractions. However, the discharge is very low currently, suggesting the effect of climate change and large water withdrawals from the rivers for agricultural activities. On other hand, this difference in discharge might be attributable to poor data used by CDM (2016), most of the KV tributaries were ungagged. The results imply that large scale agriculture investments schemes increase water demands irrespective of the available water, consequently aggravating hydrological risks particularly drought. Everard (2016) reported that, manipulation of water flow for irrigation agriculture interfers with flood recession agriculture affecting its yield and contribution to local livelihoods and security. In addition to the ongoing construction of the Stiegler´s Gorge hydropower dam in the Selous Game Reserve downstream, it might reach a point that available flowing water will not support large scale agriculture investments schemes in dry season. This is paving a way for recession farming to secure food and income security and environmental flow in the dry season since it relies on soil moisture left during the offset of rain season.

4.5 Occurrence of Hydro-climatic Risks and Uncertainties in the KV

4.5.1 The hydrological risks and uncertainties related to variability and climate change in KV

Farming activities in KV are vulnerable to floods, draught, extreme temperature and soil erosion (Table 7). Recorded climate stresses are in line with stresses outlined by another studies (IPCC, 2007; Kiwango, 2015).

Table 7: Hydrological hazards related to variability and climate change in KV

Hydro-climatic risks	**Percentage (%)**				
	1*	**2***	**3***	**4***	**Average**
Floods	100	100	100	100	100
Drought	53.3	53.3	73.3	43.3	55.8
Extreme temperature	6.7	30	26.7	20	20.8
Soil Erosion	26.7	13.3	13.3	23.3	19.2

*****Village → 1 = Idete, 2 = Mbingu, 3 = Mkula, 4 = Minepa

Source: Field data, 2021.

4.5.2 Perception of farmers on hydro-climatic risks

Most of farmers (94.2%) strongly agree that floods occur yearly in March to April (Table 8). Also some farmers (38.3%) strongly agree that drought occurs yearly in June to September (Table 8). These two perceptions are consistent with the rain trend observed in the study area (Figure 6). Näschen *et al*. (2019), reported that, drought-related risks might be aggravated in KV due to rising temperatures in combination with decreasing low flow and availability of water in the dry season.

Table 8: perception of farmers on hydro-climatic risks

Variable	**Response (%)***				
	SA	**A**	**N**	**D**	**SD**
Floods occur yearly in March to April	94.2	5	0	0	0.8
Drought occurs yearly in June to September	38.3	34.2	5	12.5	10
Heatwaves occur yearly in June to September	15	26.7	25.8	25	7.5
Landslide or soil erosion occurs yearly	32.5	7.5	14.2	3.3	42.5
Small-scale farmers are more vulnerable to hydro-climatic risks and uncertainties	59.2	13.4	3.3	3.3	20.8
Floods are always destructive	58.3	21.7	2.5	4.2	13.3

*SA- Strongly Agree; A- Agree; N- Neutral; D- Disagree; SD- Strongly Disagree

Source: Field data, 2021.

Results from the interview reveal that 66.7% and 55.1% of farmers strong agree that deforestation and increase in population respectively, aggravate hydro-climatic risks (Figure 7). Majority of farmers (58.3%) perceive that floods are always destructive to rain-fed agriculture. However, Duvail and Hamerlynck (2007) reported floods as blessing and plague to farmers and the government respectively. Furthermore, CDM, (2016) reported that, floods enhance floodplain soil physical and chemical characteristics, replenishing soil moisture and fertility for flood recession agriculture and cultivated vegetables.

In focus groups, all participants expressed the view that the droughts and the extreme temperature are the main threat to recession farming. Duvail and Hamerlynck (2007) reported the same findings on farmers' perception on droughts.

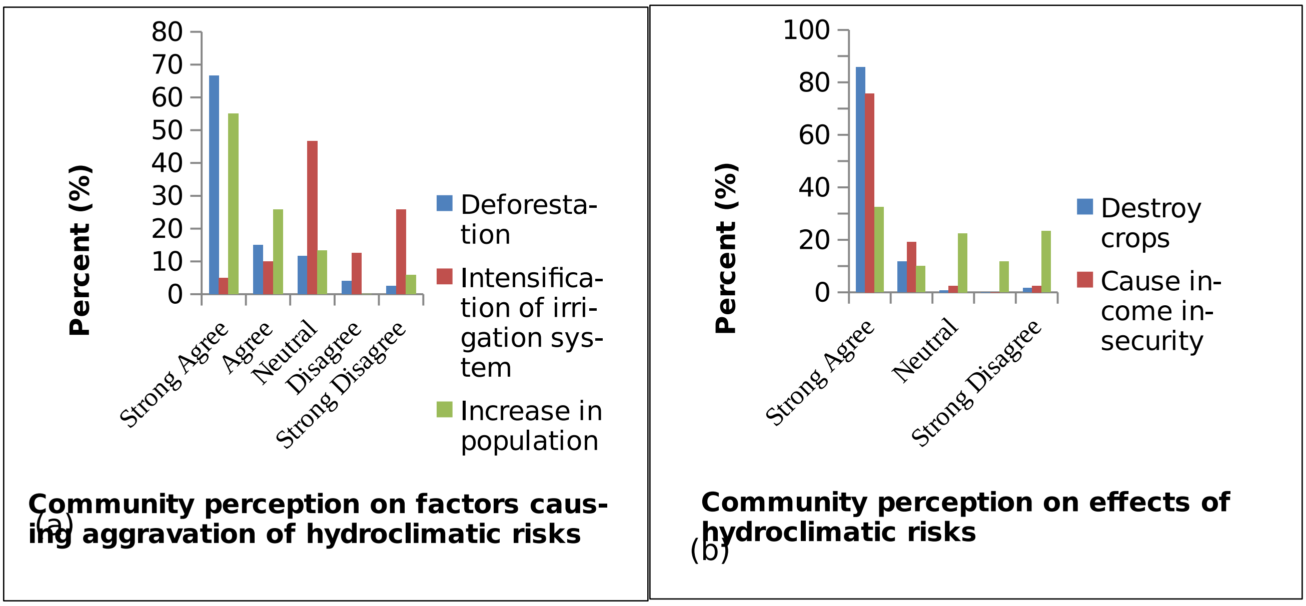


Figure 7: Perception of farmers on: (a) factors causing aggravation of hydro-climatic risks, (b) effects of hydro-climatic risks

Source: Field data, 2021.

Farmers perceive that hydro-climatic risks cause income insecurity, water conflict and destruction of crops (Figure 7). In KV, farmers (59.2%) believe that small-scale farmers are more vulnerable to hydro-climatic risks because are economically weak (Table 7). Balama *et al*. (2013), reported the same results. The farmers' responses indicated that they are aware of the floods and drought seasons and are able to prepare copping strategies. However, they are not aware the importance of floods on soil fertility.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study has revealed the crucial role of recession farming in respect to hydro-climatic risk reduction. Farmers have knowledge on crop selection with respect to availability of water. Maize crop dominated in recession farming and provided high yields particularly in the villages with no irrigation scheme since it is very resistant to water stress/shortage. The over utilization of land and presence of resistant pests in the study villages lead to additional cost of practicing recession farming. Agriculture inputs (inorganic fertilizers) are sold at high cost in the dry season.

The study has revealed that farmers practice recession farming for subsistence. Unavailability of market discourages farmers to sell their crops. This causes farmers to generate low income from recession farming compared to rain-fed agriculture. Recession farming contributes only 37% of the mean annual household income, less than rain-fed agriculture which contributes 45% of the household income. Also the study revealed that diversification of crops help to maximize annual household income. Households that cultivated both maize and rice crops generated more income than the once that relied on maize grains only.

Promotion of initiatives such as large scale agriculture investments schemes increased water demands, threatening recommended normal river flows in the dry season. Intensive water withdraw for agricultural activities (irrigation schemes) caused downward trend of water flow. Also the annual fee of established schemes is high (47 000 TZS), preventing small scale farmers to water their crops.

The study also revealed that the community of the study villages is aware on hydro-climatic risks (floods and drought), although they donnot know the role of floods on the soil fertility. Majority of farmers (58.3%) perceive that floods are always destructive while floods improve soil fertility for recession farming.

5.2 Recommendations

Based on the aforementioned research results, discussion and conclusions, the following recommendations are made:

i. The study recommends farmers to cultivate more crops which have similar characteristics as maize crop in recession farming. Also the government should provide subsidized agricultural inputs (fertilizers) to farmers for both rain-fed and recession agriculture. This will help to maximize recession farming productivity. This government will achieve this through effective implementation of Agricultural Sector Development Strategy – II.

ii. The government should promote a favorable market environment for farmers in villages and divisions through effective implementation of Agricultural Sector Development Strategy – II. This will help farmers to generate high income from agricultural activities.

iii. The downward trend of water flow due to large scale agricultural investments schemes, calls for new small scale investments demanding little water (recession farming inclusive) to protect the environment and community livelihood.

iv. The study recommends sensitization education to farmers on the role of floods on the soil fertility for recession farming. Also the government should train farmers to harvest flood water during rainy season for recession farming in dry season. This will help to reduce conflicts related to water scarcity during dry season.

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APPENDICES

Appendix 1: Tentative Schedule of Activities

Activities	DURATION															
	2020										2021					
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Proposal Development																
Proposal Presentation																
Pre-testing																
Data Collection																
Data Process and Analysis																
Dissertation Writing																

Appendix 2: Estimated research budget

S/N	Activity	Budget	
		In EURO	**In TZS**
1	Printing	300	811653
2	Transport (Morogoro-Kilombero)	500	1352755
3	Transport (Within the field villages)	400	1082204
4	Driver	500	1352755
5	Researcher accommodation	500	1352755
6	Researcher assistants	600	1623306
7	Compensation for farmers	300	811653
8	Per diem supervisor for travelling	235	635794.85
	Total	**3335**	**9022875.85**

Appendix 3: Farm household interview

Section A: Information on respondent's characteristics

1. Ward name…………………………
2. Village name …………………..................
3. Sex 01)Male 02)Female
4. Age of respondent 01)16-25 02)26-35 03)36-45 04)46-55 05) Above 55
5. Family size 01)1-3 02)4-6 03)5-7 04)8-10 05)Above 10
6. Marital status 01)Married 02) Not married
7. Education

01= none 02=primary school 03= Secondary school 04= college (Certificate, Diploma) 05=University

8. For how long have you been living in the Kilombero Valley? 01)Less than 5 years 02) 5-10 years 03)11-16 years 04)17-22 years 05)Longer than 22 years

Section B: Characterization of farming practices in the past and present with an emphasis on recession cropping

9. Do you own land in the floodplain? 01)Yes 02) No
10. How long have you owned the land? 01)Less than 5 years 02) 5-10 years 03)11-16 years 04)17-22 years 05)Longer than 22 years
11. If no in qn9, why? 01)Buffer zone restriction 02)Non-indigenous household
12. Which crops do you grow? 01)Rice 02)Maize 03)Sorghum 04)Bean 05)Water melons 06)Vegetables 07)Millet 08)Others (Specify)..
13. Do you perform recession farming 01)Yes 02)No

14. How do you perform recession farming?

01)Mono-cropping 02)Rotation cropping 03)Intercropping 04) Shifting cultivation 05) Integration of crop and livestock

15. How does recession cropping system change over seasons, over time? 01)Changed from mono to intercropping 02)Changed from shifting to rotation cropping 03) Changed from cropping only to integration of crop and livestock 04)Changed from intercropping to mono-cropping 05)Changed from rotation to shifting cultivation 06)No changes at all

16. How does inundation area change over time? 01)Is increasing since 2004 02)Is decreasing since 2004 03)It is not changing with time

17. How many bags of grain required in your household per annual? 01)1-3 02)4-6 03)5-7 04)8-10 05)Above 10

18. How many bags of grain do you harvest from rain-fed agriculture in the floodplain? 01)1-3 02)4-6 03)5-7 04)8-10 05)Above 10

19. How many bags of grain do you harvest from recession farming in the floodplain? 01)1-3 02)4-6 03)5-7 04)8-10 05)Above 10

20. Does your yield from recession farming sustain you to next season 01)Yes 02)N0

21. Do you get surplus production from recession farming? 01)Yes 02)No

22. What do you do with the surplus production? 01)Selling 02) Storing for emergence

23. What are tools/ equipments do you use to prepare land for recession cropping? Put a mark in the table below (√). Multiple responses are allowed.

Equipments used to prepare land	
01)Hoe	04)Power tiller
02)Plough	05)Weeder

03)Tractor	06)Fire
07)Others (Specify) ……………………………………………………………….	

24. What are additional inputs you use for recession farming apart from land, seeds and labour?

Input for recession farming	Put a tick (√). (Multiple response allowed)
01)Organic fertilizer	
02)Inorganic fertilizer	
03)Pesticides	
04)Others (Specify).............................	

Section C: Water availability and variation during the year for farmers

25. Do you use other sources of water to maintain soil moisture for recession cropping? 01)Yes 02)No ☐
26. What are those sources of water in the floodplain? 01) Dam 02)Constructed reservoirs 03)Constructed wells (Groundwater) 04)River flow from the catchment ☐
27. Is there any variation of sources of water with time? 01)Yes 02)No ☐
28. If yes, how is the trend of water variation in present and past? 01)Water quantity decrease since 2004 02)Water quantity increase since 2004 ☐
29. What mechanism used to allocate water to every community member? 01) Free access 02)You have to pay for to access ☐

30. How does water allocation mechanism affect your farming activities? 01)Increase yield 02)Decrease yield 03)Influence expansion of land ☐

Section D: Relevance and perception of hydro-climatic risks in KV

31. What are the hydrological risks and uncertainties related to variability and climate change?

No	Hydrological risks and uncertainties	Put a tick (√). (Multiple response allowed)
01	Flood	
02	Drought	
03	Heatwaves	
04	Landslide or soil erosion	

32. Respondent's perception on hydro-climatic risk.

    01)Strongly agree 02)Agree 03)Neutral 04)Disagree 05)Strongly Disagree

33.

Variable	Score
Occurrence of hydro-climatic risks and uncertainties 1) Floods occur yearly in March to April 2) Drought occurs yearly in June to September 3) Heatwaves occur yearly in June to September 4) Landslide or erosion occurs yearly	
Hydro-climatic risks and uncertainties in KV are aggravated due to: 1) Deforestation 2) Intensification of irrigation system 3) Increase in population 4) New development e.g road construction	
Hydro-climatic risks and uncertainties in KV 1) Destroy crops 2) Cause income insecurity 3) Cause water conflicts 4) Cause eruption of diseases	
Floods and drought aggravate yearly since 2004	
Small-scale farmers are more vulnerable to hydro-climatic risks and uncertainties	
Rising temperatures in combination with low flow, water availability in the dry season help to predict occurrence of drought	
Floods are always destructive	

How does recession cropping respond to high or low floods?

Level of floods	01=High yield 02= Low	Period used for floods to

	yield	recede (Day/month)
High		
Low		

34. Does recession cropping reduce severely impact of drought? 01)Yes 02)No

35. If yes in qn36, how does recession cropping equip you during drought period?

    01)Provide household food security 02)Provide household income security

Section E: Contribution of recession farming to household income

36. What are your sources of income? 01) Below 20000 02) 20000-40000 03) 40000-60000 04) 60000-80000 05) 80000-100000 06) Above 100000.

Source of income	**Income per year (Tshs)**					
	01	02	03	04	05	06
Rain-fed agriculture						
Livestock						
Recession farming						
Fishing						
Formal employment						
Informal employment						

THANK YOU FOR YOUR TIME AND INFORMATION

Appendix 4: Focus Group Discussion Checklist

1. Do a lot of farmers practice recession cropping? If no: Why not? What are the constraints for not practising recession cropping?
2. Does recession farming affecting the environment in KV? If yes: How?
3. Have you noted any changes in the environment that can be attributed to recession farming practices?
4. Are there any institutions that control recession farming and watershed management?
5. Are there any agro-technology developments in recent past?
6. How do agro-technology developments affect recession cropping systems?
7. How agro-technology developments influence utilization of water from watershed?

THANK YOU FOR YOUR TIME AND INFORMATION