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FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

ASSESSMENT OF BENEFITS OF FLOODPLAIN RECESSION FARMING IN MBIRE DISTRICT, MASHONALAND CENTRAL PROVINCE, ZIMBABWE

By

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A thesis submitted in partial fulfilment of the requirements for the Master of Science degree in Integrated Water Resources Management

HARARE, DECEMBER 2013

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In collaboration with

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HARARE, SEPTEMBER 2013

DECLARATION

I declare that this research is my own work. It is being submitted for the degree of Master of Science in Integrated Water Resources Management to the senate of University of Zimbabwe. It has not been submitted before for any degree of examination in any other University.

FADZAI T. MUNODAWAFA…………………….........
(Signature of the candidate)

…………………………………………day of…………………………………..2013

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Lastly, my thanks goes to WaterNet for granting me a scholarship to undertake these studies at the University of Zimbabwe as well as Eco-Hydro project which made the funds available for undertaking this dissertation.

DEDICATION

To God, I give praise and honour to Your name for your faithfulness till the very end,
My husband, Prince, I will ever be thankful for your unwavering support, I love you,
My family, you believed in me and gave me support.

Abstract

Food insecurity is a major challenge in Mbire district as the grain yield (maize and sorghum) from rain-fed farming are low due to erratic rainfall distribution (400 - 650 mm). The inhabitants of this area have resorted to floodplain recession farming as a way of boosting their food production. However, no studies have been carried out to assess whether the adaptation benefits farmers and the environment. A study was conducted to analyse the impacts of floodplain recession farming in Mbire District on household food security, soil fertility, environment and the community. Data was collected using questionnaires, key informant interviews, focus group discussions and soil samples from six fields. Soil samples were analysed for pH, Total nitrogen, Total Organic matter, phosphorus, potassium, soil moisture, calcium and magnesium. The soil analyses were used to create maps of individual fertility parameters through the inverse distance weighted interpolation method in ArcGIS. In the same fields, yield was estimated using the cob weight measurement method. Leaf samples were analysed for nitrogen and phosphorus to relate them to the soil fertility status. 30% of total number of households in each ward of the district have access to fields in the floodplain. The results from the farmers' survey show that dry-land farming generally produces 0.2t/ha of maize while recession farming contributes 0.71t/ha. Field trials in the floodplain showed a yield of 1.32t/ha. Recession farming had more contribution (47%) to food security, according to the surveys than dry-land farming (24%), although leaving a deficit of 29%. In contrast, recession farming, contributes only 2% to household yearly income. Variability in access to floodplain land does not depend on gender ($p > 0.05$). However age has a predictive ability for access to floodplain land ($p < 0.05$), therefore 8.7% of variability ($R^2 = 0.087$) in access depends on age. The analysis of topsoil of the floodplains shows that, there is great potential for maize production. Fertility is significantly higher in floodplains ($p < 0.05$) than in rain-fed field, which encourages growth of crops such as maize, beans and cowpeas. In conclusion, the potential of recession farming exists but the practice poses a risk on human life through attacks by hippopotami and the environment through cutting down of trees. Crop production is not be limited by fertility but rather the farmers' management practices and there is potential for yield improvement.

Keywords: recession farming, floodplains.

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Chapter 1

INTRODUCTION

1.1 Background

One of the challenges the world faces is food insecurity, exacerbated by persistent droughts and erratic rainfall leading to low yields in rain-fed agriculture, with strong implications on environmental management and socio-economic development (Rockstrom, 2003), (Magombeyi *et al.*, 2008). There is generally enough rainfall to double or even triple yields in rain-fed agriculture, even in water constrained regions. The greatest challenge is the distribution of the rain which leads to dry spells in which most of that water is lost (Rockstrom *et al.*, 2010).

In southern Africa, the challenge of rainfall distribution is coupled with poor soil fertility (Kundhlande *et al.*, 2004). In parts of the region, some smallholder farmers have tried to overcome these challenges by resorting to floodplain agriculture (flood recession farming). Floodplains are areas where water and nutrients are concentrated, and therefore represent high production potential and low production risk, especially in semi-arid regions (Pérez *et al.*, 2011). In Africa, floodplains have an important place in the economy of many African countries which includes direct production of surplus food or other commodities or simply providing sound and sustainable incomes in both good and bad years for fairly large numbers of people (Adams, 1993). Southern Africa's geographic location, steep orography, contrasted oceanic surroundings and atmospheric dynamics are conducive to extreme weather events and great inter-annual variability of the hydrological cycle (Fauchereau *et al.*, 2003). In such semi-arid to arid conditions, floodplain agriculture provides a way in which farmers can reduce crop yield losses that come with low and unreliable rainfall and frequent droughts and increase food security and income for the rural poor who depend on agriculture for food (Frenken and Mharapara, 2001).

A study on floodplain agriculture in Senegal showed that the recession farming system receives no controllable input other than land and labour and therefore has a very high net return to energy expenditures in which the output is very important to household subsistence during months where other contributions to the household subsistence are limited (Saarnak, 2003).

In Zambezi and Save valleys of Zimbabwe, floodplains are one of the food security "safety nets" potentially available to the rural poor (Kotze, 2002). Based on the conditions of the floodplains mentioned above, a farming system from indigenous knowledge, now known as flood recession farming, was developed to take advantage of the floodplains. Flood recession farming is an agricultural practice in which water floods areas adjacent to the stream and brings with it rich sediments and after the flood recedes, farmers plant in the rich, moist soils. Flood recession farming is a form of flood-based agriculture in which farmers use the residual moisture of seasonally flooded lands when floods recede (Nederveen, 2012). Recession farming has been shown to allow growth of more crop types and varieties such as rice, potatoes and beans, most of which fetch lucrative prices on the market (Chigwenya and Muparamoto, 2009). This shows that the benefits of recession farming go beyond the subsistence level.

Changes in the hydrology of the Zambezi River due to the construction of Kariba and Cahora Bassa dams have had a profound effect on farming practices in the lower Zambezi (Beilfuss *et al.*, 2002). Prior to construction of the dams, natural flooding played a central role in rural economies such as the Zambezi Delta, providing fertile agricultural land which supported a large human population (Beilfuss *et al.*, 2002). The flood waters provided a breeding ground for large numbers of fish and brought essential moisture and nutrients to the soil for recession agriculture. As the flood waters recede, arable alluvial soils are exposed and crops are grown (Acreman *et al.*, 2000). This is the case in the large floodplain systems of Africa and the study area of this research, Mbire district. In the rainy season, the fertile alluvium is deposited onto the floodplains adjacent to the rivers through floods. Farmers make use of the soil moisture and plant crops after the flood waters begin to recede, sowing seeds just after the water goes below soil surface and harvesting at the end of the dry season (Beilfuss *et al.*, 2002).

Due to the low rainfall experienced in Mbire district, uncertainty of the onset of rain occurs mostly early in the season (October and November), and coincide with the germination stage when crops are sensitive to moisture stress (Bosongo, 2011). Erratic rainfall patterns inhibit proper plant growth. After the dry spells, floods occur mid-season, thereby washing away crops in the fields. The dry spells, erratic rainfall patterns and floods eventually lead to very low rain-fed yields. Since the villagers of Mbire district have limited forms of livelihoods, food security is seriously threatened. The people are also poor because they do not have access to major economic activities. Although the district receives food aid from organisations such as the Christian Care, the aid is inconsistent, leaving them with limited options. Despite these challenges, the inhabitants of Mbire still need to survive somehow.

Although recession farming is widely practiced, it is important to ask, how productive the system is. It is also important to understand the benefits which smallholders derive from this system.

1.2 Problem statement

To survive, people need to have some way of gathering food. Due to the low yields obtained from fain-fed agriculture, households in Mbire district practice recession farming as a major source of food security and livelihood. However, no studies have explored if the farming system provides sufficient benefits and therefore should the practice be supported or should alternatives be made available to the people. Studies have shown that households benefit from recession farming but the benefits not quantified (Barbier and Thompson, 1998; Adams, 2000, Bosongo, 2011). This study focused on productivity, household food security and social benefits and costs of the recession farming system.

Wetlands and other areas where water is close to the surface have been identified as being well suited to increase crop production for communal farmers (Owen *et al*., 1995). The Mbire district is vulnerable to floods and droughts. Relying on rain-fed agriculture as a source of food is not sustainable in this flood and drought prone area (Bosongo, 2011). There is therefore need to adopt non-conventional methods of agriculture to achieve food security. This study focuses on conducting an agro-ecosystem analysis of the benefits of recession farming in Mbire district and therefore assist in decision making at both local and national level. Accurate recording of the costs and benefits of this traditional crop production system is important. The socio-ecological costs of losing systems like floodplains used by several interacting food-production groups should be built into cost-benefit analyses in the foresight of water resource planners (Rofanaf, 2007).

1.3 Objectives

1.3.1 Main objective

The main objective of the study was to analyse the productivity and benefits of recession farming to smallholder farmers in floodplains of Mbire district.

1.3.2 Specific objectives

1. To characterise the crop production system and practices in the floodplain and their implications on sustainability of recession farming.
2. To investigate the contribution of recession farming to household food security and income.
3. To assess the distribution of benefits and costs of recession farming to smallholder farmers and the environment.

1.4 Research outline

The study is organised into five chapters. The first chapter outlines the background to the study in which recession farming is defined and explained. Problem statement, objectives and justification are also outlined in this chapter. The second chapter explains what other researchers have discovered in relation to this study. The third chapter outlines the study area as well as methods used to achieve the objectives of the study. The fourth chapter presents the results and discussion of the research. The fifth chapter gives the conclusions and recommendations with respect to the results obtained.

Chapter 2

LITERATURE REVIEW

2.1 The role of floodplains in supporting livelihoods

Typically, floodplains are flat lands or regions which serve as floodways and are usually inundated by lateral overflow of water at some point of the year as a result of their proximity to a water body (stream or a river) (Junk *et al*., 1989). Flood plains are associated with major drainage systems and are mostly well developed in low lying flat areas (Mharapara *et al*., 1998). Mbire district, under study is one such low lying area in Zimbabwe. One of the most significant downstream riparian ecosystems in river basins, in Africa, are the seasonally flooded savanna or forested floodplains. These "wetland" ecosystems are relatively flat areas adjacent to rivers coming into existence through sedimentary deposits of meandering rivers as well as periodic flooding (Cech, 2003). Zimbabwe is situated on a plateau and hence there are not many flood plains except in the Zambezi Valley, the Save-Runde confluence in the south-eastern section of the country and the Shashi-Limpopo confluence (Mharapara *et al*., 1998)**.**

In areas where rainfall is a constraint, the value of floodplains in agriculture, is largely due to the fact that they remain wet far into, and sometimes throughout, the dry season. Floodplain farming increases food security by providing crops when other plots fail and opens up opportunities for cash cropping of vegetables (Scoones, 1991). Traditional societies in Southern African Development Community (SADC) had been planting intensively in floodplains, even prior to the colonial era, creating the basis of their livelihoods (Chigwenya and Muparamoto, 2009). In these semi-arid regions, floodplain resources are critical in securing livelihoods during drought periods due to their fertile soils and high moisture levels (Chirinda *et al*., 2001).

To some, floods are just sources of destruction, yet to some they are a source of important nutrients and moisture for agriculture. Flood associated benefits, according to Wisner (2004), include the provision of critical habitat for fish, waterfowl and wildlife; maintenance of high levels of plant and animal diversity; replenishment of agricultural soil nutrients; and transporting sediments which maintain downstream deltas and coastal areas. As floods come they deposit nutrient rich soils and leave moisture, these two being essential for plant growth. This is the basis for recession farming in floodplains.

A study by Adams (2000) shows that in areas of low rainfall around the Senegal River, the annual flood by the river is necessary to life in that, close to the end of the rainy season, it floods its banks and the broad alluvial plain of the middle valley, where cultivation takes place in the dry season after the flood water has receded.

Access to floodplain patches offers the opportunity of diversification into crops that cannot be grown in nearby dry-land areas. The production of high-value market-garden vegetables is a feature of wetland farming in many areas (Scoones, 1991).

A study by Barbier (1998) and associates shows that the economic benefits of floodplains compared to those of irrigation schemes in semi-arid regions of the developing world, especially in Africa, in dry-lands are highly significant and diverse (Barbier and Thompson, 1998) as shown in (Table 2.1).

Table 2.1**: **Comparison of net present value of economic benefits: Kano River Irrigation Project Phase I (KRIP-1) and Hadejia-Jama'are Floodplain (HJF), Nigeria (USD 1989/90 Prices). Source: Adapted from (Barbier and Thompson, 1998).

	8%, 50yrs	8%, 30yrs	12%, 50yrs	12%, 30yrs
Total (USD 000)[a]				
HJF	37 084	34 179	25 335	24 595
KRIP-I	593	546	403	391
Per ha (USD ha^{-1})[b]				
HJF	51	47	35	34
KRIP-I	31	29	21	20
Per water use (USD m^{-3})[c]				
HJF	14 548	13 409	9939	9648
KRIP-I	40	36	27	26

Notes: a) Based on total net benefits from agricultural, fuel wood and fish production attributed to the Hadejia-Jama’are floodplain (HJF), and total net project benefits of irrigated crop production from the Kano river Irrigation Project Phase I (KRIP-I).

b) For HJF, weighted average of per hectare agricultural, fuel wood and fish production with weights determined by total cropland (230 000ha) forest area (400 000ha) and fishing area (100 000ha) to total production area (730 000ha). For KRIP-I, based on a total cultivation area of 19 107ha in 1985/86.

c) For HJF, based on an estimated annual average river flow into the floodplain of 2 549 10^6 m^3. For KRIP-I, based on an estimated annual water use by the project of 15 000 m^3ha^{-1}.

The study shows that the total net present benefits at 8% and 12% of floodplains from agriculture, fuel wood and fish production is much greater than that of the analysed irrigation scheme. This confirms the benefits of floodplain agriculture in semi-arid regions.

Floodplain recession farming also has economic benefits to the community practising it. This has been researched in Nigeria by Barbier (1994). An early 1990s ecosystem valuation indicated that the Hadejia-Nguru floodplain in Northern Nigeria provides US$167 per hectare in agricultural benefits to a wide range of local people (Barbier, 1994).

2.1.1 Recession farming in the floodplains

The flood recession farming system in floodplains is dependent on flooding and fertilization of the flood plain (Saarnak, 2003). This farming practice is normally associated with the rural poor who have no source of livelihood other than agriculture (Scoones, 1991; Barbier and Thompson, 1998; and Magole and Thapelo, 2005). Recession farming normally occurs in areas of low rainfall and provides a fallback for the villagers in such areas in which there is more crop failure than success. Various crops are grown on the remaining soil moisture from annual inundations of a river valley. The crops grown include; melons, sorghum, beans, rice, beans, and maize.

Saarnak (2003), researched on the importance and future role of recession agriculture. This study concluded that, the major significance of the flood recession farming to farmers in the studied villages of Senegal River Valley is the sorghum, beans and melons to add to the household subsistence particularly in months where alternative contributions to the household subsistence are limited. Findings from the study show that the size and extent of the farming system is dependent on availability of water. The study is in line with the contribution of recession farming to food security but did not show the actual benefits and costs of the farming system.

In Botswana, flood recession farming is termed ‘molapo’ farming (Bendsen and Meyer, 2002). Research in Ngamiland, Botswana shows that there is great agricultural potential in ‘molapo’ farming. Yields in the fertile molapo areas are generally higher than in the dry-land. Under rain-fed conditions 500 kg/ha sorghum could be obtained whilst under optimal flooding conditions 1800 kg/ha - 2900 kg/ha sorghum have been recorded (Bendsen and Meyer, 2002). To protect their standing crop from the second flood caused by the precipitation over the Okavango Delta (setting in between November and January) and to benefit optimally from this additional source of moisture, the molapo farmers traditionally construct small hand-built dams (bunds) out of grass sods. These structures are meant to control the rainwater distribution but do not obstruct the main flood. They subdivide the cultivated molapo in sections to avoid rainwater from collecting in the lowest places (Bendsen and Meyer, 2002).

In a study carried out on the ‘fadama’ (seasonally flooded) lands in Nigeria, it was established that recession farming is practiced on these lands in the dry season after the floods have receded (Kundiri *et al*., 1997). In this study there was consultation with the farmers and it shows the importance of consulting the people involved in research.

2.1.2 Limitations of floodplain recession farming

The problem in evaluation of the potential of floodplain is the dynamic nature of water availability, since water tables fluctuate over several meters during one year and in differing patterns between years (Scoones, 1991). It depends on the entire watershed, as well as the topographic situation of the wetland, as to whether it will receive sufficient water during the dry season to produce a viable crop (Ingram, 1991). As established by Kundiri *et al* (1997), continued use of land for flooded rice and recession crops has undoubtedly modified the soil, and, coupled with shortened periods of fallow, soil fertility decline as reported by farmers as measured by crop yield.

2.1.3 Law and regulations on floodplain use

There is a lot of contention around issues of floodplain use for cultivation or any other development. The policies that protect these floodplains may prohibit research as well as the development of livelihood in various places in which floodplains are the only source of livelihood. Colonial administration brought with it western agricultural practices and did not give much respect to the traditional farming systems, thereby regarding them as primitive and unorthodox systems (Chigwenya and Muparamoto, 2009). Under traditional utilisation, floodplain management was holistic and it considered factors that were necessary for sustainable utilisation of these fragile lands (Frenken and Mharapara, 2002).

The trade-off between environmental protection and development is most acute in fragile ecosystems such as floodplains. Floodplains are significant because they play an essential role in maintaining environmental quality, sustaining livelihoods and maintenance of biodiversity (McCartney *et al*., 2005). A common perception is that cultivation of floodplains tends to 'mine' natural capital (for example, depletes organic matter and erode soil) in providing short-term food security or economic benefits, but at the cost of potential benefits for future generations. However, while this may be the situation sometimes, there is not much evidence that highly modified working floodplains are intrinsically unsustainable over the long-term intensive use and infrastructure development can contribute in a positive way to the provision of some goods and services. This is evident in the rice cultivation practices across Asia, as they demonstrate that highly modified floodplains, if carefully managed, can be very productive and the benefits can be maintained for the benefit of future generations (McCartney *et al*., 2005).

In relation to the Ramsar Resolution IX. 14 on 'Wetlands (including floodplains) and poverty reduction', it is clear that sound wetland management is now expected to not only cover conserving the ecological integrity of the ecosystem but also play specific attention to the local people's well-being, thus contributing to alleviating their poverty status (Sellamuttu and Sonali, 2008).

In Zimbabwe, the Environmental Management Act of 2002 defines a wetland as "an area of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brakish, or salt, and includes riparian land adjacent to the wetland" as adopted from the Ramsar definition (Environment Management Act, 2002). With this definition in mind, the Statutory Instrument 7 of 2007 provides for the protection of wetlands and public streams, therefore cultivation in floodplains is prohibited and enforced by the Environmental Management Agency.

2.2 The importance of farmer participation in management of floodplains

A weakness of many land evaluation projects is that they frequently do not take much account of the opinion of the local farmers (Kundiri *et al.*, 1997). The failure by planners to integrate this local knowledge and skill into land use decisions has contributed to the poor results of many well intentioned rural development projects (Saarinan, 1976); (Dalal-Clayton and Dent, 1993).

In a study carried out on recession farming by Kundiri *et al.* (1997), in Nigeria, it was realized in that scenario that many 'fadama' farmers are well informed and have a large body of skill and knowledge about local soil use and management. This knowledge has been seen to be invaluable for validating and/or amending assessments based on scientific principles. Furthermore, building this local knowledge into development programs will help to ensure better acceptance. It is clear that plans to develop rural areas or introduce new crops should only be embarked upon after careful evaluation of the local farmers' knowledge. Involvement of local people is now widely accepted as a prerequisite to successful planning and management especially where access to wetland resources is important for livelihood security (Ramsar Convention, 2004).

2.3 The importance of assessing soil fertility and productivity

The productivity of a given area is largely determined by the chemical and physical attributes of the underlying soil (Windingstad *et al*., 2008). Soil fertility and plant nutrition are two closely related subjects that emphasize the forms and availability of nutrients in soils, their movement to and their uptake by roots and the utilisation of nutrients within plants (Foth and Ellis, 1997a). To get optimum, sustained- long lasting and self-sufficient crop production, soil fertility has to be maintained (Tilahun, 2007).

An intimate knowledge of soil type, its spatial distribution is essential in developing rational land use plan for agriculture, forestry, irrigation, drainage, among other issues. Soil resource assessment provides an insight into the potentialities and limitations of soil for its effective exploitation. Soil survey provides an accurate and scientific inventory of different soils, their kind and nature, and extent of distribution so that one can predict their characters and potentialities (Manchanda *et al.*, 2002).

2.4 Common methods of yield estimation

Crop yield as defined by Fermont and Benson (2011) is defined as:

Crop yield = (amount of harvested product) / (crop area)

which is normally expressed as kilograms (kg) of product per hectare (ha). Accurate yield estimation can be a difficult task, in particular in the African farming systems that are mainly constituted by smallholder farmers who produce a range of crops (Fermont and Benson, 2011). There are several methods that can be used to estimate maize grain yield and these include visual, farmer experience, Maize-Water Satisfaction Index, harvesting a sample from a known area and weighing and cob length and cob weight measurement (Arex, 1999).

Cob weight measurement method

To estimate the maize yield using this method, three steps should be followed:

1. Establish cob population

   Carry out a visual assessment of the whole field to establish variations then select 5 points in the field that represent the variations noted above. The inter-row spacing is determined in metres by measuring spacing between planting rows using a measuring tape. 10 rows are measured and number of rows recorded. Inter-row spacing = Number of metres/Number of rows, Running metres =10 000 (area of hectare)/Inter-row spacing. At each of the five sections selected, 10 metres are measured and the number of effective cobs (cobs which the farmer will shell) counted.

2. Average cob weight

   Select 5 representative cobs (one that represents the marjority of the cobs in terms of size) and measure the weight of the cob using a balance. The average is calculated to find an average cob weight (W).

3. Derive yield from multiplying the number of cobs per hectare*average cob weight.

   The average number of cobs (X) is calculated by adding the numbers of cobs from the 5 different sections and dividing by 5. The population = running metres * X (calculated above)/10 metres

The yield per hectare (Yg) is found by multiplying the cob population by the average cob weight (W) in grams. To obtain the yield in tonnes/Ha, the yield is divided by 10 000.

2.5 Common spatial interpolation methods in Geographical Information Systems

Spatial interpolation is a method in Geographical Information Systems (GIS) that is used to generate a map of a variable that was measured at point locations (Varekamp *et al*., 1996). Such variables include soil characteristics, climate and gradient. “The GIS models for the spatial interpolation are based on the advanced methodological concept, which includes application of spatial auto-correlative mathematical analysis between pluviometric data and climate factors, such as altitude, exposition, slope, degree of continentality. Applied models are mostly based on several functionality interconnected operations: (i) data entry (transformation of the data into adequate form), (ii) geoprocessing (via defined process script) and geovisualisation that includes development of spatial model for treatment of the input data into thematic maps (output)” (Seppelt *et al*., 2011). Reliable interpolation tools, suitable for GIS applications, should fulfill essential requirements:

a) Accuracy,
b) Predictive power,
c) Robustness,
d) Flexibility in describing various types of variables,
e) Smoothing for noising data,
f) *d*- dimensional formulation and ease of use,
g) Direct estimation of derivatives (gradients, curvatures) and
h) Applicability to large data sets, computational efficiency (Mitas and Mitasova, 1999).

There are several methods used in interpolation

2.5.1 Inverse distance weighted interpolation (IDW)

With this method, the sample points are weighted during the interpolation such that the influence of one point relative to another declines with distance from the unknown point one wants to create (Mitas and Mitasova, 1999). Weighting is given to sample points through the use of a weighting coefficient that controls how the weighting influence will decrease as the distance from new point increases. If points are distant from the unknown point, as the weighting coefficient gets higher, it will have less effect on the points. As the coefficient increases, the value of the unknown point nears the value of the nearest known point. However, the quality of the interpolation result can decrease, if the distribution of the sample data is uneven (Mitas and Mitasova, 1999).

2.5.2 Triangulated Irregular network (TIN)

The method creates a surface formed by triangles of nearest neighbour points by creating circum-circles around selected sample points and their intersections are connected to a network of non-overlapping and as compact as possible triangles as illustrated in Figure 2.1 below.

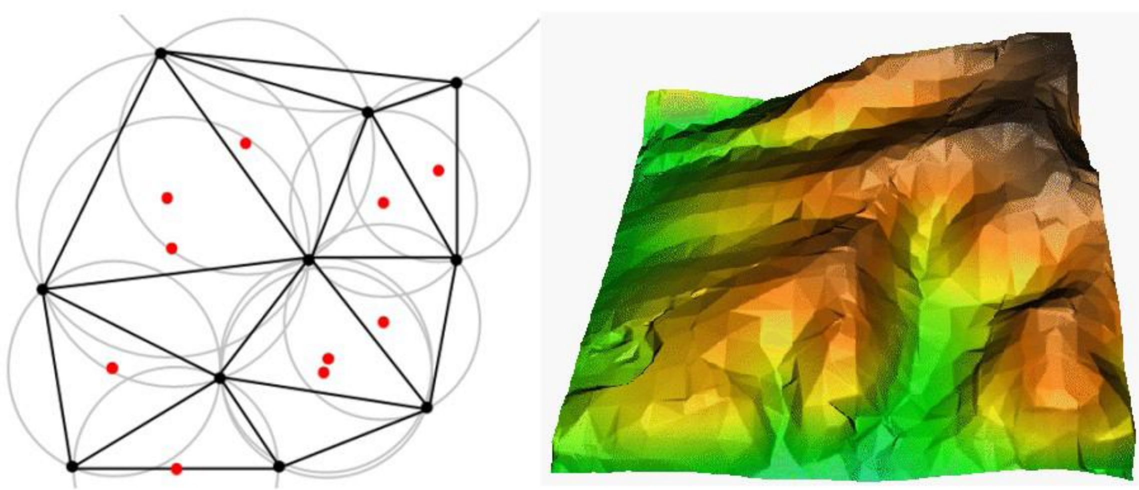

Figure 2.1: Delaunay triangulation with circumcircles around the red sample data. The resulting interpolated TIN surface created from elevation vector points is shown on the right. Image Source: Mitas, L., Mitasova, H. (1999)).

The disadvantage of the TIN interpolation is that the surfaces are rough and may have an unsmooth appearance due to continuous slopes at the triangle edges and sample data points. In addition, triangulation is generally not suitable for extrapolation beyond the area with collected sample data points (Mitas and Mitasova, 1999).

2.5.3 Kriging

"The method assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface (Childs, 2004). It fits a function to a specified number of points or all points within a specified radius to determine the output value for each location." (Childs, 2004). "It depends on expressing spatial variation of the property in terms of the variogram, and it minimises the prediction errors which are themselves estimated" (Oliver and Webster, 1990).

2.6 Household food security definition and indicators

Food security, at the individual, household, national, regional and global levels is achieved when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet dietary requirements and food preferences for an active and healthy life (FAO, 1996). Over time definitions of food security have been transformed from a focus on supply to questions of distribution and access (Khatri-Chhetri and Arun, 2006). Household food security is an essential dimension of well-being. Although it may not encapsulate all aspects of poverty, the inability of households to obtain access to sufficient food for an active, healthy life is surely a significant component of their poverty (Hoddinott and Yohannes, 2002).

The American Institute of Nutrition has the following conceptual definitions that were published in 1990 by the Life Sciences Research Office (LSRO) of the Federation of American Societies for Experimental Biology:

- **Food insecurity** is defined as limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable food in socially acceptable ways (for example, without seeking emergency food supplies, scavenging, stealing or other coping strategies).
- **Hunger** is defined as the uneasy or painful sensation caused by lack of food. The recurrent and involuntary lack of access to food. Hunger may result in malnutrition over time and is a potential, although not necessary, consequence of food insecurity.

There are approximately 450 indicators of food security (Hoddinott, 1999). One volume on household food security by Maxwell and Frankenberger (1992) lists 25 broadly defined indicators. The full range of food insecurity and hunger cannot be incorporated by any single indicator. Instead, a household's level of food insecurity or hunger must be established by obtaining information on a variety of specific conditions, experiences, and behaviours that serve as indicators of the varying degrees of severity of the situation (Bickel *et al*., 2000). Household surveys are used to obtain this information.

2.6.1 Food Consumption Score and Annual Grain Consumption for households

The Food Consumption Score (FCS) is a proxy indicator of household food security based on the weighted frequency (number of days in a week) of intake of 8 different food groups (Brown, 2012). It is a composite score based on dietary diversity, food frequency, and relative nutritional value of different food groups. Data is collected from the defined study area of food item lists and groups. The interviewed is asked about frequency of consumption (in days) over a recall period of the past seven days (WFP, 2008). It is measured as:

Equation 1: $$FCS = a_1x_1 + a_2x_2 + \ldots + a_8x_8$$

Where i= food group, x= frequency, a= weight

The average per capita consumption of maize as food is over 94kg/yr in Kenya, over 100kg/yr in Malawi, Zambia and Zimbabwe, a mere fraction of that level in Ghana and Nigeria (Smale and Jayne, 2004). Corn consumption in Zimbabwe, is estimated at 120kg per person per year (Murendo, 2009).

2.7 Potential impacts of climate change on sustainability of recession farming

The IPCC's Special Report on Emissions Scenarios (SRES) entitled Scenarios for a river-runoff projection for 2050, indicate that there will be a significant decrease in runoff in Southern Africa (Arnell, 2004). According to projections, there will be a decrease in precipitation leading to increased water stress (Nakicenovic *et al*., 2000). These changes are bound to negatively impact both rain-fed and recession farming systems. Increased water stress may result in longer dry spells in those areas that are prone to dry spells, leading to even lower yields.

The floodplains for recession farming may be greatly compromised due to reduced runoff as a result of low precipitation upstream that may reduce the areas inundated by water which would be potentially used for recession farming. Such changes as reduction in size of floodplains and drying up of rivers, have been observed in the Okavango Delta (Omari, 2008). Climate change may pose serious threats to the livelihood of people (recession farming, fishing, livestock production) (Omari, 2008). Household food security may therefore be increasingly threatened with climate change.

"Increasing temperatures and inconsistent rainfall are two factors that further put pressure on natural resources. Areas that receive less rainfall will most likely face more drought and fires, while other areas will face more frequent floods of greater magnitude. Such changes will make agriculture difficult and reduce productivity (WWF, 2011). This indicates the need to expand agricultural practices beyond the traditional forms such as dry-land farming and formal irrigation. It will also enhance problems with wildlife as fewer resources mean animals will push into human settlements" (WWF, 2011).

2.8 Chapter summary

Although there are some benefits known to exist in floodplain recession farming to farmers in previous researches (Barbier and Thompson, 1998; Bendsen and Meyer, 2002;Sanaark, 2003; Chigwenya and Muparamoto, 2009; Taruvinga, 2009), there is still contention on the use of floodplains for agriculture in Zimbabwe (Chigwenya and Muparamoto, 2009). To assess the benefits of recession farming it is important to know how fertile the soils are for crop production.

Chapter 3

STUDY AREA AND METHODOLOGY

3.1 Study area

3.1.1 Location

The study area was the Mbire district located in the Manyame catchment within the Middle Zambezi valley between 30.60º and 31.20º east and 15.60º and 16.40º south. It is within the Mashonaland Central Province. The main areas of concentration were wards 9 (Mushumbi), 10 (Chitsungo) and 12 (Chikafa) as shown in Figure 3.1. These were chosen due to the existence of intense recession farming. The three wards are drained by the Manyame River and it is within the floodplains of Manyame River that recession farming is being practised in the three wards.

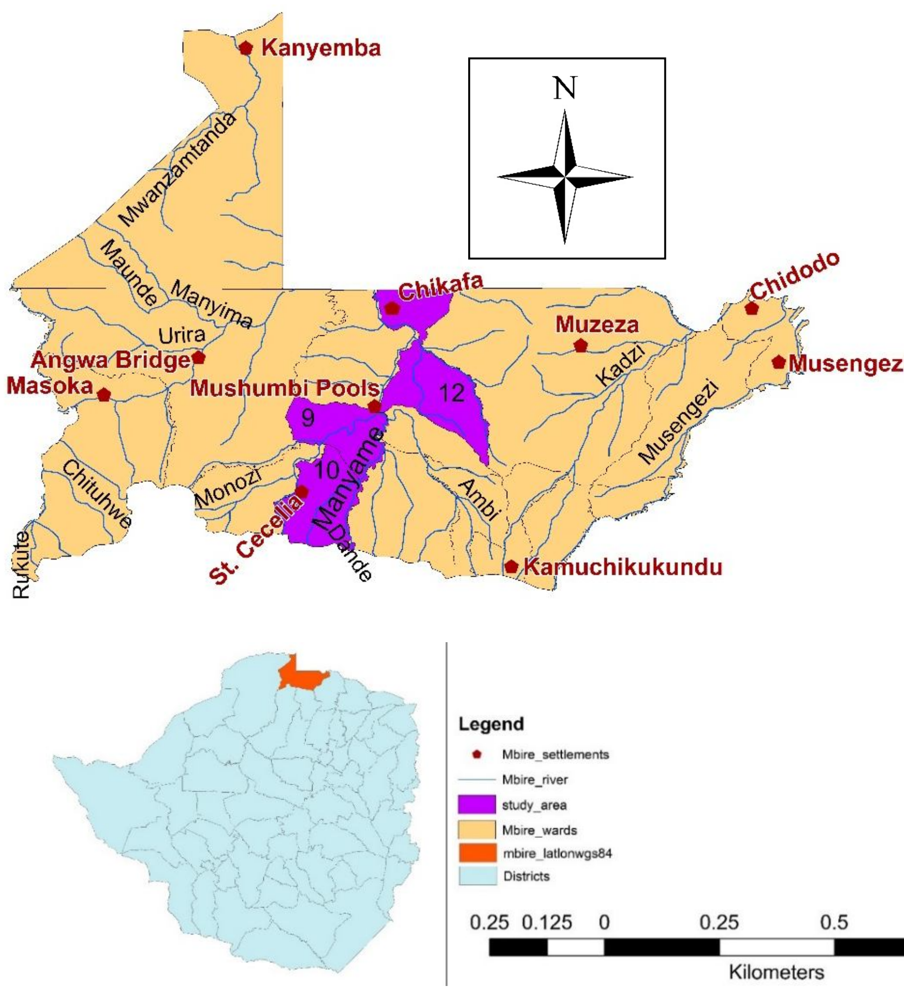

Figure 3.1: Map of study area

3.1.2 Climate

Agro-ecological region IV of Zimbabwe receives an average of 400 - 650mm rainfall per year. Mbire district falls under this region. In the district, the rainfall distribution within the season is erratic leading to a lot of dry spells and therefore prone to droughts. It is at an elevation that ranges between 300 and 400 m above sea level and therefore prone to floods from Cahora Bassa and Kariba dams. The wet seasons runs from late November to mid-March with the highest amount of rainfall normally recorded in January and the rest of the months recording low rainfall. For example at the Mushumbi weather station for the years 2009-2013, an average of 252 mm of rainfall were recorded in January compared to 25 mm, 160 mm, 125 mm and 75 mm for the months of Nov, Dec, Feb and March respectively. Under the climatic region of Africa, it falls under the hot and Semi-arid region (Practical Action End of Pilot Project, 2009:6). The district has a mean annual temperature of 25ºC. The months of October and November, which precede the arrival of rains are the hottest with maximum temperatures of over 40ºC (Fritz *et al.*, 2003).

3.1.3 Population and socio-economics

The populations of the three wards according to ZIMSTAT (2012) are shown in Table 3.1 below.

Table 3.1: Population of study area

Ward Number	**Ward Name**	**Population**	**Ave. household size**
9	Mushumbi	4894	4.3
10	Chitsungo	6917	4.6
12	Chikafa	6785	4.5

The population has increased since the previous census of 2003 (ZIMSTAT, 2012). This increase results in an increased pressure of existing natural resources such as land and water.

The area is suited to cultivation of drought tolerant crops supported by livestock production (Gudza and Mupunga, 2008). The latter, due to previous infestation of the area by tsetse flies, livestock production is low but has recently been on the increase. The villagers depend on agriculture as their main source of livelihood. Crops grown in the wards are maize, sorghum, cotton, cowpeas, millet and vegetables. Agriculture occurs in two seasons: rain-fed (October – March) and flood recession season (March - August). They make an effort to grow their plants though the crops may wilt or are destroyed by floods and wild animals. In a study carried out to establish the coping mechanism to droughts, floods and low rainfall in the district by Bosongo (2011), one of the major coping mechanisms was established to be recession farming.

The vegetation in the wards is of biodiversity conservation interest and is an important refuge for wildlife (Fritz *et al.*, 2003). The wards are therefore surrounded by wildlife from different parks namely, Chewore Safari area, Mavuradonha wilderness and Doma Safari area. This wildlife poses a threat to human survival in two aspects: destroying their only source of livelihood (crops) and attacking humans. In these difficult circumstances, the people living in these areas, have learnt to co-exist with wildlife.

Mbire was classified as a district vulnerable to food shortages therefore qualifying for the World Food Programme (WFP) funded Vulnerable Group Feeding (VGF) programme based on the results of the ZIMVAC (2010), Zimbabwe Community Household Surveillance (CHS, 2010) and the Crop and Food security Assessment Mission (CFSAM) (FAO and WFP, 2010) to Zimbabwe. This research has resulted in some identified individuals receiving food aid in the form of maize and cooking oil from organisations such as Christian Care, World Food Programme and Social Services.

3.2 Conceptual Framework

In the conceptual framework (Figure 3.2), three major factors affecting the potential of floodplain recession farming are identified that include: its contribution to livelihood and household food security, sustainability of the farming system and the soil and crop productivity of the floodplains. These factors have their constituents. The contribution to livelihood and food security factor includes the contribution of farm produce to food security, livelihood and income. The sustainability of the farming system is in turn affected by soil condition, its environmental impacts, the future environmental conditions such as climate change as well as potential conflicts between the farming system and other economic activities. Soil and crop productivity is affected by the soil condition but in turn impacts on the yield and quality of crops. These three factors to be analysed try to answer the research questions as illustrated in (Figure 3.2).

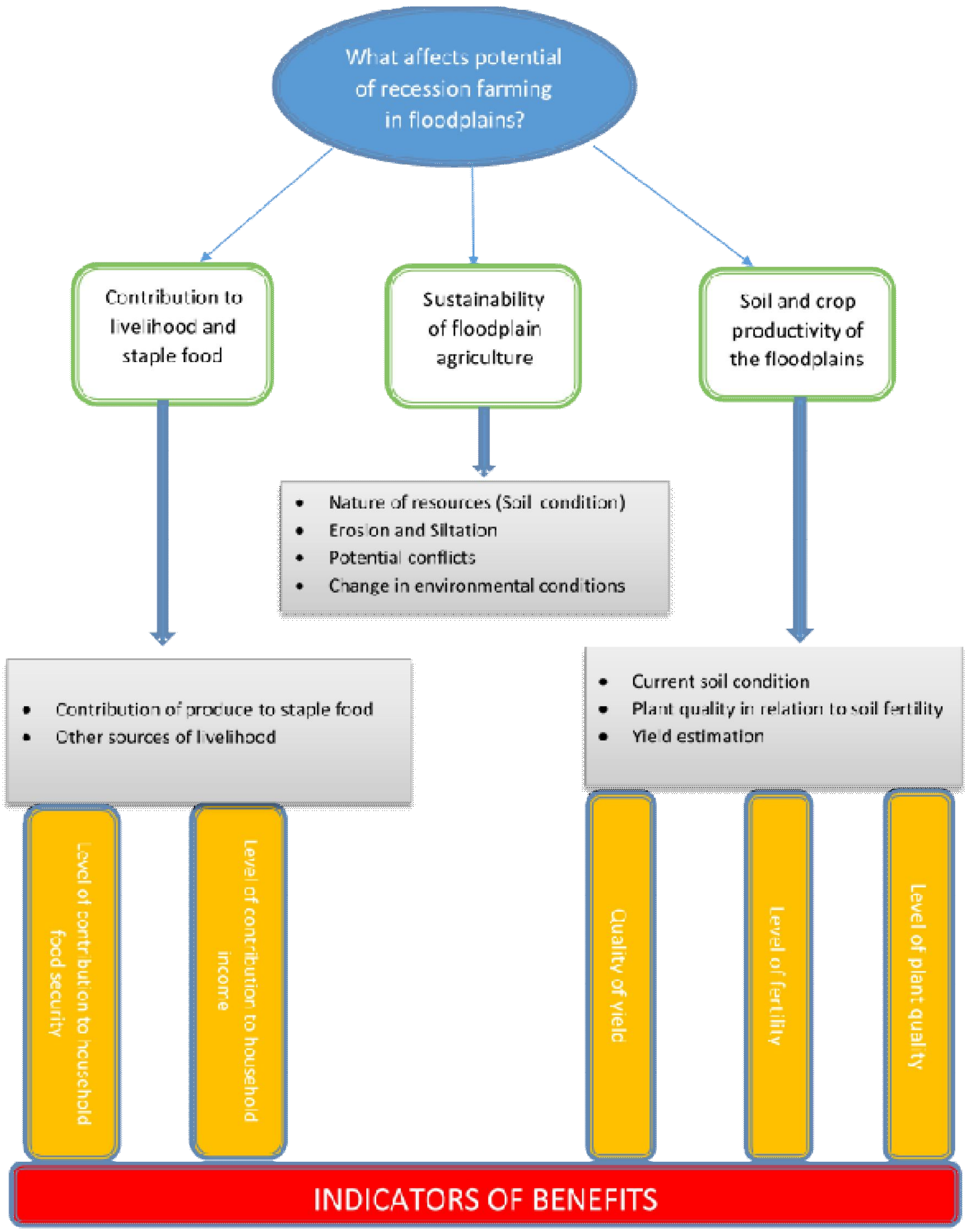

Figure 3.2: Conceptual Framework of an evaluation of the potential of floodplain recession farming

3.3 Sampling Frame

This study was designed to present a case study of how recession farming is helping to sustain livelihoods in a semi-arid environment. A case study is a problem to be studied, which reveals an in-depth understanding of a "case" or bounded system, which involves understanding an event, activity, process, or one or more individuals (Creswell, 1994). VanWynsberghe and Khan (2008) redefined a case study as a trans-paradigmatic and trans-disciplinary heuristic that involves the careful delineation of the phenomena for which evidence is being collected (event, concept, program or process). This study focused on three wards of the Mbire District namely (Figure 3.1), Mushumbi (Ward 9), Chitsungo (Ward 10) and Chikafa (Ward 12) having adopted the definition of a case study by Creswell (1994). The selection of the wards was based on intensity of recession farming, recession farming practices on the floodplains of Manyame River as well as accessibility. Compared to other wards, these three wards have more intense recession farming.

3.4 Case study a): Based on perceptions and experiences of the farmers

This case study is based on interviews on farmers. The case study method allows the interviewee to form relationships with the respondents and therefore obtain true information on the basis of trust. This study employed both qualitative and quantitative methodologies.

3.4.1 Sampling procedure for household questionnaires

The random sampling method was used as a tool to gather data. Since the study area focused on three wards of Mbire district, 20 questionnaires were administered per ward, adding up to a total of 60 household questionnaires. Random sampling ensured that each household had an equal opportunity of being interviewed. This method was employed to make sure both the households that practice and those that do not practice recession farming, give an input to provide the balance that is necessary for this research.

The questionnaires administered (appendix 1) were semi-structured having both closed and open-ended questions giving both quantitative and qualitative results. Thirty questionnaires were initially designed and tested prior to the actual interviews to make sure they are well understood and will provide suitable responses for data analysis. After this exercise, sixty questionnaires were adjusted and finally administered between May and July 2013. The questionnaires gathered information on the people who actually benefit from recession farming and what this farming systems costs to them, those that do not practice it as well as the environment.

3.4.2 Key informant interviews

A separate questionnaire was designed for key informant interview to collect qualitative data. A total of 8 key informant interviews were carried out and these included Agritex officer, Environmental Management (EMA) officer, National Parks officer, Herdmen and a Secretary to the councillor. Chitsungo and Chikafa wards each had two key informant interviews carried out while four interviews were carried out in Mushumbi as it is a centre of the important offices for this study.

3.4.3 Focus group discussions

A question guide focusing on qualitative data was designed for the focus group discussions. Small groups of 8-11 people (Figure 3.3) were gathered at a given time for the discussions. The group composition was based on willingness to participate as well as availability but was always gender balanced. Two focus group discussions were carried out in each ward.

Figure 3.3: Focus Group Discussion, Basiyawo, Chikafa, 2013

The questionnaires, key informant interviews and focus group discussions were designed to gather information on:

1. The contribution of recession farming to household food security and income,
2. The dynamics of the farming system in relation to rain-fed farming system,
3. The implications of recession farming on the environment and potential conflicts,
4. The distribution of benefits and costs of recession farming.

3.5 Case study b): Based on actual field assessments

3.5.1 Crop management

Selection of fields to be analysed was based on availability of farmers. Six fields were therefore selected for collection of soil samples as well as interviews on how they manage their fields and protect their yield. The number of fields was limited due to limited financial resources available for the research. The fields were selected in the same ward (Mushumbi) to keep environmental conditions constant.

The assessments were not experiments as it was difficult to obtain pieces of land in which field trials could be carried out, therefore farmer's fields (0.2-0.3 ha) were used for the assessments. Planting was carried out by the farmers themselves between March and May 2013. The farmers use the *kanongo* seed. The time of the research did not allow the student to be part of the planting. The plants were observed at different stages of growth till time of harvest (Figure 3.4) as well as individual questionnaires were administered to understand the crop management. Weeds were removed using a hoe once in the life of the plants

Figure 3.4: Different stages of the maize plants

3.5.2 Soil fertility data collection

This section of data collection made use of the participatory approach. The participatory approach to research is defined as the use of partnerships between researcher and the people affected by and responsible for action on the concept under study (Jagosh *et al.*, 2012). The approach increases the quality of outputs and outcomes over time (Jagosh *et al.*, 2012). Soil fertility mapping was carried out due to the existence of intense recession farming. These resulted in qualitative information that was recorded.

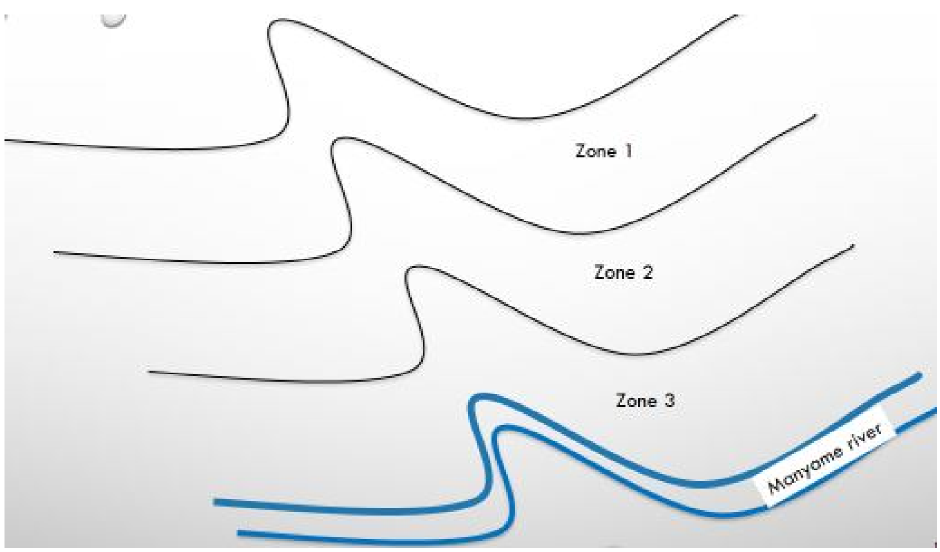

Figure 3.5: Delineation of zones in floodplain

Local farmers' empirical knowledge was used to delineate the different soil fertility zones. This is a participatory approach which made use of the farmers' knowledge. Using a transect walk around the floodplains of Mushumbi area, farmers assisted in defining the different fertility zones. Three zones were delineated with respect to soil moisture availability and gradient as defined by farmers (Figure 3.5). The zone furthest from the river (with less moisture and the highest with respect to elevation) was classified as Zone 1, followed by Zone 2 in the middle and lastly Zone 3 (highest soil moisture and lowest with respect to elevation) which is the closest to the river.

Once these zones were delineated, 6 fields which had all three zones as composition of the field, were selected based on willingness and availability of farmers. GPS Coordinates of the plots and study site were noted using an *E*-trex GPS instrument. Soil samples in each selected plot were collected for analysis. Top soils were dug using a shovel up to 30cm. For each plot, ten 200g soil samples were taken following the letter Z within the field then mixed to make a single composite sample. Each sample was collected in cans for analysis. The samples were taken to the Department of Research Specialist Services (DRSS) laboratory for analysis of soil organic carbon (OC), total nitrogen (N), total phosphorous (P), potassium (K), pH, Magnesium, Calcium and soil moisture. In the same plots, ten randomly selected maize (*Zea mays*) leaf samples were collected in each field and analysed for N and P contents at the DRSS laboratory. The results of the soil and plant leaf samples were compared to measure the crop productivity in relation to available nutrients.

Soil samples from six randomly selected rain-fed fields were collected and analysed for the same nutrient parameters mentioned above at the DRSS laboratory.

The soil nutrient analysis was meant to give a picture of the current soil nutrient status therefore samples were not collected over time. The samples were collected in July 2013.

3.5.3 Yield estimation

At the time of harvest (July, 2013), yield estimation was conducted in the six fields where soil samples were collected and analysed. The method employed was that of harvesting a sample from a known area and weighing. Initially the cob population was established by selecting five points in the field that represent the variations in the field. Inter-row spacing was established by measuring using a tape measure. Ten rows were measured and number of rows recorded.

Equation 2: Inter-row spacing = Number of metres/ Number of rows

Equation 3: Running metres = 10000 (area of hectare)/ Inter row spacing

At each of the five sections selected, ten metres were measured and the number of effective cobs counted (cobs which the farmer will shell).

Five representative cob samples were harvested and weighed using a scale and the average weight calculated and noted. With all these parameters, the yield was calculated using the formula below:

Equation 4: $$\text{Yield (t/ha)} = \frac{\text{CP * ((Average weight of cob* 80\% sp)/1000)}}{1000}$$

Where SP is shelling percentage

CP is cob population

3.5.4 Field observations

Observations were carried out within the floodplain fields, rain-fed fields and photographs were taken. These included observing the yields and crops grown in the different fields and livestock available. The observations assisted in confirming the feedback from respondents.

3.6 Data analysis

The results from the questionnaires were transferred to Microsoft Excel sheets and coded for analysis in SPSS using the correlation method at 95% significance level. This method was used to establish whether there is a relationship between gender and floodplain field access and between age and floodplain access. Descriptive statistics (profile of responses, percentages) in the SPSS package was used to summarise the data. Graphs and tables were used to represent the results. For analysis of contribution of recession farming to household food security, an analysis of the grain required per household (120 kg/capita/annum) was compared to the yield obtained in the rain-fed and floodplain fields. For analysis of household income, the respondents were asked to rank their sources of income and these ranks were used to calculate the contribution of each factor to household income. For sources of livelihood, the interviewed would rank with order of importance their sources of livelihood which was then analysed in Excel to give a mean rank in percentage, of each source of livelihood.

Using the delineated zones and GPS coordinates of the plots within the study site, soil fertility results, interpolation of the specific nutrient parameter was made into a map using the Inverse distance weighting method in ArcGIS. This produced maps of the different nutrient parameters.

3.7 Ethics

Two important aspects of ethics were adhered to:

a) Respondent's confidentiality,

b) Respondent's informed consent (Kelley *et al*., 2003).

In this study, authority was obtained from Ward Councilors before proceeding with the research. The respondents to questionnaires had to be willing to participate before commencing the interview with a knowledge of the background and academic use of the provided information. The respondents were assured of confidentiality and anonymity which was maintained to the end of the study.

Chapter 4

RESULTS AND DISCUSSION

Mushumbi, Chikafa and Chitsungo wards in Mbire District are characterised by two agricultural systems. The first system is the rain-fed agriculture which stretches from October to March. All households practise this farming system. It is characterised by erratic rainfall and long dry spells. The dry spells may last 14 days or even up to thirty days. This results in very low yields. After such long dry spells some seasons are characterised by extremely heavy rains that destroy the little left of the crops. In these rain-fed lands, it is only productive to plant drought resistant crops such as sorghum and their cash crop, cotton. As a habit, people still plant maize in these lands but very little yield is obtained and does not contribute much to their food security.

The second system is flood recession farming. In this system, the farmers make use of residual moisture that is retained in the soil after a flood. The season stretches from March to August. When the soil moisture is almost depleted, due to the proximity of the land to rivers, there is dew every morning to water the crops in the field. In general, yield is high but may be greatly reduced by wild animals that also feed on the crops right from the vegetative stage to the harvest. There is therefore constant conflict between animals and the farmers. Floods may also destroy crops as in some seasons they come after planting and this adds to yield reduction.

4.1 The dynamics of recession farming and dry-land (rain-fed) farming

Recession and rain-fed farming systems form part of the livelihoods of the study area. As such, there are other sources of livelihoods available in the district.

4.1.1 Sources of livelihood

There are 7 sources of livelihood in Chikafa, Chitsungo and Mushumbi (Figure 4.1). According to the respondents as they ranked their sources of livelihoods, the main source of livelihood which contributes 29% of survival is recession farming. This suggests that the people of Mbire mainly rely on the produce of recession farming than any other source of livelihoods. The second source of livelihood is rain-fed farming (26%) in which sorghum, groundnuts, cotton and cowpeas are harvested.

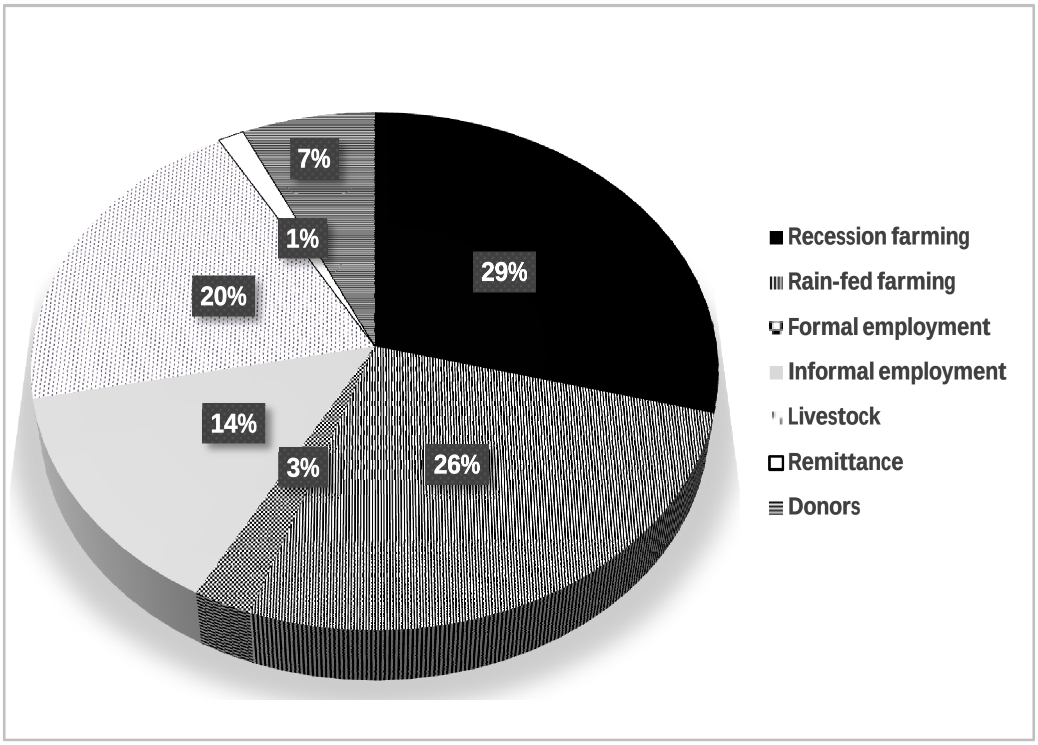

Figure 4.1: Sources of livelihoods in Chikafa, Chitsungo and Mushumbi wards

Livestock rearing as another source of livelihood (20%) brings income to households as they sell their domestic animals during times when food supply is low (October - February) and livestock also provides a source of food. The livestock available in these areas are chicken, goats, pigs, cattle and sheep (Figure 4.2).

Figure 4.2:Livestock observed in Chikafa, Chitsungo and Mushumbi

Some get maize grain and cooking oil from donors such as Christian CARE. Seven percent (7%) of the respondents consider donor aid a source of their livelihood (Figure 4.1). The food aid is not beneficial to all as a few are selected to benefit from it on the basis of being poor and vulnerable in society. The donations are inconsistent and therefore unreliable. The few who benefit, in their poor state have to wait in long queues (Figure 4.3) without food on the particular day in which the food is said to be available.

Figure 4.3: People in queues for donor funded food, Mushumbi 2013

4.1.2 Distribution of recession and rain-fed farming practices among households

In Mbire district, recession farming is common but it is not available to all people. Data gathered from a key informant at the Mbire Agritex office, shows that about 30% of the total households in Mushumbi, Chikafa and Chitsungo practice recession farming while all farmers practice rain-fed farming in all three wards. However, from the study, it was established that 38% of the respondents practice recession farming. Table 4.1 below illustrates the differences in the number practicing the two farming systems in the three wards.

Table 4.1: Recession farming practice

	Ward	No. of households	Households practicing the farming system	Percentage of total households (%)	Area under cultivation(ha)
Recession farming	9	1 162	349	30	28
	10	1 978	593	30	119
	12	1 587	476	30	95
Dry-land farming	9	1 162	1 162	100	2 645
	10	1 978	1 978	100	5 123
	12	1 587	1587	100	2 391

4.1.3 Land access

Land access refers to land which is under the household's use rights, so long as it is regularly utilized, including rented land (Jayne *et al.*, 2003).

Land access with respect to gender

Of the interviewed, 60% of the household heads were male and 40% female. Of the total interviewed, 30% of female headed households and 70% male headed households have access to land in the floodplains (Figure 4.4).

H_0: there is no significant relationship between gender and land access

Analysis of relationship between sex and access to floodplain land for all wards showed no significant gender influence ($p > 0.05$), therefore variability in access does not depend on gender. The null hypothesis is therefore accepted. This is different from a study by Cox and Magel (2002) which states that women's direct access to land through inheritance is limited in traditional societies in Africa. In Mbire, the inheritance of access to land is given to the male children and the females benefit from marriage. Both eventually co-own the piece of land and therefore having access to land is not necessarily determined by one's gender.

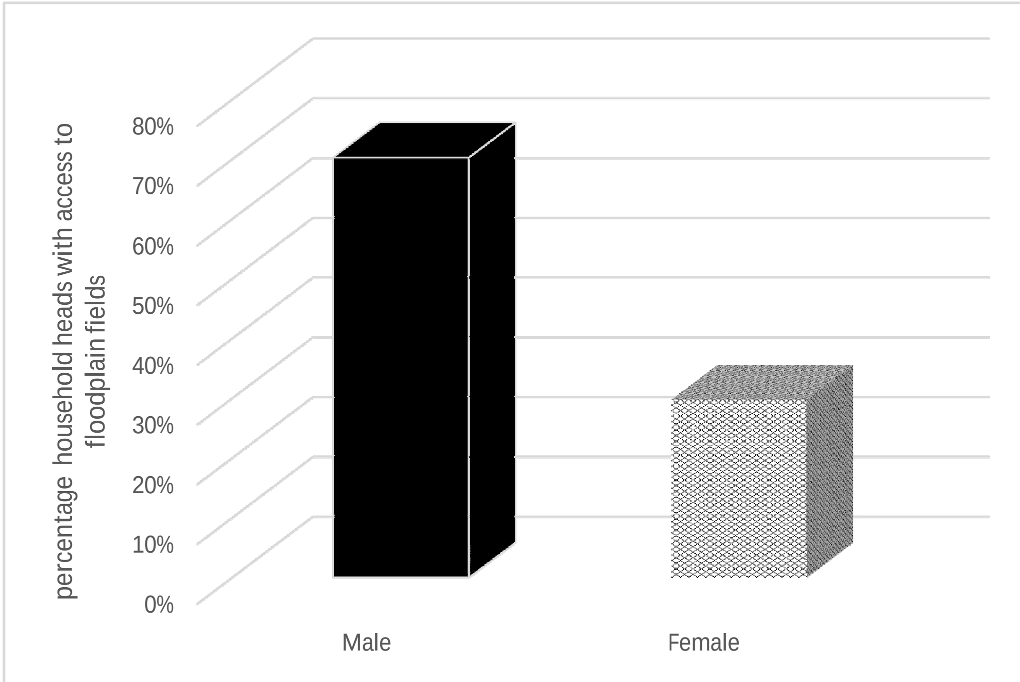

Figure 4.4:Land access with respect to gender

Land access with respect to age

The categories of ages were as follows; under 25, 25-39, 40-59, 60-80 and above 80. An increase in access to floodplain land was observed with increasing age as shown in Figure 4.5 below. The older one gets, the higher the chance of owning a floodplain land. According to the focus group discussions conducted in the three wards, recession farming was established in Mbire since time immemorial therefore ownership depends on whether one's fore fathers owned floodplain land. This in turn explains why the individuals above 80 all own land. Those that are not originally from Mbire do not have access to this land. Of the households without floodplain land, 61% are not originally from Mbire, 22% argue that there is no land and it has never been allocated to them and 17% had their parents never owning the land.

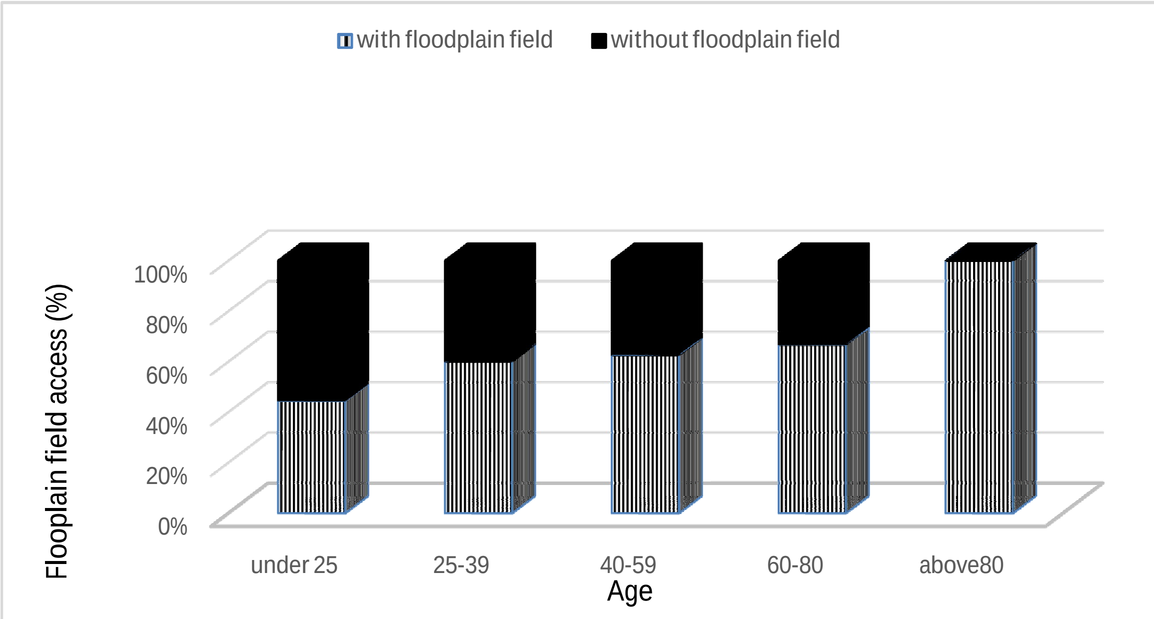

Figure 4.5: Relationship between floodplain land access and age

H_0: there is no significant relationship between age and land access

Analysis of relationship between age and access to floodplain land showed a significant age influence on land access ($p< 0.05$), therefore 8.7% of variability ($R^2 = 0.087$) in access depends on age. The unstandardized coefficient ($b = 0.098$) shows that as age increases, access to floodplain fields increases. The null hypothesis is therefore rejected. This follows a study which suggests that wealth accumulation increases with age (Atkinson and Salverda, 2003), (Rowlingson, 2012). The younger one is, the lesser wealth they have as they still need time to work for and accumulate wealth. This relationship also shows that land is inherited from parents to children. Therefore, those who have had their ancestors reside in Mbire are almost guaranteed of land. It does not necessarily segregate new settlers but those who reside in an area have the right to land access as inhabitants of the land.

The length of time one has access to land increases with age (Figure 4.6). The household heads under 25 years of age have access time between two and five years while those between 25 and 35 have had access from 2-20 years. The age group 40-59 had access to floodplain fields for 5-50 years, those in the age group 60-80 from 5-20 years and the above 80 from 20-50 years.

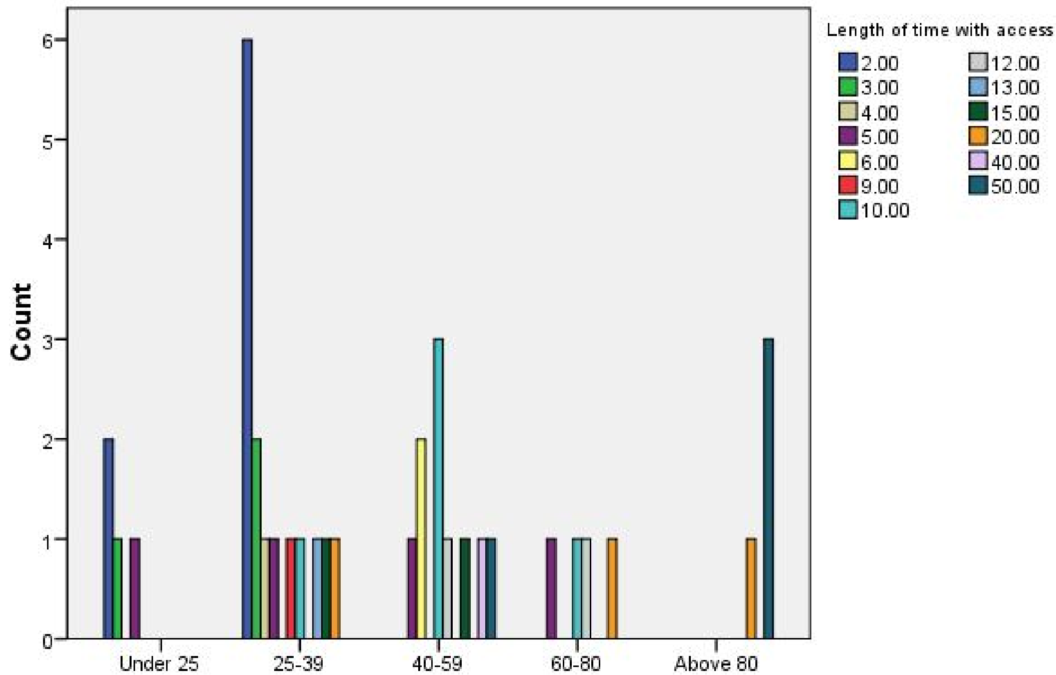

Figure 4.6: Relationship between age and land access

4.1.4 Planting in the floodplain

Planting of maize in the floodplain is totally dependent on flooding of the fields (Figure 4.7) and on when the floods recede. The flooding normally occurs from January to the early weeks of March. The floods leave soil depositions which also determine whether farmers plant that year or not. If sandy soils are deposited, in that year, no planting takes place as these soils quickly dry up and do not allow for growth of plants to maturity stage. Therefore planting in the floodplain is not guaranteed for every farmer each year.

When capping soils are deposited by the floods, the farmer has to wait for one week after the water has subsided then they can dig deep holes of up to 30 cm and plant their seed. This is because capping soils quickly become dry and cracked. Immediately after planting, the dry cracked soil is used to fill the holes as a mulch to preserve soil moisture.

When alluvial sandy-loam is deposited, the farmer waits for the water to just subside (just below soil surface) then they plant. In all cases, two weeks after planting, more soil is added around the germinated plant to preserve soil moisture.

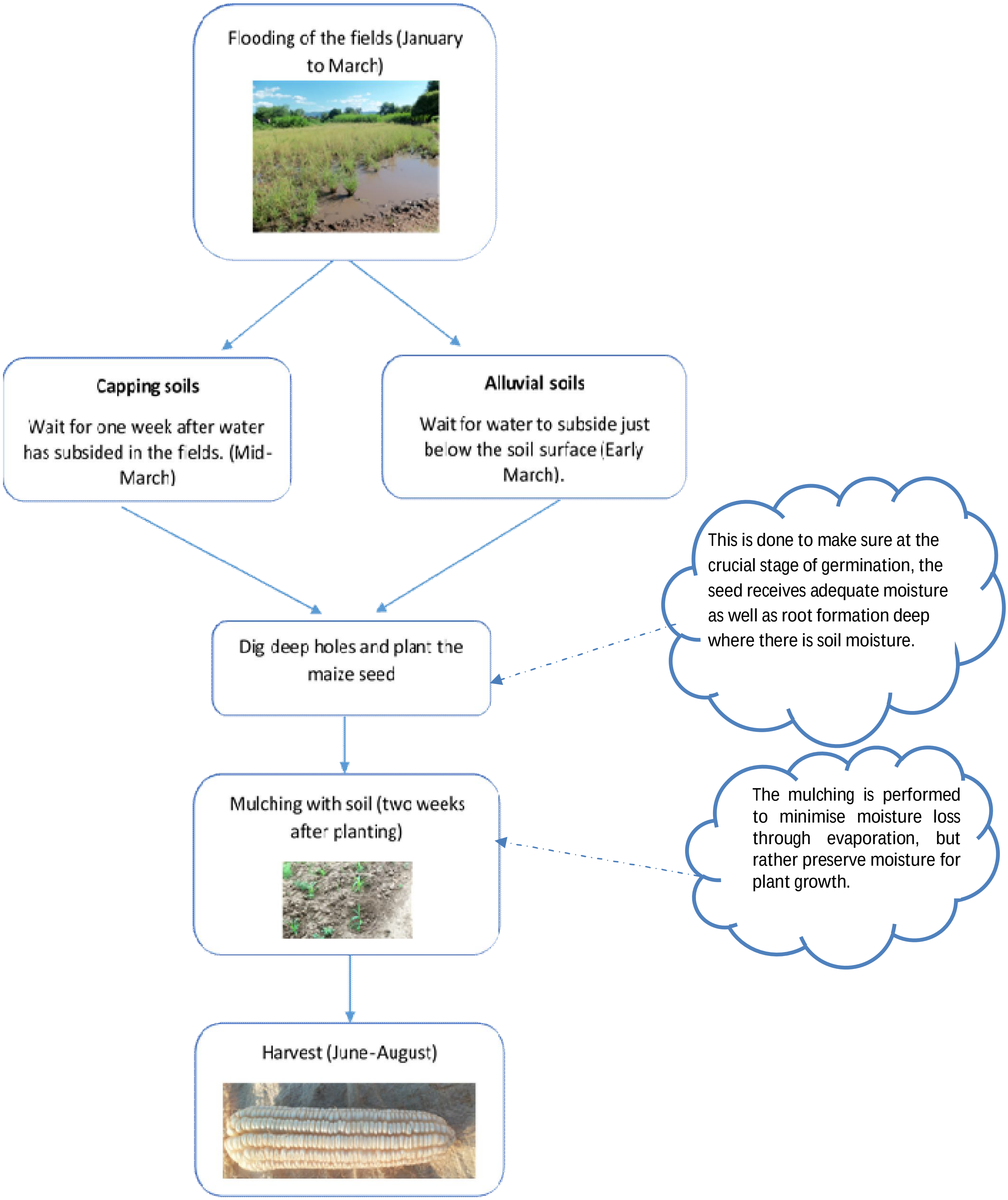

Figure 4.7: Maize growing process in the floodplain

4.1.5 Factors affecting yield

Recession farming yield is mainly reduced or negatively impacted by animals (Figure 4.8; Table 4.2) (hippos, baboons and cattle). With the wild animals, they tend to feed on the plants in the rain-fed fields during the rainy season. Further from rivers, (near the rain-fed fields) water in the ditches quickly dries up and the animals then move to the rivers in search of water. At this time (May), maize plants will just be a few weeks old in the floodplains and the animals then feed on the plants. By the time of harvest in the floodplains, cattle have not much grass to graze on and therefore resort to the maize in the floodplains.

Table 4.2: Rank of factors affecting recession and rain-fed farming

	Mean rank of factors	
Factors reducing yield	Recession farming	Rain-fed farming
Floods	3	5
Dry spells	4	1
Animals	1	2
Pests	2	3
Lack of inputs	5	4
***The order of rank is in ascending order, that is, 1 is a factor with the greatest contribution to yield reduction while 5 has the least impact on yield.**		

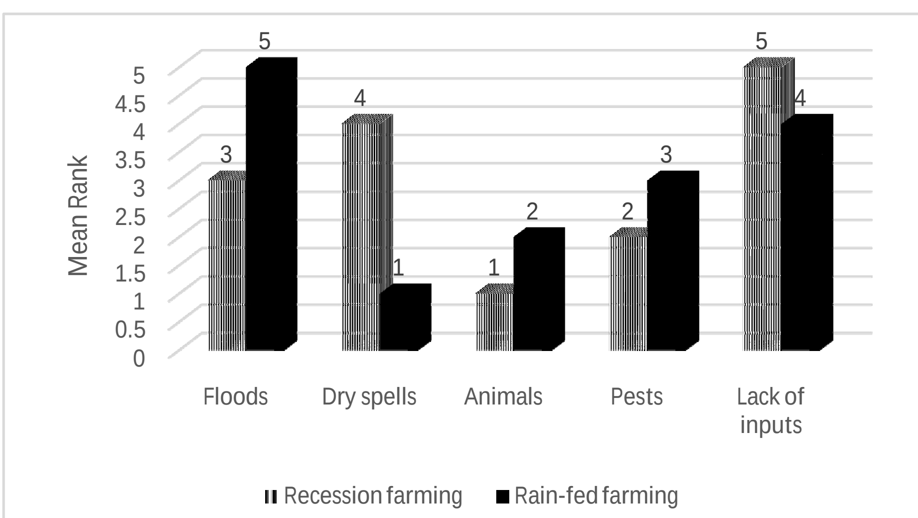

Figure 4.8: Mean Rank of factors affecting yield

Pests are the second major contributor to reduction in yields of the floodplains while third in the rain-fed fields. There are several pests that are nuisance (birds, *magomba*) in the Mbire district, with the main one being what they call in their local language *mamunye* (Figure 4.9). They are green, wide bodied, six legged crickets. They feed on millet, sorghum and maize through biting and chewing the leaves. *Mamunye* feed on plants from a few weeks old to the time of harvest and during the day as well as night. Their control can only be through spraying pesticides unlike the birds which attack the plants during the day but can be drove out of the fields by farmers.

Figure 4.9: Mamunye pests affecting yield

Floods are a source of moisture essential in the recession farming system but may also bring destruction to crops if they come after the farmers have planted their crops. The farmers use their indigenous knowledge and experience to determine the time of planting with the hope that flood will not return after their planting. According to the respondents, floods are third factor in rank of destroying or reducing yield. In the particular year of research (2013), the floods destroyed plants twice after planting. Despite these challenges, the farmers do not tire in planting, with the hope of acquiring a yield to feed their families.

4.2 Contribution of recession farming to household food security and income

4.2.1 Contribution of recession farming to household food security

The basic benefits of recession farming were maize as a grain for households. Recession farming contributes substantially to the maize grain required per annum per household. A comparison was carried out to establish how much recession and rain-fed yield contributes to the total maize grain requirement per household per annum. The results show that 47% of the maize required per household per annum is obtained from the floodplain fields, while 24% is obtained from the rain-fed fields and a deficit of 29% is realised (Figure 4.10). In the absence of recession farming, the deficit of maize grain rises up to 76% which may be difficult to cover. There is not much research that has been carried out to find out the contribution of recession farming to household food security but based on the available literature by Theissen (1975) shows that there is a positive relationship between area of floodplain cultivation in Zimbabwe per household and their socio-economic well-being. Umoh (2008) conducted a study on the contribution of Nigerian wetlands to household food security and established that wetlands contribute 56% to food security compared to 33% in the uplands. Taruvinga (2009) establishes that floodplains in Mashonaland East province of Zimbabwe, have a significant potential contribution to household food security. These studies concur with the results of this study in that recession farming has a significant contribution to household food security.

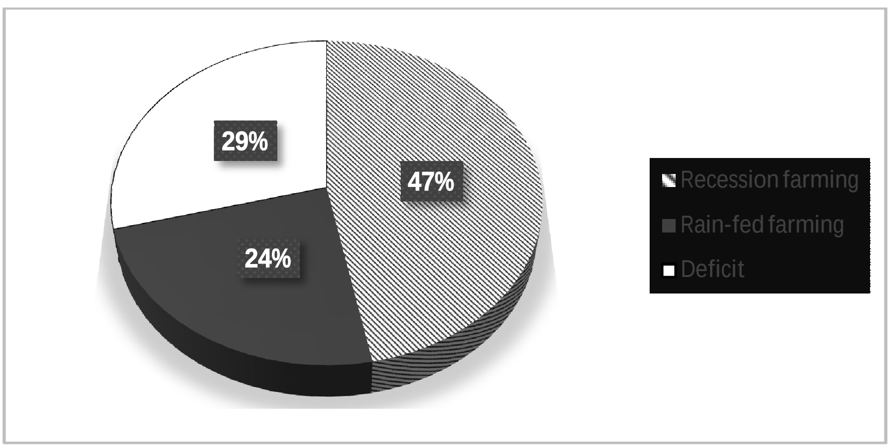

Figure 4.10: Contribution of recession farming to household food security

4.2.2 Contribution of recession farming to household income

Despite its meaningful contribution to household food security, recession farming does not have the same contribution to income. It only accounts to 2% of the total income per household per annum (Figure 4.11). This is because only maize is cultivated in the floodplains and the produce is only for subsistence. Only a few farmers who have larger pieces of land sell their maize produce. The greatest contribution to income is acquired from rain-fed farming where cotton is cultivated as their cash crop. Though the returns of cotton are low, they contribute up to 38% of total income earned. Other sources of income are livestock (15%), informal employment (16%), formal employment (6%) and remittances (1%). For household requirement all these sources of income do not cater for all the needs and there still remains a deficit of 20%.

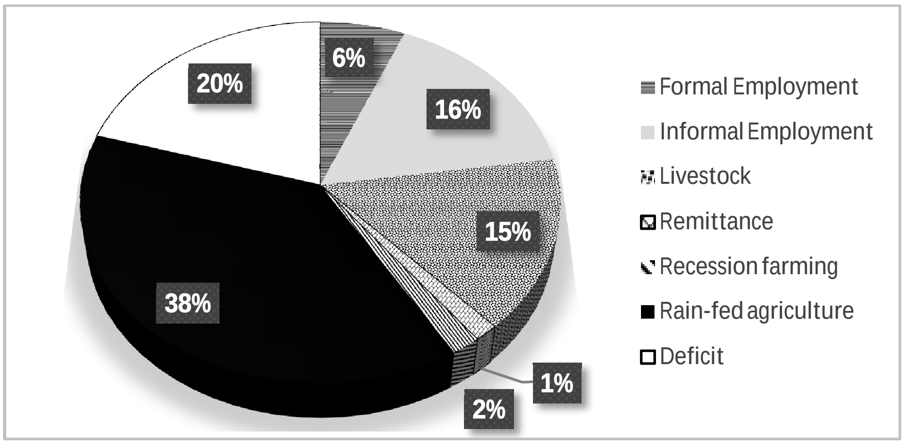

Figure 4.11: Sources of income per household per annum

4.3 Yield and crop differences in recession and rain-fed farming

There are 5 crops that are cultivated in Mushumbi, Chikafa and Chitsungo wards, namely; maize, sorghum, cowpeas, groundnuts and cotton (Table 4.73). The distribution of the five crops in the two farming systems are uneven as only maize is cultivated during recession farming while all the five are cultivated in the dry-lands. Vegetables such as cabbage, rape (Figure 4.12) and onions are also cultivated in the floodplain, not as recession farming but under irrigation. The irrigation is done by getting water from the river using buckets and watering the plants.

Figure 4.12: Vegetables in floodplain under irrigation through buckets

Figure 4.13 below shows the average yield of the various crops within the two farming systems. Maize yield in the floodplains is more than double the yield in rain-fed agriculture. This difference in yield has been established by other researchers who report that floodplain productivity is ten times greater than dry-land cultivation in the rural areas (Rukuni *et al.*, 2006). With respect to this fact, African policy makers were rethinking the 'wise use' of floodplains (Makombe *et al.*, 2001), (Taruvinga, 2009).

Table 4.3: Yield of various crops in the rain-fed fields

Crop	Yield (t/ha)
Sorghum	0.5
Cotton	0.5
Groundnuts	0.6
Cowpeas	0.4

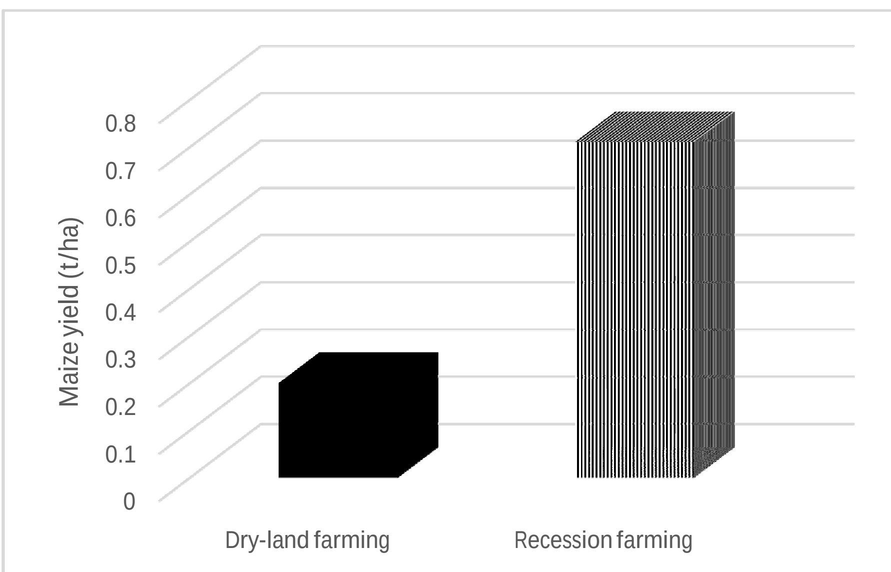

Figure 4.13: Maize yield comparison between recession and dry-land farming systems based on farmers' experience

The yield as provided by key informants was 0.8 t/ha in the floodplains yet the mean as obtained from farmers was 0.7 t/ha. Having estimated the yield for the 2013 season, a yield of 1.32 t/ha (Table 4.4) was obtained. The results showed an even greater difference with the yield that is obtained in rain-fed fields. Though size of rain-fed fields is about five times greater than that of floodplain fields (Table 4.1), there is greater potential with respect to yield in the floodplains than in rain-fed fields.

Table 4.4: Estimated maize yield in the floodplains

Field	Yield (t/ha)
1	1.4
2	1.30
3	1.57
4	1.33
5	1.2
6	1.15
Mean	**1.32**

4.4 Fertility status of soil in the floodplains

There is a general increase in fertility as we move closer to the river from zone 1 to zone 3 (Table 4.5). In the table, the figures highlighted in yellow show the mean phosphorus (P) per zone which ranges from 24ppm (P) in zone 1, 26ppm (P) in zone 2 and 32ppm (P) in zone 3. The floodplain therefore acts as sink of nutrients from the catchment as well as from upstream flood deposition. The secondary elements calcium and magnesium are usually in sufficient quantities if crop-lime pH needs are met (5.8 - 7.0) (Espinoza and Ross, 2005). Therefore the soil in the floodplain has sufficient calcium and magnesium for crop growth.

Table 4.5: Mean soil fertility in the Mushumbi (Ward 9) floodplain

Zone	Field	pH	Total Organic matter (%)	Total Nitrogen (%)	Phosphorous (ppm)	Potassium (me%)	Soil moisture (%)	Calcium (me%)	Magnesium (me%)
Zone 1	Field 1	7.1	0.23	0.02	28	0.11	9.3	7.44	2.89
	Field 2	7.2	0.48	0.04	19	0.2	8.9	10.4	3.5
	Field 3	7.1	0.9	0.09	33 24	0.38	13.1	9.79	3.87
	Field 4	6.3	2.7	0.12	22	0.21	7.5	9.68	3.79
	Field 5	6.3	2.71	0.12	20	0.15	6.7	8.5	2.91
	Field 6	6.5	2.7	0.11	23	0.55	3.2	13.82	4.65
Zone 2	Field 1	7.1	0.73	0.05	28	0.2	12.6	10.4	4.64
	Field 2	7	1.24	0.09	14	0.7	22.6	12.92	6.55
	Field 3	7.1	0.58	0.04	30 26	0.33	14.7	12.55	6.54
	Field 4	6.4	4.72	0.16	26	0.32	28.1	15.7	7.76
	Field 5	6.4	2.93	0.14	28	0.35	26	16.33	8.36
	Field 6	6.5	1.02	0.09	32	0.35	27.2	15.36	8.1
Zone 3	Field 1	7.1	1.11	0.13	30	0.39	13.8	11.82	5.46
	Field 2	6.7	1.04	0.08	27	0. 28	13.8	9.11	4.96
	Field 3	6.6	0.92	0.08	19 32	0.58	24.5	12.11	6.07
	Field 4	6.4	2.71	0.11	51	0.4	2.9	13.61	3.96
	Field 5	6.5	2.28	0.11	45	0.43	3.2	14.85	4.44
	Field 6	6.1	1.24	0.09	45	0.33	5.7	11.45	4.86

Table 4.6: Maize leaf nutrients in the floodplain

	Field	Total Phosphorus (mg/l)	Total Nitrogen (mg/l)
Zone 1	1	14	189
	2	11	190
	3	15	188
	4	14	176
	5	17	187
	6	10	191
Zone 2	1	15	255
	2	19	266
	3	16	257
	4	16	202
	5	12	256
	6	16	293
Zone 3	1	21	429
	2	20	305
	3	18	435
	4	21	411
	5	25	427
	6	19	385

4.4.1 Potassium

Potassium levels ranged from 0.11% to 0.7% (Table 4.5). In some parts of the floodplain analysed, levels of potassium increased (Figure 4.14). The green sections show high values of potassium while the red show low values. The spatial variation of potassium is highly diverse as there are some patches in zone 1 (circled in Figure 4.14) that have high potassium. Variations in potassium may be dependent on how long the water stays depending on the gradient, topographyof the stream or land. The nutrient variations are therefore intepreted across the river and not along the river.

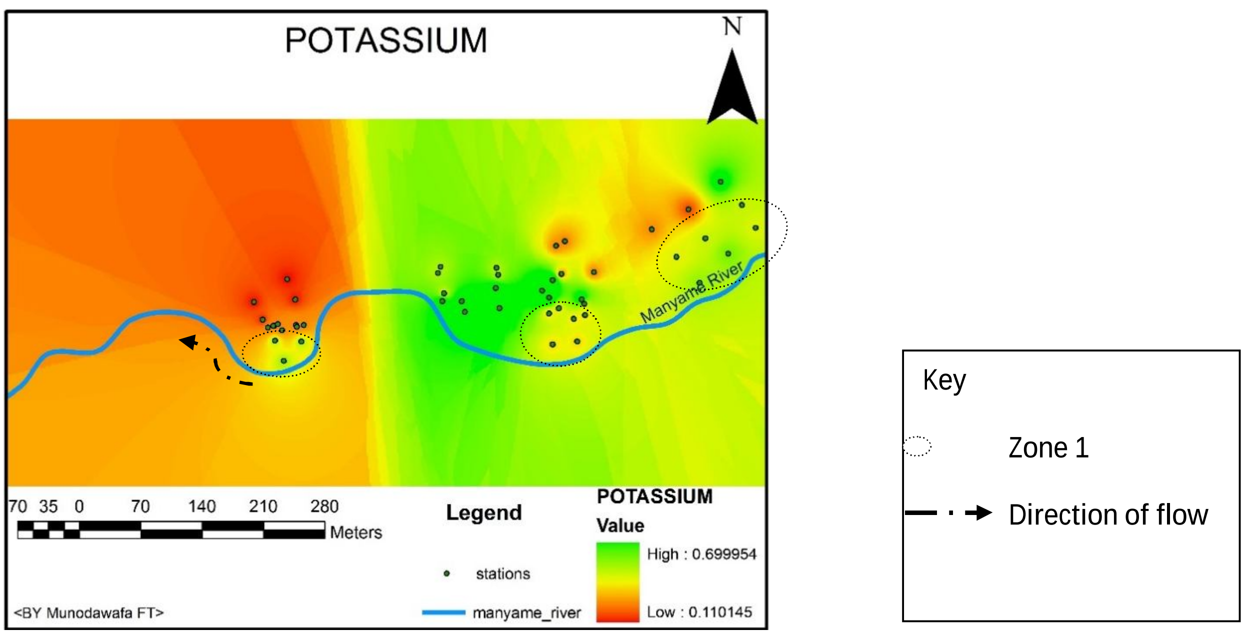

Figure 4.14: Potassium interpolated map

4.4.2 Phosphorus

"Phosphorus is known as the master key to agriculture because lack of available phosphorus in the soil limits growth of both cultivated and uncultivated plants" (Foth and Ellis, 1997b). Phosphorus ranged from 14% – 51% (Table 7). These are high values and show that the floodplain are a sink to nutrients within the catchment. They trap phosphorus which may be a potential cause of eutrophication in the Manyame river and downstream. The floodplain and its use in farming therefore plays an important role in nutrient cycling and reduction in pollution. Figure 4.15 shows that phosphorus concentration decreases further from the river, therefore the most productive areas are those closest to the river as depicted by the dotted circles which have high concentrations of phosphorus. Variations in phosphorus may be dependent on how long the water stays depending on the gradient, topography of the stream or land. The nutrient load of the soil depends on the trapping efficiency of the floodplain which in turn depends on the flow velocity and settling velocity of the silt particles (Van der Lee *et al*., 2004). At very high discharges, the sediment load conveyed onto the floodplain is high, but sedimentation is low due to exceeding critical current velocity for deposition of fine suspended sediment. This results in decreased sedimentation rates and hence in decreasing nutrient retention by sedimentation (Van der Lee *et al*., 2004). The nutrient variations are therefore intepreted across the river and not along the river.

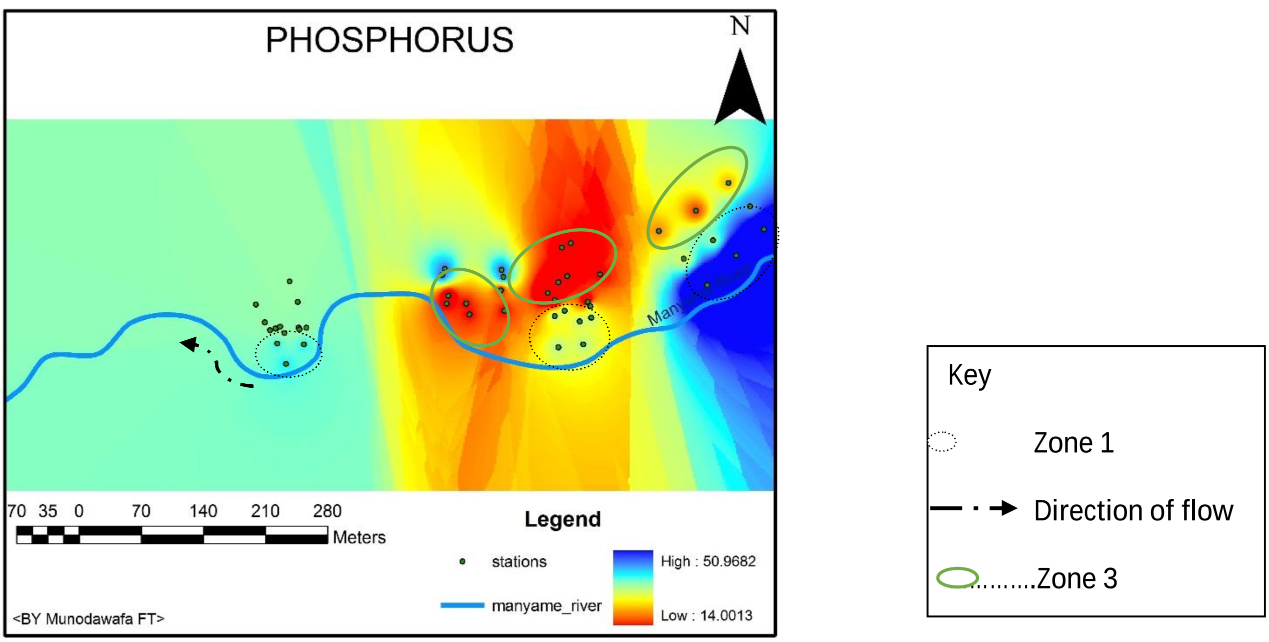

Figure 4.15: Phosphorus interpolated map

4.4.3 pH

pH is an important factor in plant growth because it influences several factors affecting plant growth such as, soil bacteria, nutrient leaching, nutrient availability, toxic elements and soil structure (Perry, 2003). The pH of soils ranged from acidic to alkaline, ranging from 6.1 – 7.2 (Figure 4.16). Alkalinity slightly decreased as gradient decreased nearing the Manyame river. As pH increases, organic matter develops a negative charge, thus increasing cation exchange capacity. As pH decreases, organic matter develops an increased positive charge, thus increasing anion exchange capacity (Stockman, 2007). Increased anion exchange capacity may enhance plant growth through the sorption of anionic toxic pollutants such as herbicides and the retention of exchangeable nutrients such as NO_3^- and PO_4^{3-} (Wei *et al*., 2009). This explains the general increase in organic matter (Figure 4.17) from zone 1 (furthest to the river) to zone 3 (closest to the river) . Optimum soil pH for maize growth is between 5.8 and 6.5 (Tagwira *et al*., 1993), therefore the areas closest to the river would produce better yields as zone 3 had a mean of 6.6. The nutrients available in the flood waters influence the pH of the soil, therefore the variations in pH may have been influenced by the quantity and type of nutrients available in the flood waters.

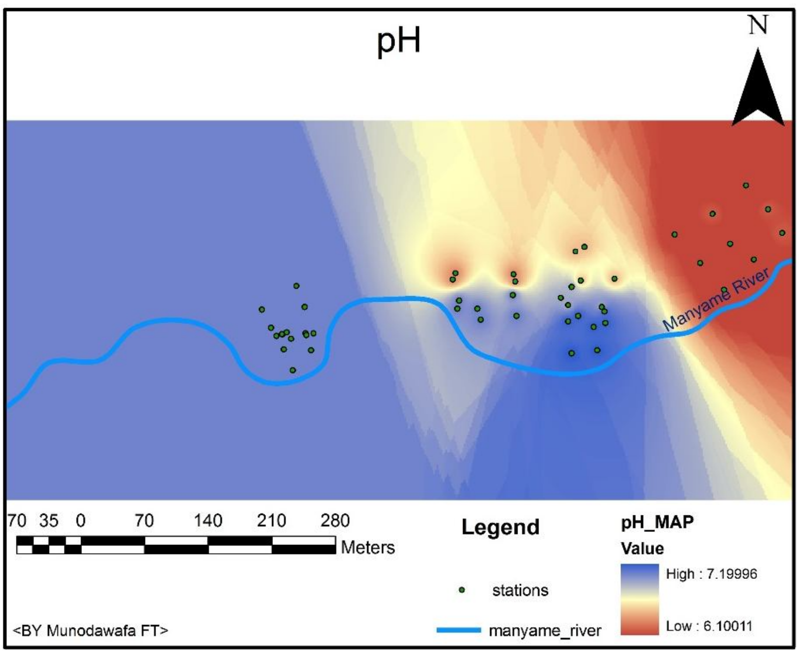

Figure 4.16: pH interpolation map

4.4.4 Total Organic Matter (TOM)

According to Enwezor (1989) and other researchers, the total organic matter ranged from high (4.7%) to low (0.23%). Organic matter has a high pH dependent cation exchange capacity as well as a high water holding capacity, which perpetuate the saturated conditions that enhance organic accumulation (Stockman, 2007). TOM tends to mineralize to yield CO_2, NH_4^+, NO_3^-,

PO_4^{3-} and SO_4^{2-}, thus creating a source for plant nutrients (Stockman, 2007). These results show that there is a general potential for high yield in the floodplains if they are managed well. Within the floodplain, the catena closest to the river has higher organic matter values which make them more productive than the higher zones. However, some sections of fields (Figure 4.17) had much higher TOM values showing variations in fertility of the floodplain. This may be attributed to differences in nutrients deposited within a flood event as well as the time the water is retained by the soil after a flood event, topography and soil type.

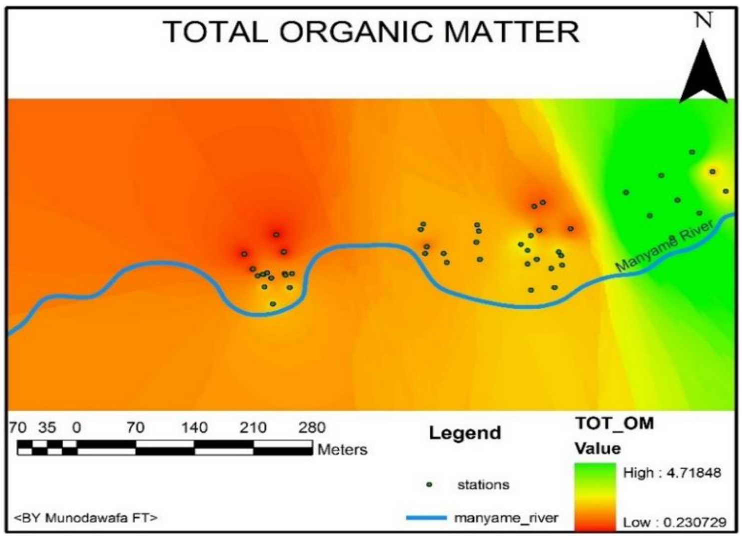

Figure 4.17: Total Organic Matter interpolated map

4.4.5 Total Nitrogen

The results of the soil analyses range from 0.02 to 0.16%. For high productivity, it is important for the soil to contain high amounts of nitrogen. The total nitrogen of a soil is directly associated with its total organic matter and its amount on cultivated soils is between 0.03% and 0.04% by weight (Mengel and Kirkby, 1987); (Tisdale *et al.*, 1995). Therefore, the soils of the floodplains have high nutrient content which supports plant growth except for zone 1 of field 1 which has a value of 0.02%. There is high concentration of total nitrogen at the right side of the study area (Figure 4.18) with a general decrease in concentration as one moves away from the river.

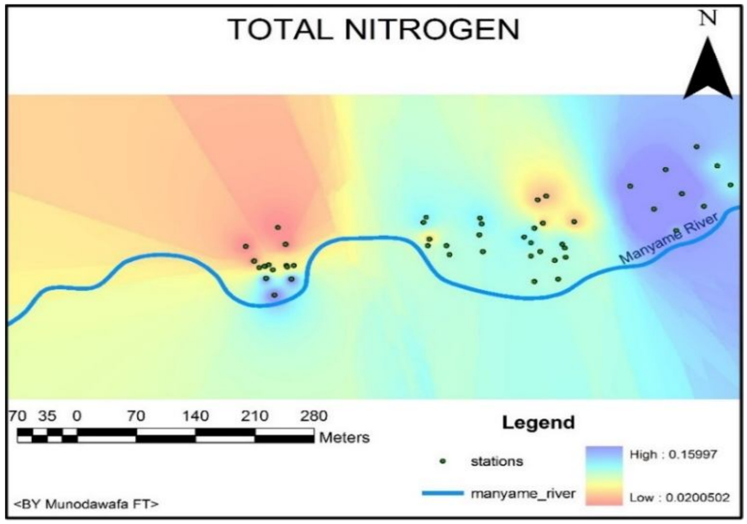

Figure 4.18: Interpolated map of total nitrogen in the floodplains

4.5 Relating soil fertility to yield

Considering the high fertility in the floodplain, the average yield of 1.32t/ha (Table 4.4) is low. There is room for improvement of yield if management practices are improved. Sandy soils that have a low organic matter content tend to have yields that are below 1.0t/ha. These highly fertile alluvial soils are expected to have high yields. The low yields can be attributed to poor management practices that include poor weed control. As obtained from the farmers, they weed once a season which may not be sufficient for optimum yields. Weeds can reduce yield by competing for nutrients, moisture and light during the growing season and interfere with harvest (Ferrell, 2002). There is therefore room for improvement as the highly fertile soils are being under utilised.

4.6 Soil fertility in the dry-lands compared to floodplain land

The pH of the soils are within acceptable range as they range from 6.2 to 7.0. Some of the samples that have a pH of 6.7-7.0 do not however fall within the optimum pH for maize growth which is between 5.8 and 6.5.

The phosphorus levels are generally low within a mean value of 6.2 ppm. This shows low fertility compared to that of floodplains, hence the need for the use of fertilisers. The total nitrogen and contents in the dry-fed fields is generally ten times lower (Figure 4.20) than that of floodplain fields while organic matter contents (Figure 4.20) are at least twice lower in the rain-fed fields.

Table 4.7: Soil fertility in the rain-fed fields

Field	pH	Total Organic matter (%)	Total Nitrogen (%)	Phosphorous (ppm)	Potassium (me%)	Soil moisture (%)	Calcium (me%)	Magnesium (me%)
Field 1	6.5	0.03	0.003	8	0.02	0.9	3.65	1.32
Field 2	6.2	0.02	0.002	6	0.02	0.5	2.17	1.29
Field 3	6.3	0.04	0.004	7 **6.2**	0.06	0.6	4.50	1.54
Field 4	6.7	0.02	0.002	4	0.05	0.6	4.24	1.55
Field 5	7.0	0.05	0.006	7	0.04	0.5	4.18	1.47
Field 6	6.3	0.03	0.005	5	0.02	0.4	3.26	1.53

4.6.1 Total Organic Matter

For the first rain-fed field, the total organic matter value of 0.23% is higher than that of the first recession farming field value of 0.3% (Figure 4.59). The rest of the five fields have values of total organic matter in the rain-fed fields lower than the values in the floodplains. The rain-fed fields require addition of nitrogen through fertiliser application for optimum yields.

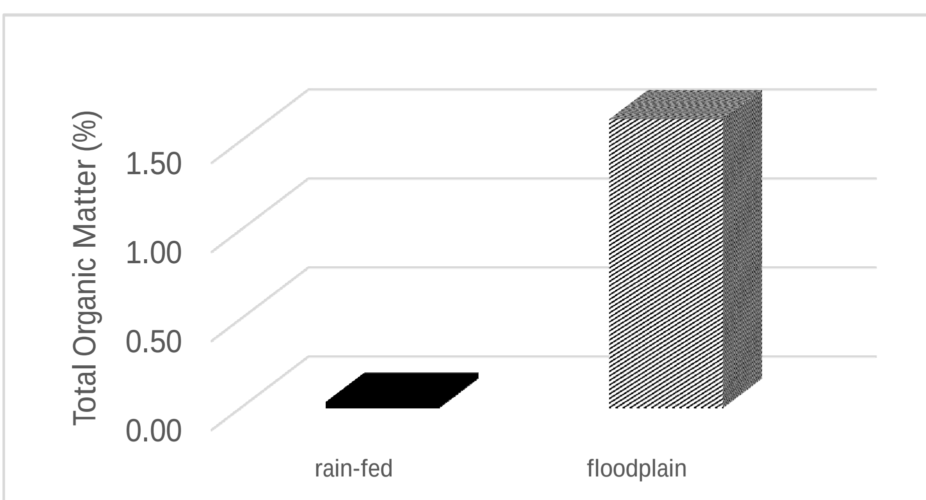

Figure 4.59: Comparison of Total Organic Matter in floodplain and dry-fed fields

4.6.2 Total Nitrogen

Nitrogen values in the floodplain are ten times greater than those in the rain-fed fields (Figure 4.20). The difference compliments the difference in yield of the fields in which yield in recession farming is double that of the yield of rain-fed farming. There is need for additional nitrogen through fertiliser use within the rain-fed fields.

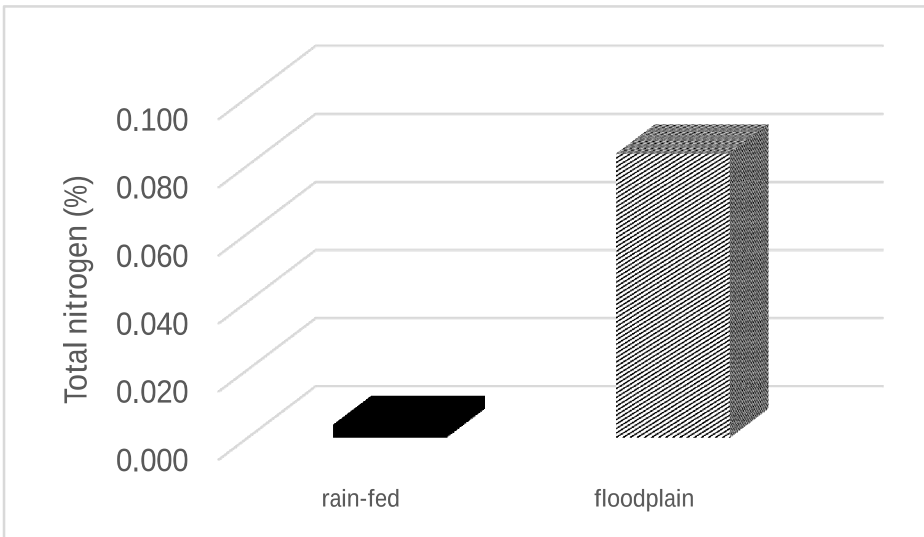

Figure 4.20: Comparison of Total Nitrogen in floodplain and dry-fed fields

4.6.3 Phosphorus

The phosphorus levels in the rain-fed fields are at least two times lower than those in the floodplains (Figure 4.21). This confirms the above statement that floodplains may act as sinks for nutrients from the rain-fed lands as well from upstream. The phosphorus levels in the rain-fed fields indicate the need for fertilisation of the fields while it may not be necessary in the floodplains.

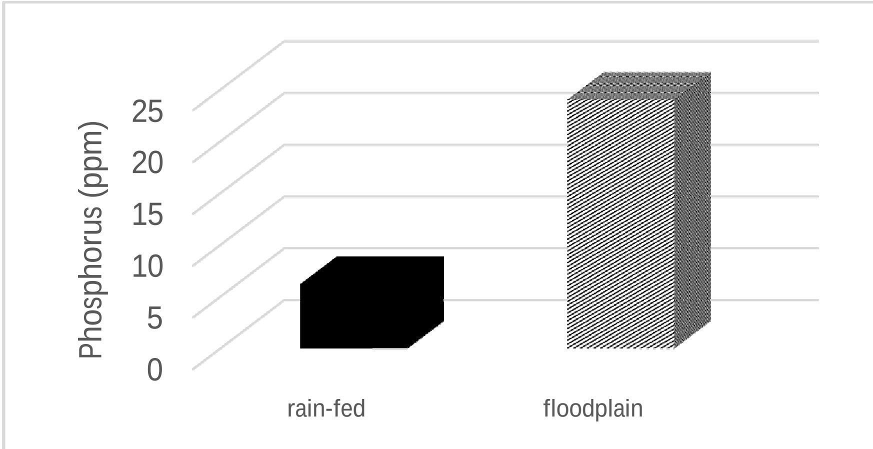

Figure 4.21: Comparison of Phosphorus in floodplain and dry-fed fields

4.7 Distribution of benefits and costs of recession farming.

4.7.1 Fertiliser use in the floodplain

Of the interviewed, only 14% use fertiliser to enhance growth of their plants in the floodplain (Figure 4.2). Of the 14%, 5.6% use organic fertiliser (cow and goat dung) while 8.4% apply artificial or synthetic fertiliser. The low use of fertilisers may imply that there is little impact on the environment through fertiliser use.

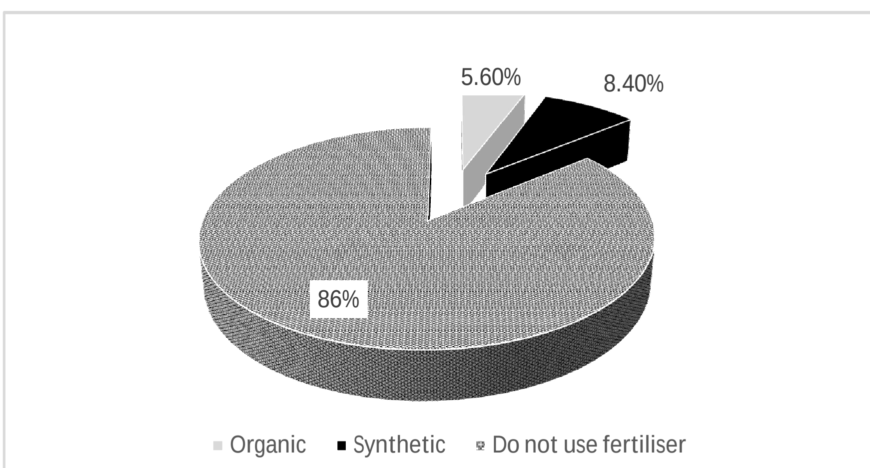

Figure 4.22: Fertiliser use in the floodplain

Fertilisers are applied in the rain-fed fields for better yields. Since these fields are upstream, the fertilisers applied are washed into the floodplains as well as the river. The floodplains are of great importance as they assist in reducing nutrient load in water from upstream loaded with fertilisers from the dry-lands. The contact time between floodwaters and sediment allows for retention of nutrients in the floodplains (Noe and Hupp, 2007). Floodplains act the role of buffers for floodwater and filters for nutrients and pollutants (Lair, *et al.*, 2009). There is therefore nutrient recharge in floodplains which is important for plant growth.

4.7.2 Pesticide use in the floodplain

Of the interviewed, only 33% use pesticides and herbicides to protect their plants from pests in the floodplain (Figure 4.23). There are two types of pesticides and two herbicides that are used in the study area, namely, carbaryl, rogor, paraquat and fernkill respectively. Rogor is used in controlling pests in vegetables which are cultivated in the floodplains not as recession farming but bucket irrigation within the floodplains. Since only 33% of the respondents use pesticides, it can be concluded that the impact of pesticides on the environment are minimal. Therefore recession farming cannot be said to negatively impact the environment through pesticide use.

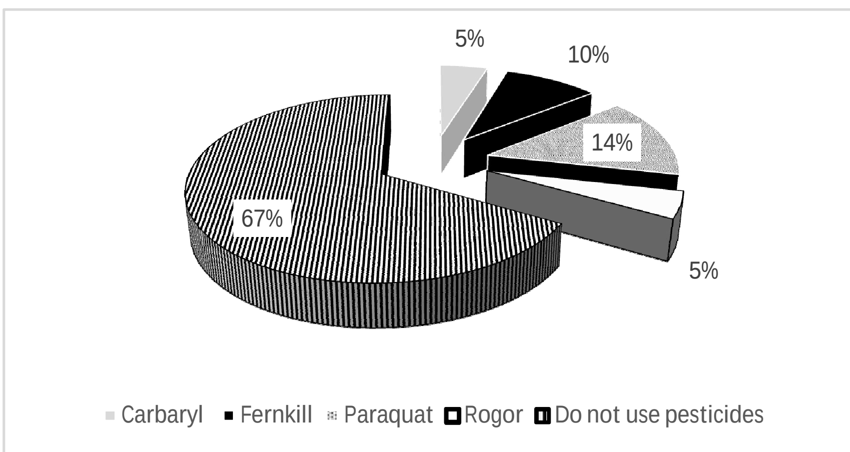

Figure 4.23: Pesticide use in the floodplain

4.7.3 Conflict with Environmental Management Agency (EMA) and National Parks

EMA under the Environmental Management Act [Chapter 20:27] of 2002 does not allow farmers to cultivate in the floodplains. This is because floodplains are designated as protected areas under part XII section 113 of the Environmental Management Act. The Act states that "no person shall reclaim or drain any wetland; disturb any wetland by drilling or tunneling in a manner that has or is likely to have an adverse impact on any wetland or adversely affect any animal or plant life therein" (Environmental Management Act, 2002). It also prohibits or restricts the cultivation or use, or method of cultivation or use of beds, banks or course of a public stream. They are deemed to be prone to environmental degradation through erosion because of the gradient and proximity to water sources. According to an EMA officer key informant, they have advised farmers not to plough these areas but this has faced major resistance and has become difficult because:

1. There are more elderly people practicing this farming practice and it becomes difficult to make them pay fines for the cultivation.
2. The enforcement agencies are weak.
3. There is witchcraft associated with prohibiting them from ploughing.

Therefore there is constant conflict between recession farmers and EMA. Of the respondents, 15% clearly stated that they do not follow the laws around floodplain use because that is where they obtain most of their produce for survival.

There is also constant conflict between the recession farmers and National Parks particularly after a farmer has been attacked by animals in the floodplains. According to the Parks and Wild Life Act of 1975 Chapter 20:14, Section 24, no person shall: hunt any wild life or take or destroy the nest therefore in a national park; except in terms of such regulations as may be prescribed- introduce into or convey in a national park any weapon or explosive or any prescribed article (Parks and Wild Life Act, 1975). When farmers complain of attack from animals National Parks tell them that they are encroaching on the wildlife area and there is bound to be conflicts. Therefore there is no help that comes from National parks.

4.7.4 Conflict with wildlife

There is constant conflict between recession farmer and wild animals, particularly hippos that stay in Manyame River just adjacent to the floodplains. This challenge calls for farmers to protect their fields by building guard rooms (*madara*) (Figure 4.24) in which they reside during the night and scare away hippos.

Figure 4.24: Madara (guard rooms) in the floodplain fields for yield protection against wild animals

4.7.5 The benefits of wildlife to the community of Mbire district through CAMPFIRE

In Zimbabwe, community based natural resource management (CBNRM) took root in the late 1980s onwards under the flagship Communal Areas Management Programme for indigenous Resources (CAMPFIRE) which sought to devolve the management of wildlife on communal land from the state to local producer communities (Murphree, 1990). CAMPFIRE is a programme designed to assist rural development and conservation. It is aimed at promoting sustainable management of wildlife and natural resources and equitable sharing of their benefits at the local level (UN, 1997).

Through the programme, communities earn income through sustainable utilisation of their natural resources. This is the case of Mbire district in which the district council leases sport hunting to private sector operators for a fee and they receive some of the proceeds from this activity. The benefit is rather at community level than household level. However, despite the conflict between farmers and wild animals, the villagers of Mbire district benefit from these wild animals through development of infrastructure such as roads, clinics and schools. This should therefore be a point of encouragement to farmers to find ways of managing conflicts they have with wild animals as well as the National Parks and Wildlife, knowing that they can benefit from those animals. In this regard, recession farming can be allowed with ways in which conflicts may be minimised.

Box 4.1: Guarding against wildlife to protect yield

Floodplain fields are vulnerable to wild animals that may eat the farmer's crop. Protecting the yield is therefore crucial for each farmer to feed his family. In Mbire, this is done by constructing guarding huts in the fields, which are called madara (Figure 4.24) in their local language. These madara are used as shelters in which farmers stay mainly during the night to as they make sure animals do not feed on their crop. They are constructed using the locally available Mopane (Colophospermum mopane) materials and this is done yearly as the madara are washed away by floods in the rainy season. They are constructed at a strategic position in the field, that is, at the centre of the field for better vision of the animals as well as high up for their protection. The madara become a second home to the farmers as they have a set of pots and plates with them in the fields for preparation of dinner and at times lunch. The average distance from a farmer's home to the floodplain field is 750 m.

Hippopotami due to their proximity to the floodplains are the main animals that eat the crops in the floodplain fields. These animals feed during the night, therefore farmers go down to their fields to guard from 7.00 pm to 6.00 am. The household heads are the ones who go out and guard the crops from animals. This is because the job can be dangerous for the children as there are chances of attack by the hippos. When the hippos get into the fields to eat during the night, torches and fire (using Mopane trees as firewood) are used to scare away the hippos as they are afraid of light. This is done with all carefulness and from a distance for their protection. One of the challenges the farmers face is that hippos eat their crop from the time the maize crop germinates to the time of harvest. There is never a time to rest during the life of their crops.

In some instances, people may be attacked by the hippos within their fields. These cases are rare in Mushumbi and Chikafa but in Chitsungo once each year an individual is attacked to the point of death. They become particularly violent when their young are attacked. Safety is only guaranteed up in the guarding huts and the use of lights such as torches and fire (Group Discussion, July 2013*)*.

The Mopane trees are used for constructing the *madara* in the floodplain fields because they are the strongest locally available trees and are not easily attacked by termites. There is no regulation of how trees are cut down unless if one needs to cut trees from another ward. The trees were generally abundant in Mbire district, however, they have become scarce as there are no sustainability measures used to replace the cut trees. In some parts of Mushumbi, they are no longer available such that *Muzunga* (Acacia species) trees are used as a substitute. There are no planting programs in place for afforestation. This increases the chance of deforestation and eventually erosion.

"There are no seeds available for replanting of the trees." (Group Discussion, July 2013)

4.7.6 Erosion in lowland floodplains

Though widely accepted that cultivation in floodplains causes erosion, this does not apply in all areas. In a study within the Mbire district, it was established that the district has a low erosion hazard (Dube, 2011). In particular the study area, (Wards 9, 10 and 12), have an erosion hazard generally below 10 Erosion Hazard Units (EHUs). Despite these findings, it was also established that high erosion hazards were found in pockets associated with settlement and dry-land and floodplain cultivation (Dube, 2011). This study did not encompass research on the effect of floodplain agriculture on erosion. However, observations made during the study, show that erosion occurs from the bottom and eventually causes all the top soil to collapse, therefore erosion that occurs in the district cannot entirely attributed to floodplain cultivation and settlement but the type of soil as well. It is therefore necessary to carry out further study on the relation between erosion and floodplain agriculture.

4.8 Recharge of water and nutrients in floodplains

The water balance within lowland floodplains is strongly influenced by the temporally variable spatial extent of the interactions between groundwater and surface water (Krause, 2005). Overall, the nutrient and organic matter composition of a river-floodplain systems depends on the source of water and the biogeochemical transformations that occur in the floodplain system (Tockner, 2002). In the rainy season, fertile alluvium is deposited onto floodplains through floods (Beilfuss *et al*., 2002). It can then be assumed that recharge of nutrients and water occurs every year as long as rainfall is received. In Mbire district, the recharge occurs in the rainy season, that is, between October and March. This explains why the plants grown in the floodplains are able to reach maturity when planted after the rainy season has ended.

4.9 Other potential benefits of recession farming

Recession farming can be a source of tourism. Eco-tourism is a form of tourism whose main function is to raise ecological and environmental awareness, and includes cultural and historical sites that are closely related to the ecosystem and provide opportunities to learn about the environment (Siphan, 2004). It is important to develop it as eco-tourism which involves making the floodplains and its surrounding a tourist area to generate income and employment for the community while minimising the impacts to the environment and local culture. The way the farming is practised can be of interest to other people who have never witnessed it. If the community is allowed to live in the natural way in which they live, development can be done around them by building infrastructure that allows tourists to be comfortable yet viewing the unique farming system with the madara. Just like the CAMPFIRE programme, the community may benefit from the proceeds of the tourism project. If it is functioning well, ecotourism must provide income to meet the needs of the local community (Chernela, 2011). Floodplains in different countries have been assessed for their potential for ecotourism and have been found to have great potential such as in Cambodia (Siphan, 2004), Minjiang river, China (Ye and Huang, 2006) and East Khasi Hills district, India (Pyngrope, 2012). For the success of ecotourism, the value of the resource, that is, its 'product' should be preserved (Chernela, 2011). Its sustainability in the future occurs if indigenous groups (a) are decision makers in all areas of tourism in their territories; (b) do not themselves become 'watchable wildlife' for the client; and (c) benefit justly from the rewards of tourism (Chernela, 2011).

There are opportunities for people of Mbire to benefit from recession farming, therefore there should be means to minimise conflict that exists.

4.10 Summary

Integrated water resources management IWRM) is a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives. IWRM is based on the understanding that all the different uses (drinking, agriculture and environment) of finite water resources are interdependent (GWP Editor, 2008). The findings from this study show that water is important for agriculture in the floodplains as it brings with it moisture for the soil and nutrients necessary for plant growth. Floodplains are important areas in nutrient cycling before water goes back in the stream, thereby reducing water pollutants. There is potential in the floodplains in terms of crop productivity.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Recession farming is likely not going to be limited by soil fertility. The soils are fertile and do not particularly require additional fertilizer as they can allow for growth of plants. The soils in the rain-fed fields have general low fertility and require application of fertilizer. There is therefore more cost associated with rain-fed farming than required in recession farming.

Recession farming contributes up to 47% to household food security for those practicing it, in particular the staple grain, maize. However it still leaves a deficit of 29%. Its contribution to household income per annum is however very low, contributing only 2% of the total income required per household per annum. The practice of recession farming comes with a cost of land degradation of cutting down trees unsustainably and conflicts with wildlife, EMA and the National Parks. As long as the farming system is being practiced, the conflicts with EMA may never be solved unless policy makers allow these people to continue farming based on consideration of its contribution to household food security in such a food insecure place.

Despite only 30% of households having access to the floodplain field, benefits also reach the other 70% as the people function as a community by helping each other. In the Mbire district, those who benefit from recession farming assist those that do not have access to floodplain fields by giving them food or having them work in their fields and paying with some maize grain. The benefits of the farming system are therefore for the majority of the inhabitants of Mbire district.

Farmers may not be realizing the full potential of recession farming within the community due to general low productivity (yields). Environment may not be the main limiting factor to crop productivity. There are opportunities for manipulation of plant genetic potential and agronomic practices to increase yields.

Recession farming could be allowed in some areas in which the costs associated with recession farming are low and the community depends on the system for food because of low rainfall and severe dry spells. The community can be taught how to use their natural resources in a sustainable and environmental friendly manner.

5.2 Recommendations

1. The Environmental Management Agency (EMA), should consider allowing the farmers to cultivate in the floodplains with the assistance of National Parks and Wildlife to help the farmers find ways to live with the animals

2. Experts in agriculture in collaboration with government to advise farmers to focus on high productivity for food security and enhance nutrition in the floodplains by ploughing legumes and let the rain-fed fields be used solely for income generation.

3. Further studies may be required to evaluate the impact of recession farming on other environmental aspects. Further research might be required to develop options for efficiently utilizing nutrients available to this farming system to increase productivity.

4. Further studies on the impact of recession farming on soil erosion.

5. Further studies on the potential of ecotourism.

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APPENDICES

7.1 Appendix 1: Household Questionnaire

The questionnaire collects information on the potential of recession farming in floodplains in Mbire district, how the environment is affected by the farming system and coping strategies to droughts and floods. Your responses will be treated with strict confidentiality.

Ward Name :

Ward Number :

Date of Interview :

Questionnaire Number :

Section A: General information

1. Household head Sex: M F ☐

2. Age:

Under 25	25-39	40-59	60-80	above 80

	1-3	4-6	7-10	above 10
3. What is the size of your household?				
4. How many bags of grain do you require in your household per annum?				

5. Does your yield sustain you to another season? Yes [1] No [2]

6. How many agricultural seasons do you make use of? 1 ☐ 2 ☐ other ☐

7. How long do the agricultural seasons stretch?

8. Do you own a field in the floodplains? Yes ☐ No ☐

How long have you owned the field? If no why?

SECTION B: Rain-fedagriculture

9.Crop	**Beans**	**Maize**	**Sorghum**	**Cotton**	**Groundnuts**	**Cowpeas**
What is the size of your rain-fed season field?						
What do you grow in the rain-fed season?						
How many bags do you normally get out of this season?						
Do you sell any of these crops?						
How much income do you get on average per season?						
What inputs do you use?						

SECTION C: Recession farming

10. Crop	**Beans**	**Maize**	**Sorghum**	**Cotton**	**Groundnuts**	**Cowpeas**
What is the size of your floodplain field?						
What do you grow in the recession season?						
How many bags do you normally get out of this season?						
Do you sell any of these crops?						
How much income would you get on average per season?						
What inputs do you use?						

11. What factors affect your yield?

Factor	**Rank**	**Enhance**	**Reduce**	**Season (rain/recession)**
Floods				

Dry spells				
Wild animals				
Pests				
Lack of inputs				

SECTION D: Other coping mechanisms and sources of livelihood

12. Do you own any livestock?

Type	**Cattle**	**Goats**	**Sheep**	**Pigs**	
Number					

13. What are your sources of income?

Source of livelihood	**Income per year ($)**					
	Below 100	**100 - 200**	**200-300**	**300 - 400**	**400 - 500**	**Above 500**
Formal Employment						
Informal Employment						
Livestock						
Remittance						
Recession farming						
Rain-fed agriculture						
Amount required for sustenance						

14. How would you rank your source of livelihood?

Source of livelihood	**Rank**
Recession farming	
Rain-fed agriculture	
Formal Employment	
Informal Employment	
Livestock	
Remittance	
Donors	

SECTION E: Environmental protection and hazards in the floodplains

15. What land preparation methods do you use? Plough Hoe Both

16. Do you use any form of fertilizer to improve your yields? Yes ☐ No ☐

17. If yes which one? Artificial ☐ Organic ☐

18. Are you aware of any environmental hazards that occur as a result of floodplain agriculture? If yes please explain.

Environmental aspect	**Rank**	**Explanation**
Water quality	1	
Siltation	2	
Soil fertility	3	
	4	
	5	

19. Do you know of any regulations that protect the integrity of floodplains? What are they?

20. Do you practice them? Give reasons.

21. Do you use any pesticides in the floodplains? Yes ☐ No ☐

22. If so which ones?

23. Are there any people in the community who enforce environmental protection?

Institution	**Rank**
EMA	1
RDC	2
AGRITEX	3
Community authorities	4
	5

SECTION D: FOOD CONSUMPTION SCORE

24. What have you eaten in the last seven days?

Item	Cereal	Cereal	Cereal	Cereal	Veget	Veget	Veget	Meat	Meat	Milk	Fruits	Pulses	Sugar	Oil
No. of times / week														

7.2 Appendix 2: Focus Group Discussion Question Guide

Ward Name :

Ward Number :

Date of discussion :

Description of group composition :

SECTION A: AGRICULTURE: Recession farming Vs. Rain-fed agriculture

1. What agricultural seasons do you have?
2. When do floods normally occur?
3. What variations occur in flooding times?
4. When do floods normally start receding?
5. How do you cope when floods recede earlier or later?
6. Which crops do you grow?
7. Do you change the type of crops you grow when flood recession periods change?
8. What farming conservation methods do you practice in the floodplain?
9. In your own opinion is recession farming more beneficial to you than normal season farming? Explain

Aspect	**Rain-fed**	**Recession**
Yield		
Crop quality		
Input		
Labour		
Fertility		
Vulnerability to floods		

Vulnerability to droughts		
Vulnerability to wild animals		

10. What factors affect your yield? Explain

11. Does your rain-fed yield sustain you to another season?

12. Does your yield recession yield sustain you to another season?

13. If not, how then do you cope? What are the available options?

14. Are there any differences in fertility and moisture content within the flooplains?

15. Do these differences result in differences in yield?

16. What are the reasons for any differences in yield?

17. Does this warrant differences in planting dates?

18. Which development options do you think may improve recession farming?

SECTION B: OTHER SOURCES OF LIVELIHOOD AND COPING STRATEGIES

19. Do you have any other source of livelihood?

Source of livelihood	**Income/ Food gain**	**When do you require them**	**Reliability**	**What can you say about it compared to recession farming?**
Livestock				
Formal employment				
Informal employment				
Remittance				
Donors				
Fruit gathering				

20. How do you cope with droughts and floods?

SECTION C: FLOODPLAIN AND ENVIRONMENTAL ASPECTS

21. What land preparation methods do you use? Plough ☐ Hoe ☐ Both ☐

22. Do you use any form of fertilizer to enhance yield? If yes which one? If no why?

23. Do you use any form of pesticides or herbicides? If yes which one? If no why?

24. Have you noted any changes in the environment that can be attributed to floodplain recession farming?

Environmental aspect	Changes
Water quality	
Siltation	
Soil fertility	

25. How can these changes be minimized or enhanced?

Environmental aspect	How to minimize or enhance changes
Water quality	
Siltation	
Soil fertility	

26. Are there any institutions that control recession farming or protect the environment?

27. What laws do they enforce concerning recession farming and the environment?

28. Are these followed? If no why?

7.3 Appendix 3: Key Informant Interview

Ward Name :

Ward Number :

Date of Interview :

Position of key informant :

SECTION A: General Information

1. How many households are in the ward?

2. How many households are registered as farmers?

3. How many agricultural seasons do farmers make use of?

4. How long does the agricultural seasons stretch?

SECTION B: RECESSION FARMING AS A COPING STRATEGY COMPARED TO RAINFED AGRICULTURE

5. How many farmers practice recession farming?

6. When do the floods normally recede?

7. Which crops are grown in the ward?

Crop	**Reason for choice**	**Average rainfedyield (per household/year)**	**Average yield per year recession(per household/year)**
beans			
Maize			
Sorghum			
Millet			
Cotton			
groundnuts			

8. In your own opinion is recession farming more beneficial to you than normal season farming? Explain

Aspect	Rain-fed	Recession	Other
Yield			
Crop quality			
Input			
Labour			
Fertility			
Vulnerability to floods			
Vulnerability to droughts			
Vulnerability to wild animals			

9. How often do floods occur in a year?

10. Which periods do they normally occur?

11. What factors affect your yield? Give estimates.

Factor	**Enhance**	**Reduce**	**Season (rain/recession)**
Floods			
Dry spells			
Wild animals			
Pests			

12. With the data that you have, do you think recession farming is beneficial to the villagers practicing it?

13. What advice do you render to farmers practicing recession farming?

14. Which development options do you think may improve recession farming?

SECTION C: ENVIRONMENTAL ASPECTS

15. How does flood recession farming affect the environment?

16. Have you noted any changes in the environment that can be attributed to floodplain recession farming?

Environmental aspect	Changes
Water quality	
Siltation	
Soil fertility	

17. Are there any institutions that control recession farming or protect the environment?

18. What laws do they enforce concerning recession farming and the environment?

19. Are they followed?

20. If not what are the reasons for not abiding to the laws and regulations?

21. What role do you have in enforcing these laws?

SECTION D: OTHER SOURCES OF LIVELIHOOD AND COPING STRATEGIES TO FLOODS AND DROUGHTS

22. What other source of livelihood exists in the ward?

Livelihood	Income	Food
Formal Employment		
Informal employment		
Hunting		
Livestock raring or sale		
Donors		

24. Which development options do you think may improve the livelihood of this community?

7.4 Appendix 4: Farmer's management practices questionnaire

The questionnaire collects information on the farm management practices in floodplains in Mbire district. Your responses will be treated with strict confidentiality.

Field number :

Ward Number :

Date of Interview :

Questionnaire Number :

1. When do you normally plant your crops?
2. How do you know the best planting time?
3. How often do you weed?
4. How do you control pests?
5. Do you apply any form of fertilizer to your field? Yes ☐ No ☐
6. If yes which type
7. What do you do to enhance our yield?