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THE ROLE OF INDIGENOUS KNOWLEDGE SYSTEMS IN COPING WITH FOOD SECURITY AND CLIMATE CHALLENGES IN MBIRE DISTRICT, ZIMBABWE

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In collaboration with

THE ROLE OF INDIGENOUS KNOWLEDGE SYSTEMS IN COPING WITH FOOD SECURITY AND CLIMATE CHALLENGES IN MBIRE DISTRICT, ZIMBABWE

by

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

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DECLARATION

I, **Patience Alvera**, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Integrated Water Resources Management (IWRM) of the University of Zimbabwe. It has not been submitted before for examination for any degree in any other University.

Date: ____________________

Signature: _____________________

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LIST OF ABBREVIATIONS

AGRITEX	Agricultural Research and Extension Services
AWF	Africa Wildlife Foundation
AN	Above Normal
BN	Below Normal
CCCM	Climate and Carbon Cycle Modeling model
ENSO	El Nino Southern Oscillation
FAO	Food and Agricultural Organisation
GDFL	Geophysical Fluid Dynamics Laboratory model
FGDs	Focus Group Discussion
IKS	Indigenous Knowledge Systems
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
JFM	January February March
LGDA	Lower Guruve Development Association
MDG	Millennium Development Goals
MSD	Meteorological Services Department
SADC	Southern African Development Community
SARCOF	Southern Africa Regional Climate Outlook Forum
SCF	Seasonal Climate Forecasts
SPSS	Statistical Package for Social Sciences

DEDICATION

This piece of work is dedicated to my husband Matthew, son Matthew Ishemunopa and daughter Mutsawashe Pearl for their love and patience.

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ABSTRACT

Agriculture is the main form of livelihood in the Mbire District of Zimbabwe. The district lies in Natural Region IV and the average rains are 650 mm per year and experiences frequent droughts and floods. Weather forecasting is done by the Meteorological Services of Zimbabwe and information is issued in the form of seasonal climate forecasts (SCFs) which are based on probabilities and rainfall amounts, not distribution and referring to large spatial scales. On the other hand, indigenous knowledge which has been gained through a long period of observation of the environment by local people is site specific, cheap and can fill in the gaps that are left by scientific forecasting. The objectives of the research were to identify the different indigenous knowledge indicators used in the district, comparing the SCF and IKS for the 2012/13 rainfall season and the role IKS can play in ensuring food security in a changing climate.

A total of 181interviews, 5 focus group discussions and 7 key informant interviews were used to collect data in Ward 9, 10 and 12 of Mbire District from March to June 2013. Analysis of data was done using SPSS and Microsoft Excel statistical packages. Qualitative data was analyzed using the thematic approach. IKS of weather forecasting is well known in the area; with 93% of the respondents having some knowledge of it. Of all the respondents, 54% found IKS more reliable than SCFs. For the 2012/13 rainfall season, 42% predicted that normal rains were going to fall using IKS. SCFs forecasted normal/ above normal rains and this forecast were true but the district was not food secure due to uneven rainfall distribution which caused poor yields. Although IKS is widely known, only 14% of the small scale farmers used it to plan their agricultural activities. Use of IKS as the sole weather forecasting system is low. Both IKS and SCFs can be integrated together to provide forecast information to farmers and improve food security in the Mbire District. The reliability of both IKS and SCFs is being affected by changing weather patterns, like the late starting of the rains and noticeably shorter rainy seasons.

Validation of indigenous knowledge against scientific knowledge should be done over a long period of time, capturing normal, below normal and above normal seasons. There is a need to document IKS and young people need to be taught about it as this form of knowledge currently belongs to older people (age> 55) who have been observant of the environment. Both systems should be integrated in order for farmers to make informed decisions which will make them more food secure.

KEY WORDS: Food security, Indigenous Knowledge Systems, reliability, Seasonal climate forecasts, weather forecasts, climate change.

1. INTRODUCTION

1.1 Background

The climate of Africa is warmer than it was 100 years ago and changing climate will place additional stresses on water resources, whether or not future rainfall is significantly altered (Hulme *et al.*, 2001). Climate change could reduce total agricultural production in many developing countries by up to 50% in the next few decades, particularly South Asia and sub-Saharan Africa (Hoffmann, 2011). A large fraction of Africa's crop production depends directly on rainfall, for example, 89% of cereals in sub-Saharan Africa are rain-fed (Cooper, 2004). Rainfall is highly variable in Africa and it is important to have a reliable forecast so as to enable farmers, of whom the majority are small-scale, to plan types of crops that produce a good yield under the forecast conditions.

Speranza (2009) states that the problem of climate variability and change needs to be addressed from various angles and using different methods in order to achieve effective mitigation and adaptation and one such angle is how indigenous knowledge (IK) could contribute to climate change monitoring, mitigation and adaptation. Currently, science is unable to predict reliably either duration or distribution of seasonal rainfall, but the integration of scientific forecasts with indigenous knowledge might allow some inferences in this regard (Roncoli *et al.*, 2002). Seasonal forecasts are probabilistic and rainfall is often forecast as the chance of being 'above normal', 'below normal' or 'near normal'. The 'normal' amount of rainfall is the middle third of the average rainfall for the past number of years of rainfall data used to develop the forecast (Agrawala *et al.*, 2001). The forecast is usually issued for a period of one, three or six months and suggests the total amount of rainfall expected over that period, but not the distribution of rainfall within that period (Githungo *et al.*, 2009). If the amount of rainfall forecast were to fall over a few days, the seasonal forecast would still be correct but the impact on agriculture could be catastrophic (Agrawala *et al.*, 2001).

Modern forecasts are made at very low spatial resolutions; focus is on rainfall amounts rather than on the timing of the rains, which is of greatest importance to the farmers.

Studies show that indigenous knowledge could contribute to fill gaps in formal seasonal forecasts, which are largely at broader spatial and temporal scales and focus on rainfall amounts rather than on the timing of the rains (Luseno *et al*., 2003). According to Warren *et al.* (1995), evidence shows that local knowledge can and must be integrated with research-generated information and technology in efforts to improve rural livelihood.

Manatsa (2012) notes that in Zimbabwe, forecasts issued by the Meteorological Services Department through the Southern African Regional Climate Outlook Forum (SARCOF) process generally had limited application value to farmers. This calls for need to investigate and integrate other options like indigenous knowledge systems (IKS). The use of IKS in weather forecasting has been explored by several authors (Muguti and Maposa, 2012; Risiro *et al.*, 2012; Makwara, 2013) in the Mberengwa, Zaka and Chimanimani Districts and small scale farmers were found to be rich in IKS (92%) (Makwara, 2013). In Mbire District, Zimbabwe, the main livelihood activity is rain-fed agriculture. High rainfall variability, frequent droughts, floods and severe dry spells are a common occurrence in the Mbire district and these factors reduce yields and increases food insecurity (Bosongo, 2011).

1.2 Research problem

Rain-fed agriculture is the main source of livelihood in Mbire District, Mashonaland Central Province, Zimbabwe. A combination of high dependence on rainfed agriculture while rainfall is highly variable with recurrent droughts and floods leaves the community vulnerable to food shortages (Muhonda, 2011). Rainfall is variable, and frequency of mid season dry-spells has increased during the cropping season. For the period 1988 to 2011, rainfall had a coefficient of variation of 162% (Bosongo, 2011), resulting in yields being significantly reduced. Food security remains a challenge in the district because of drought which occurs at least 5 out of every 10 years (LGDA, 2009).

The farmers in the Mbire District do not have a reliable form of forecast and this makes planning a challenge, often resulting in poor harvests even when normal rainfall is received. The Meteorological Services Department, through the SARCOF process, is responsible for issuing seasonal weather forecasts. These forecasts are given over large spatial scales and focus on rainfall amounts only, not taking into account intra-seasonal variability. These forecasts may not be accurate all the time because of their probabilistic nature (Agrawala *et al.*, 2001). The extent to which indigenous knowledge is used in forecasting weather in the Mbire District is not known. The indigenous knowledge is in danger of being lost because it is the elderly who possess it and has not been recorded, but merely passed from one generation to the other orally.

1.3 Objectives

1.3.1 Main objective

The main objective is to identify indigenous rainfall indicators and how they can help in seasonal rainfall forecasting and improving food security in the face of changing climatic conditions in the Mbire District.

1.3.2 Specific objectives

1. To identify indigenous knowledge indicators for weather forecasting used in the Mbire District
2. To compare the usefulness of traditional and scientific weather forecasting methods for the 2012/13 season in the Mbire District
3. To establish the role of indigenous knowledge systems in food security under changing climate conditions in the Mbire District.

1.4 Research questions

1. What are the indigenous knowledge weather indicators in the Mbire district?
2. How does IKS of weather forecasting compare with seasonal climate forecasts in the Mbire District?
3. What is the role played by indigenous knowledge in ensuring food security in the Mbire District?

1.5 Scope and limitations of the study

This study seeks to establish the role that IKS can play in weather forecasting to help ensure food security in the Mbire District. It identifies the various biotic and meteorological indigenous knowledge indicators for normal and drought seasons. It compares IKS and SCFs for the 2012/2013 season. Validation of indicators is not covered in this study. For validation of indigenous knowledge of weather forecasting against scientific data to be conclusive, a number of seasons are supposed to be studied to capture indicators for the normal, drought and above normal seasons. In this study, field observations were supposed to start in winter up to the time of harvests, but due to financial limitations, observations before the start of the season where not possible. Entry to the field for data collection purposes was only possible in March 2013. By this time, the crops had almost reached maturity stage and the researcher could only rely on what the respondents were saying.

1.6 Outline of the thesis

This thesis report is presented in five chapters. Chapter 1 introduces the report and looks at the background of the study, research questions, specific objectives, problem statement and scope of the research. Chapter 2 reviews the related literature on scientific weather forecasting, indigenous knowledge systems of weather forecasting, various indicators used in weather prediction and impacts of climate change on food security. Related researches elsewhere in Africa about possible integration of seasonal climate forecasts and indigenous knowledge are also presented. The third chapter describes the general characteristics of the study area such as climate, vegetation; demographics, location as well as the various methods used to collect and analyze the data. Chapter 4 presents data analysis, results of the study and discussions. The final chapter of this report is on conclusions that can be drawn out of the research and the recommendations.

2. LITERATURE REVIEW

2.1 Climate change and variability: Impacts on the whole world

The Intergovernmental Panel on Climate Change (IPCC, 2007) proclaims that there is now little doubt that human-induced climate change is happening. The Third Assessment Report (IPCC., 2001b) of the IPCC projects that some areas that are currently dry might experience an average increased dryness with global warming. The IPCC (2007) also reports that variability is also expected to increase with more rain falling in intense-rainfall events, larger year-to-year variations in precipitation in areas where increased mean precipitation is projected. While some countries in the temperate zones may reap some benefit from climate change, many countries in the tropical and sub-tropical zones appear more vulnerable to the potential impacts of global warming (Rosenzweig and Parry, 1994). Warming in the Indian Ocean and an increasingly "El Nino–like" climate could reduce main-season precipitation across parts of the Americas, Africa, and Asia (Brown and Funk, 2008).

High yield improvements in Northern Europe are caused by lengthened growing season, which decreases cold effects on growth and extends the frost-free period. Crop productivity decreases in Southern Europe is caused by a shortening of the growing period, with subsequent negative effects on grain filling. Concerning the 2020s, all European regions would experience yield improvements, particularly in Northern Europe, with the exception of some areas in central Europe South and Southern Europe, with The EU overall yield gain would be 17% (Ciscar *et al.*, 2009). In Asia, the IPCC (2007) projected that crop yields could increase by up to 20% in South-East Asia while they could decrease by up to 30% in the central and southern parts of Asia by the mid 21st century. Taking into account the rapid population growth and urbanization, the risk of hunger is projected to remain high. Consistent with global trends, Australia has warmed 0.8^{o}C over the last century with minimum temperatures warming faster than maxima. There have been significant regional trends in rainfall with the northern, eastern and southern parts of the continent receiving greater rainfall and the western region receiving less with rainfall being associated with an increase in the number of rain days and heavy rainfall events (Hughes, 2003). South American drier areas, climate change is expected to lead to salinization and desertification of agricultural land. Changes in precipitation pattern and disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation (IPCC, 2007). Moderate climate change in the early decades of the twentieth century in North America is projected to increase aggregate yields of rain fed agriculture by between 5-20%, but with important variability among regions (IPCC, 2007).

Recent warming has affected terrestrial biological systems, including such changes as earlier timing of spring events like leaf unfolding, bird migration and egg-laying, pole ward and upward shifts in ranges in plant and animal species. Based on satellite observations since the early 1980s, there is high confidence that there has been a trend in many regions towards earlier 'greening' of vegetation in the spring linked to longer thermal growing seasons due to recent global warming (IPCC, 2007). Agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of the growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yield from rain fed agriculture could be reduced by up to 50% by 2020 (IPCC, 2007).

2.2 Impacts of climate change in Southern Africa

The projected impacts of climate change for Africa do indeed hold the potential to cause food and water supplies to become more unreliable, and to increase the frequency and severity of droughts, storms and flooding in low-lying coastal areas. In turn, livelihoods may be undermined, key resources may become scarcer, and an overall decline in the quality of life may result (Brown *et al.*, 2007). Research that explores responses and adaptation to global environment change should be a high priority in southern Africa, where the climate is highly variable and is likely to become more variable and extreme in the future (Ziervogel and Calder, 2003). Rainfall patterns will shift as the hydrological cycle becomes more intense. Annual rainfall is likely to decrease throughout most of the region, with the exception of eastern Africa, where it is projected to increase (Brown *et al.*, 2007).

Burton (2001) estimates that in Africa ,south of the Sahara expected impacts in dry land areas include reduction in rainfall, rise in temperature, and increased rainfall variability. Highland areas are expected to benefit, since the growing season would be lengthened and the incidence of frost diminished. In contrast, other, more sub humid zones, such as Burkina Faso, Mali and Ghana are expected to suffer from reductions in rainfall (Kurukulasuriya and Rosenthal, 2003).

2.3 Food security

2.3.1 Food security in Africa

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). The four pillars of food security are availability, access, utilization and stability (FAO, 1996). Armah *et al.* (2013) notes that Africa keeps falling in and out of food crises and food insecurity, causing serious hardships both social and economic for many countries and communities. Africa is worse off than the rest of the world, scoring highly on the Global Hunger Index and recording low production (Armah *et al.*, 2013). The first millennium development goal **(**MDG 1) is to eradicate extreme poverty and hunger and Zimbabwe is one of those countries that are not able to meet this goal. It is estimated that for the 2013/14 consumption season, Zimbabwe will face a cereal deficit of 870, 000 metric tonnes due to a poor rainfall season (ZimVAC, 2013).

2.3.2 Impacts of climate change on agriculture

Climate is the primary determinant of agricultural productivity (Adams *et al.*, 1998). In many parts of Africa, climate is already a key driver of food security (Clover, 2003; Gregory *et al.*, 2005). Temperature and precipitation are the climate variables most critical to measure with regard to food systems. Not only does the range between high and low values matter, but also the frequency at which these extremes occur and the intensity of the events. Climate change may affect food systems in several ways ranging from direct effects on crop production (e.g. changes in rainfall leading to drought or flooding, or warmer or cooler temperatures leading to changes in the length of growing season), to changes in markets, food prices and supply chain infrastructure (Gregory *et al.*, 2005).

African agriculture is already under stress as a result of population increase, industrialization and urbanization, competition over resource use, degradation of resources, and insufficient public spending for rural infrastructure and services (Ludi, 2009). Climate change is also going to affect food production directly through changes in agro-ecological conditions and indirectly by affecting growth and distribution of incomes, and thus demand for agricultural produce. Shifts in land suitability are likely to lead to increases in suitable cropland in higher latitudes and declines of potential cropland in lower latitudes (Ludi, 2009). Agriculture in the semi-arid regions of Africa is based on small-scale, climatically vulnerable systems where livestock is an important multi-purpose component of farming systems (Challinor *et al.*, 2007). Climate-related shocks manifested by extreme weather conditions have destroyed livelihoods and exacerbated Africa's food insecurity, resulting in a high incidence of underweight children, widespread hunger and poor dietary consumption (Armah *et al*., 2013).

Nelson (2004) states that climate affects all facets of rural life, including income and food security, and often exacerbates environmental degradation, with downstream effects on national economies. In southern Africa, although many households depend on rain-fed agriculture for their food needs, it is often considered a risky enterprise with low returns (Ziervogel and Calder, 2003). Food insecurity is likely to increase under climate change, unless early warning systems and development programs are used more effectively (Brown and Funk, 2008). The issue of food security is directly linked to climate change and variability, however, weather is not the single determinant of yield, nor is the physical environment the only decisive factor in shaping food security.

Using climate data from four agro-ecologically representative stations in Zimbabwe, (Makadho, 1996) based his analysis upon two climate change models, the Geophysical Fluid Dynamics Laboratory model (GDFL) and the Climate and Carbon Cycle Modeling Group model (CCCM). Under both irrigated and non irrigated conditions, in some regions maize production is expected to decrease significantly (by approximately 11–17 percent). Increments in temperature that shorten the crop growth period, especially the "grain-filling period," are underlined as the primary cause of the crop reductions. Downing (1992) also confirms that shifts in agro-climatic potential would affect national food production and land use in Zimbabwe. Farmers in semi-extensive zones which are particularly sensitive to changes in climate are already vulnerable in terms of self-sufficiency and food security, and they are expected to be further marginalized due to increased risk of crop failure (Kurukulasuriya and Rosenthal, 2003).

Table 2.1.Impacts of climate change on crop yields for selected crops in Africa

Region	***Crops***	***Crop response tool***	***Yield impact***	***Comments***	***Reference***
Africa	Cereals	FAO method with monthly data	-35M tons for 29 countries and+30Mtons for 17 countries	For 29 countries	Fisher *et al* (2001)
Africa	Maize and millet	Various methods	-98 to+16 -79 to +14	Range is across sites and climate scenarios	Reilly and Schimmel pfennig(1999)
Africa	Cereals	Yield transfer functions	-10 to +3	Range across sites and climate scenario, includes adaptation	
Zimbabwe	Maize	CERES crop model	-14 to+12	Two doubled CO_2 climate scenarios	Smith et al (1996)
Zimbabwe	Maize	CERES crop model	-17	HadCM2 2040-2069 Downscaled to 10 min of arc by interpolation	Jones and Thornton (2003)

Adapted from (Challinor *et al.*, 2007)

2.4 Weather forecasting

2.4.1 Seasonal forecasting

Weather information is usually given as seasonal forecasts, which can be described as the total amount of rainfall expected during the season or over a given time period (Ziervogel and Calder, 2003). Inter-annual variability in southern Africa is largely influenced by the El Nino Southern Oscillation (ENSO) phenomenon. ENSO refers to a coupled atmospheric system that links change in atmospheric pressure and sea temperature over the southern Pacific Ocean. El Nino is the extensive warming of the upper ocean in tropical Pacific, increasing rainfall in the eastern Pacific and decreasing rainfall over the western Pacific, as well as southern Africa (Philander, 1989; Nicholson and Selato, 2000; Mienke and Stone, 2005). Most rain in southern Africa is brought by the Inter-tropical Convergence Zone (ITCZ), which is a region characterized by much convection activity resulting in rainfall during summer months (O'Brien and Vogel, 2003). The probability of specific weather regimes is affected by underlying boundary conditions such as sea surface temperatures, ice cover and land-sea characteristics. These boundary conditions generally evolve slowly, and so can be used to provide a forecast of different weather regime probabilities (Mason *et al.*, 1996).

The emerging ability to probabilistically forecast future seasons in terms of climate and its consequences on agricultural systems has started to influence decision making on many levels and the potential benefits are substantial (Mienke and Stone, 2005). Currently, seasonal forecasts are being used and these are either empirical or physical model based. The reliability and potential utility of this information varies according to geographical region, that is, the area’s position in relation to oceanic atmospheric circulation, and according to the political, economic, and social context that shapes its dissemination and application (Orlove and Tosteson 1999; cited in (Roncoli *et al.*, 2002)). The forecasts are issued in terciles i.e. below normal (BN), normal.(N) and above normal (AN) with the probability of rainfall being in each of three categories as the forecast (Masinde and Bagula, 2012).

2.4.2 Seasonal weather forecasting in Zimbabwe

Climate forecasts are issued annually through the southern African regional climate outlook forum (SARCOF) process. SARCOF is a regional seasonal weather outlook prediction and application practice adopted by the southern African development community (SADC) that produces a consensus forecast for the sub-region. The current format of seasonal rainfall forecasts based on the SARCOF procedure started to be developed and issued in 1997. The seasonal forecasts which are expressed in terciles of any two consecutive combinations of above normal (AN), near normal (N), and below normal (BN), are issued in September. These forecasts provide probabilistic information on future climate of time scales of three to 6 months, hence covering the first and second half of the rainfall season, October, November, December (OND) and January, February, March (JFM) respectively (Manatsa *et al.*, 2012). Normal (N) is when an area receives between 75% and 125% of its long term average in a sub-season (OND or JFM). Below normal (B) is when an area receives below 75% of its long term average for the sub-season. Above normal (A) is when an area receives more than 125% of its long term mean for a particular sub-season (MSD, 2012).

2.4.3 Interpreting a weather forecast

The seasonal forecast for any region is given in terms of possibilities of each of the categories B, N and A occurring expressed as percentages. The category with the highest percentage will be the most favoured by the forecast. The probabilistic approach implies that the other categories may also be experienced and should not be ignored even though less likely (MSD, 2012).

2.4.4 Importance of weather forecasting

Seasonal climate forecasting can increase preparedness and lead to better social, economic and environmental outcomes within agricultural production systems. There are several farm-level decisions such as the choice of cropping pattern, whether to invest in fertilizers, pesticides, the choice of the period for planting, plant population density for which the appropriate choice (associated with maximum production or minimum risk) depends upon the nature of the rainfall variability or the prediction of climatic variables for a specific year (Githungo *et al.*, 2009). Seasonal climate forecasts, in principle, provide opportunity for farmers to adopt improved technology, intensify production, replenish soil nutrients and invest in more profitable enterprises when climatic conditions are favourable; and to more effectively protect their families and farms against the long-term consequences of adverse extremes (Vermeulen *et al.*, 2010).

Crop production in Zimbabwe is predominantly rain-fed and seasonal rainfall is highly variable, making crop failure due to rainfall extremes common (Martin *et al.*, 2000) . Improvement of the advance warning systems of rainfall extreme events should be of high priority, especially considering the resource poor farmers, who are the most vulnerable group of the southern African region (Manatsa *et al*., 2012). The most useful forecast information, according to the farmers, are the early warning on anticipated poor season, the commencement of the season and adequacy of anticipated rains (Phillips, 2001). The probabilistic nature of the forecast requires that the forecast product is well understood. This is critical in order to prevent the forecast being misinterpreted as a deterministic forecast that will lose credibility if the observed rainfall is not the same as the forecast (Ziervogel and Calder, 2003). Droughts are the most common type of natural disaster in Africa and the problem is compounded by their complexity. The agriculture sector still forms the backbone of most economies in Africa, with 70% of output being derived from rain-fed small-scale farming; this sector is the first casualty of droughts. Accurate, timely and relevant drought predication information enables a community to anticipate and prepare for droughts and hence minimize the negative impacts (Masinde and Bagula, 2012). Luseno (2003) suggests that indigenous climate forecasting methods can offer insights to improving the value of modern seasonal forecasts for pastoralists in East Africa as indigenous forecasting methods are need driven, focus on the locality, on the timing of rains, and indigenous forecasts are 'communicated in local languages and typically by "experts" known and trusted by pastoralists'.

2.4.5 Limitations of seasonal climate forecasts

Seasonal climate forecasts are normally issued for relatively large homogeneous rainfall regions (over 9,000 km^2) extending over three month period, making demarcation difficult for users located on the border line of the forecast spatial coverage since the forecast changes drastically each time (Githungo *et al.*, 2009). Furthermore there is a mismatch between farmers' needs and the scale, content, format, or accuracy of available information products and services. These factors have limited the widespread use of seasonal forecasts among smallholder farmers (Vermeulen *et al.*, 2010).

In a study carried out by Manatsa *et al.*(2012) in Chiredzi district, farmers expressed great concern regarding the seasonal rainfall forecasts and were very skeptical of the value of these forecasts resulting in a very low rate of utilization (17%) among local smallholder farmers, The forecast skills are not only very low, but also heavily biased towards normal conditions with high confidence of the forecast is persistently in the near normal range, but this confidence is never attributed to drought forecasts resulting in above normal rainfall events being rarely forecasted and droughts never in forecast. Manatsa *et al.*, (2012), also noted that climate variability over short distances inherent in the Chiredzi area, even within villages, reduces the utility of forecast information, especially when provided at the current, national scale.

The length of the season is very vaguely implied in the forecast, if defined at all, explaining the absence of the definition of other intra-seasonal variations in the forecast information, such as the distribution of both wet and dry spells, including their spatial distribution (Githungo *et al.*, 2009; Manatsa *et al.*, 2012). Various studies on uptake of seasonal climate forecasts that have been done in Zambia, Zimbabwe, Kenya and Tanzania, and it has been found that it's hard for farmers, chiefs and agricultural extension officers to interpret forecast information given in probabilities and know how to respond to them (IDRC, 2010).

Forecasts are generally grouped into three groups

1. Those forecasting the next few days -Weather forecasts
2. Those forecasting the next few months-Seasonal climate forecasts
3. Those projecting the climate in the years to come -Long-range climate forecasts (Blench, 1999). Accuracy of a forecast depends on lead times used in the forecast. The longer lead times renders the forecast less accurate.

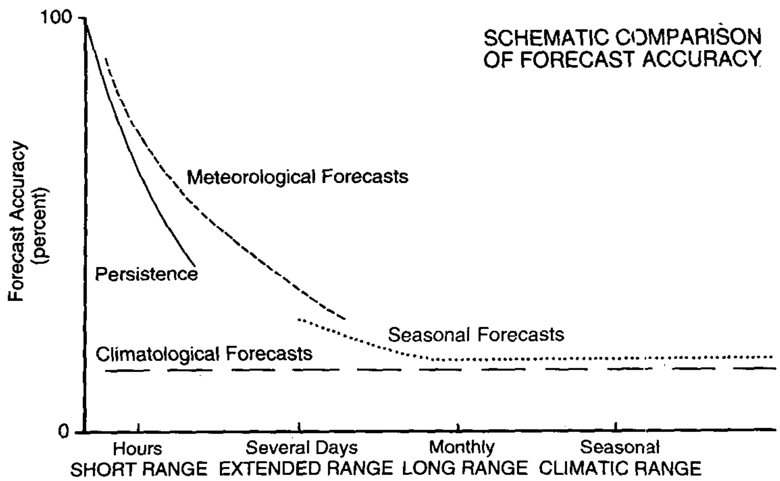

Figure 2.1. A schematic comparison of forecasting accuracy using various forecasts type. Adapted from (Mason *et al.*, 1996)

Field studies on the impact of recent forecasts in southern Africa indicate that there is a considerable gap between the information needed by small-scale farmers and that provided by the meteorological services (Blench, 1999).

2.5 Indigenous knowledge of weather forecasting

2.5.1 Definition and characteristics

Indigenous Knowledge Systems (IKS) is a body of knowledge or bodies of knowledge of the indigenous people of a particular geographical area that have survived on for a very long period of time (Mapara, 2009). According to Mugabe (2010) , the local weather and climate is assessed, predicted and interpreted by locally observed variables and experiences using combinations of plants, animals, insects and meteorological and astronomical indications. (Anandaraja *et al.*, 2008) states that indigenous knowledge systems are dynamic, changing through indigenous mechanisms of creativity innovativeness as well as through contact with other local international knowledge systems.

IKS has a number of characteristics, some of which are (1) local or specific to a particular geography or micro-environment or ecosystem and folk people living there close to nature, (2) orally transmitted, (3) outcomes of informal experiments, intimate understanding of nature, and accumulation of generation-wise intellectual reasoning of day-to-day life experiences, generation-wise intellectual reasoning tested on "religious laboratory of survival", (4) originated through interactions and not at individual level, (5) empirical rather than theoretical or any abstract scientific knowledge, (6) functional or dynamic and hence constantly changing, discovered, lost and rediscovered in a new form (open-ended IK), (7) culturally embedded (close-ended) where separating the technical from non-technical, rational to non-rational is problematic, (8) repeating with time (as because IK is both cultural and dynamic), (9) segmented into social clusters or asymmetrically distributed within a population, by gender and age, (10) shared by many and even by the global science (Ellen and Harris, 1996).

2.5.2 Use of IKS

Farmers pragmatically mix traditional farming knowledge with advice they get from agricultural extension workers, local technology with development innovations. Even in the case of local forecasting knowledge, farmers are used to combining a variety of environmental observations and spiritual traditions (Roncoli *et al.*, 2002). In the Makueni district in Kenya, agro-pastoralists usually derive indigenous knowledge based forecasts for an upcoming season just before the beginning of the farming season. As the season progresses, they acquire additional information through direct observations but can complement this by consulting other local sources. Thus many holders of IK also have access to other forms of knowledge or information sources. Agro-pastoralists also use the same signs from local weather patterns, state of flora and fauna, constellation of stars as well as features from the physical environment, such as the amount of snow on Mt. Kilimanjaro, to forecast the nature of rains in a season (Speranza *et al.*, 2009).

2.5.3 Indigenous weather forecasting prediction indicators

Indigenous weather prediction is based on a number of indicators, ranging from atmospheric conditions, biotic (plant phenology and animal behavior) to astronomic features. Other indicators like early or late onset of rains can also be used to tell the nature of that particular rainy season. In a study carried out by Roncoli *et al.*, (2002) in the Boman region of Burkina Faso, it emerged that subsistence farmers rely on traditional indicators for their forecasts and in 1998, farmers correctly predicted a good rainfall season using the early onset of the rainy season as an indicator.

2.5.4 Biotic indicators

(i)Plants

Fascinating facts in western countries have been recorded for dandelions (*Taraxacun officionale*), wild indigo (*Baptisia australis*) and tulips (*Tulipa gesneriana*), all of which fold their petals prior to rain (Acharya, 2011). In a study carried out by (Risiro *et al.*, 2012) in the Chimanimani district on the eastern part of Zimbabwe, the authors noted that a variety of biotic indicators are used to predict weather changes. Some plants like *msasa (Brachystegia spiciforms)* and *mnondo (Julbernardia globiflora)*, change their morphology with season, they lose leaves in the dry season and as the rainy season approaches they grow new leaves. Abundance of fruits from trees such as *mazhanje (Uapaca kirkiana)* and *hacha (Parinari curatellifolia)* signaled drought in the coming season. Makwara (2013) argues that few fruits could be as a result of windy conditions which often precede the rainy season may shake off flowers hence fewer fruits. In the Makueni District in Kenya, Speranza (2009) noted that indicators from flora can be in terms of tree conditions, unusual flowering of certain trees *Dombeya burgessiae/kirkii*, non-flowering ,e.g. *Acacia* flowering too little or too much. If trees produce many fruits (unusual production) then the following season will be affected by drought. Indicators can also be in form of timing, for example, the late flowering of *Acacia*. In the Ismani and Mahenge wards in Tanzania, dense flowering of mango trees (*Mangifera indica*) and Mikuyu (*Ficus ssp*) is an indicator of an oncoming drought season (Kijazi, 2012).

(ii)Animals, birds and insects

The sounds animals produce before the onset of heavy rainfall is a type of warning because storms and thunder generate sound waves at those frequencies and also a matter of changes in barometric pressure. It is now speculated that animals may be responding to the subtle variations to the earth's electromagnetic field that happen prior to extreme events like tornadoes. Other studies also suggests that animals may be reacting to ultrasound or micro temblors not significant enough to be picked by humans (Acharya, 2011). If there is a swelling on the lower portion of the camel's legs then rainfall is predicted by the farmers, swellings are probably caused by higher relative humidity (FAO, 1998).

The Fulani herdsmen of Burkina Faso who pasture animals in uncultivated areas watch the nesting of a small quail-like bird in the early rainy season and believe that when nests hang high on trees then rains will be heavy, when nests hang low rains will be scarce (Roncoli *et al.*, 2002).In Australia, when the lapwing bird (*Tatihari*) lays its eggs on the upper part of the field then good rains are expected and poor or no rains when it lays eggs on the lower part of the field. It is further believed that if it lays one egg then rains will fall for one month and two eggs imply that rains will fall for two months (FAO, 1998). Shoko (2012) found out that the highest ranked bird indicators were the ground hornbill and the rain cuckoo, termites, cicadas and frogs were ranked 1, 2 and 3 respectively in the Mberengwa district, showing that these where the most utilized indicators. Some small creatures such as millipedes and frogs are mostly seen at the beginning of the rainy season. The arrival of migratory birds indicates the approach of the summer season (Risiro *et al.*, 2012).

2.5.5 Atmospheric weather forecasting indicators

Although local people do not measure and record climatic data like in formal climate monitoring, through observation based on life long experience in their area, they can predict the average onset dates for rainfall, and a delay in onset for them is already an indicator that the season might not bring adequate rainfall (Speranza *et al.*, 2009). Several authors (Kihupi *et al.*, 2003; Speranza *et al.*, 2009; Kijazi, 2012; Risiro *et al.*, 2012) note that indigenous knowledge indicators from local weather range from temperature, humidity and wind conditions, the presence or absence of certain types of clouds, rainfall patterns and amounts. It is interesting to note that these weather indicators are also used in formal climate monitoring (Luseno *et al.*, 2003). The most widely relied upon indicators are the timing, intensity and duration of low temperatures and wind characteristics during the early part of the dry season from May to August (Makwara, 2013). In Manicaland province in Zimbabwe people know that when wind blows from the eastern side bordering Mozambique, then the rain season is just ‘around the corner’ and if the wind is continuous, it ‘tells’ that more rains would come. In Masvingo province, people can predict rainfall patterns out of the southern blowing winds (Muguti and Maposa, 2012).

People can predict weather by observing the visible spectrum (halo phenomena) around the sun or moon. If the spectrum around the sun had a greater diameter than that around the moon, they predicted rainfall after a day or two. The accuracy of this indigenous observation can be as high as 50 per cent (FAO, 1998). Speranza *et al.*, (2009) noted that astrological constellations, such as the position of the sun and moon are also interpreted for the upcoming season by agro pastoralists. The appearance of the stars in the sky could be used to predict seasons. The Milky Way changes its position in accordance with seasons and sun /moon halo appearance was regarded as a good indicator of coming rains within two weeks (Risiro *et al.*, 2012).

2.5.6 Challenges of using IKS

In spite of all the usefulness of IK in weather and climate prediction, a number of researchers, (Githungo *et al.*, 2009; Kijazi *et al.*, 2012; Makwara, 2013) bemoan that the art of indigenous weather forecasting is under threat of disappearing due to lack of systematic documentation of the knowledge and lack of coordinated research to investigate the accuracy and reliability of IK forecasts. Although IKSs are localized and more adapted to the farmers' context, this knowledge is threatened by phenomena such as climate change, population growth and urbanization (Masinde and Bagula, 2012).

The challenge in using IKS is what is considered to be a bench mark (normal). Therefore, it is imperative that more research be conducted to quantify the norms (Makwara, 2013). Just how many fruits, flowers and butterflies are considered to be 'many' ,' normal' or 'too little' is not actually defined by numerical values which are used by scientific methods. A number of documenting exercises have been done, but only a few existing studies on the contributions of IK to climate change research show that IK and science can complement each other (Luseno *et al.*, 2003). Indicators used in weather prediction are localised and communication is mostly oral, limiting the applicability of IKS over large areas (IDRC, 2010).

2.5.7 Integration of IKS and SCFs

Both IKS and SCFs have strengths and weaknesses and the major challenge is how to bring these two forms of knowledge together in a way that respects their values, while building upon their respective strengths (IDRC, 2010). Forecasts maybe more useful if ways are found to integrate local knowledge, which has enabled generations to live through severe floods and droughts into current management decision making strategies (Kihupi *et al.*, 2003). Kihupi *et al.,*(2003) further implores that if factors such as humidity, temperature and wind speed are responsible for changes observed or perceived by local people, then meteorological data from individual stations can be summarized into a mean value correlating with a derived index.

Table 2.2 comparison between SCFs and IKS

Indigenous Knowledge Systems	**Seasonal Climate Forecasts**
Use of biophysical indicators and the environment	Use of weather and climate models of measurable meteorological data
No documentation of forecasts	Well documented and developed forecasts
Up-scaling and down-scaling are complex	Up-scaling and down-scaling relatively simple
Indicators are seen/observed and not quantified	Indicators are measureable
Communication of information oral	Written communication
Explanations are based on social and spiritual values	Theoretical explanation
Taught by observation and experience	Taught through lectures and readings

Adapted from IDRC, 2010

Some critics have argued that current climate forecasts and the way they are presented and disseminated are at best ineffective, while at worst they can increase risk due to inappropriate action by the decision maker (with potentially disastrous consequences), particularly for resource-poor, risk-averse subsistence farmers. In the absence of any scientific climate knowledge, management of these agricultural systems evolved to cope with climate variability, often resulting in a wealth of indigenous knowledge relating to climate and weather (Kurukulasuriya and Rosenthal, 2003). Incorporating indigenous knowledge into weather forecasting and climate change policies can lead to the development of effective adaptation strategies that are cost-effective, participatory and sustainable (Robinson and Herbert, 2001).

3. MATERIALS AND METHODS

3.1 Description of study area

3.1.1 Physical location

The Mbire District is located at the far end of the Mashonaland Central province, where it forms the northern border between Zimbabwe, Mozambique and Zambia. It lies in the Middle Zambezi Valley, which is the whole area stretching from the Kariba Dam to the Cahora Bassa Dam. The area covers approximately 4,700 km^2. The Mbire District has a relatively flat terrain with an average altitude of 400 meters above mean sea level. In terms of drainage, the district occupies the lower end of the Manyame catchment and is drained by the Manyame, Mwanzamutanda, Kadzi, Angwa, Musengezi (on the border with Muzarabani District), Mwanzamutanda and Dande rivers.

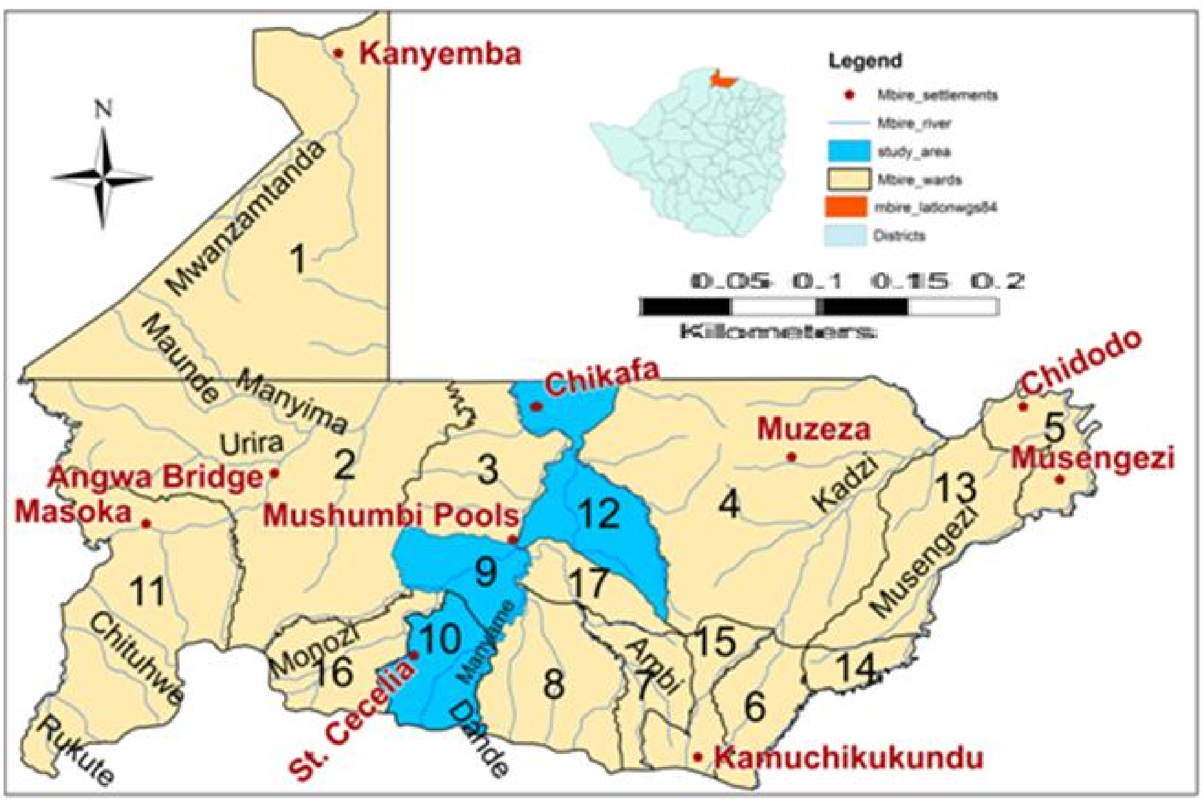

Figure 3.1. Mbire settlements, wards and rivers

3.1.2 Climate and vegetation

The climate of the Middle Zambezi Valley is dry tropical, with low and very variable annual rainfalls averaging 450 to 650 mm/year (Fritz *et al*., 2003). Two seasons are clearly defined: a rainy season from December to March, and a long dry season from April to November (Fritz *et al.*, 2003). Recurrent floods and droughts have made communities' livelihoods vulnerable, directly through reduced yields and indirectly through asset disposal and reduced income derived from agriculture (Bosongo, 2011). There are two type of floods that occur in the district, namely reservoir operation induced floods and seasonal floods which occur mostly in January and February (Phiri, 2011). In January 2013, 1,000 households lost about an acre of maize and 40 households lost farming implements due to floods in the district (FEWSNET, 2013). Severe dry spells are frequently experienced during the rainy season, resulting in crop failure (FAO, 2006b).

Mbire District is characterized by high temperatures exceeding 40ºC in October and November and minimum temperatures of about 10ºC during winter from May to July (AWF, 2010). The rainy season lasts for around 100 days. Mean annual evaporation is approximately 2,000 mm (AWF, 2010). The whole district has one meteorological station situated in Kanyemba, at the border with Zambia and Mozambique. The nearest meteorological stations are in Muzarabani, Guruve and Karoi (Phiri, 2011). The AGRITEX department at Mushumbi business centre and a few schools record daily rainfall data. Deciduous dry savannahs dominated by mopane (*Colophospermum mopane*) cover most areas of Mbire. Species diversity is low, and species accompanying mopane are often the same, including mainly *acacia nilotica* and a scattering of other species like musau (*ziziphus abyssinica*), wild mango (*cordlya Africana*) and mushuma (*diospyros mespiliformis*) (AWF, 2010).

3.1.3 Demographics and livelihoods

The Mbire District is characterised by two contrasted habitats: a dense human settlement along main rivers with croplands, and a wooded savannah (Fritz *et al.*, 2003). The population of the district as of August 2012 was 18,600 persons (ZimStat, 2012). A large proportion of the Mbire District falls in Agro-ecological Zone (IV), with only a very small part falling in zone (III) (FAO, 2006b) making it suitable for extensive livestock production with some drought tolerant crops such as sorghum, millet and rapoko. The agro-ecological regions are according to the amount of rainfall received, with region I receiving more than 1,000 mm on average and region V receiving an average of 450 mm per annum (FAO, 2006b). Agriculture is the main source of livelihoods in the district but yields are usually low due to rainfall variability, drought and floods (Muhonda, 2011). Cotton and maize farming is the dominant activity (CIRAD., 2001). Recession farming is practiced along the floodplains where mostly maize is grown, taking advantage of soil moisture and nutrients deposited by floods (Bosongo, 2011). People co-exist with wildlife in some parts of the district like Kanyemba, Masoka, Angwa and Chikafa, resulting in the destruction of crops by hippopotamus, elephants, buffalo and baboons.

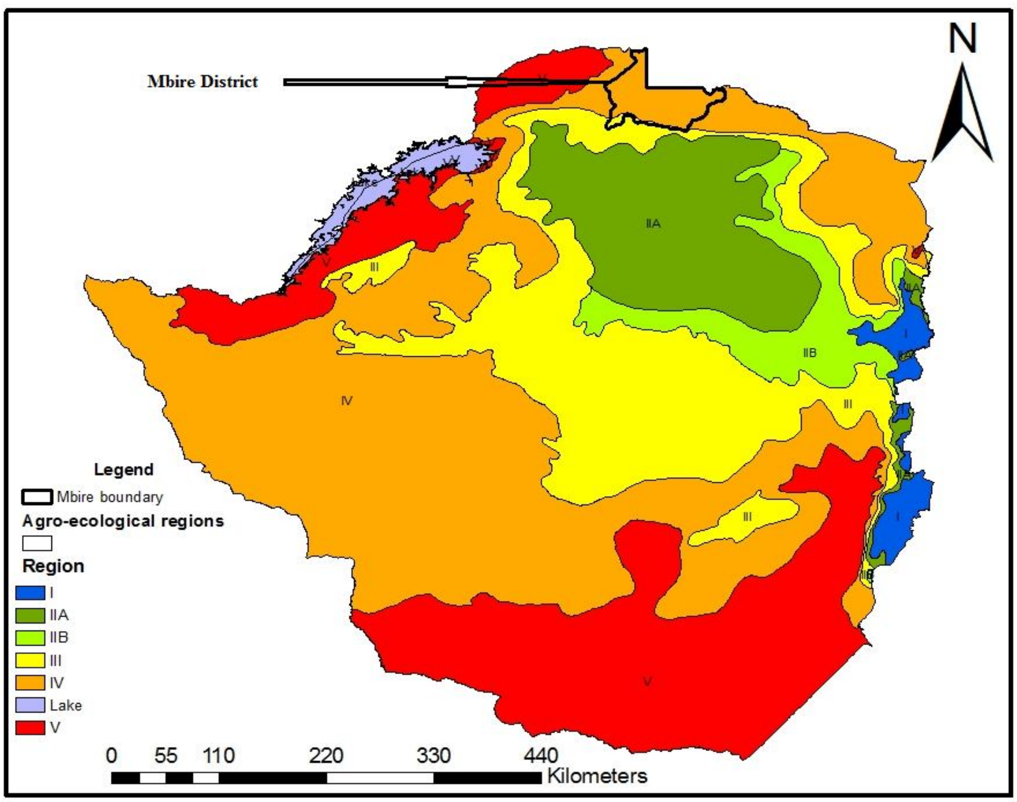

Figure 3. 2. Agro ecological regions of Zimbabwe

Source: (FAO, 2006)

3.2 Data collection

3.2.1 Sampling

Data was collected in Wards 9, 10 and 12 (Figure 3.1). The wards were chosen using purposive sampling, selecting Wards that are not affected by backflows of the Cahora Bassa reservoir as this would have an impact on some of the indicators. The wards were also chosen because they are next to each other (share common boundaries). Areas close to each other have similar environmental characteristics and because indigenous knowledge systems are localized knowledge domains. Settlements in the chosen wards date back to more than 70 years, because some old people who were more than 70 years old had been born in the area. The rivers are a major source of water for domestic use and livestock watering. The communities have practiced recession farming along Dande and Manyame rivers for many years. Dry land agriculture is affected by droughts and prolonged dry spells which cause crops to fail.

Semi structured questionnaires as well as Participatory Rural Appraisal (PRA) methods namely key informant interviews and Focus Group Discussions (FGDs) were used to collect both quantitative and qualitative data. Rainfall data and seasonal forecasting information for the 2012/2013 rainfall season was collected from the Meteorological Services Department. Additional rainfall data was collected from the AGRITEX offices at Mushumbi Growth Point.

3.2.2 Data collection methods

(i) Key informant interviews

Key informants were chosen according to their expertise, social standing and length of stay in the district. Village heads whose place of origin was Mbire district and those who had stayed in area for more than 30 years were interviewed. A total 7 of key informant interviews were done, with four of the interviews done with community heads (village headmen), and the remainder was done with the AGRITEX, Natural Resources and Wildlife officials and the District Administrator's secretary.

(ii) Focus group discussions

Focus Group Discussions (FGD) are used to get qualitative in-depth information which cannot be obtained on one to one basis. They consisted of between 7 to 15 people with ages varying from 40 to more than 80 years (Figure 3.3), and they were all selected on the basis that they have always stayed in the area, and are originally from Mbire district or they have stayed in the district for at least 30 years, which is the standard period for data that is used by the World Meteorological Organization (WMO) http://www.wcc.nrcs.usda.gov/normals/30year_normals_data.htm. Women made the larger number of older people interviewed and the researcher noted that the women would not say much despite being in the majority. A total of five focus group discussions were held in Wards 9, 10 and 12. One FGD was held in Ward 12 and for Ward 9 and 10; two FGDs were held per ward. The FGDs were aimed at establishing consensus and clarifications on the most commonly used indicators, the role of forecasting in making decisions on which crops to be planted and perceptions on climate change.

Figure 3.3 Focus group discussion at a village in Ward 12, Mbire District, March 2013

(iii) Semi structured questionnaires

A total of 181 semi-structured questionnaires (Appendix 1) were administered in the three wards. Respondents were categorized into various age groups, from the young (18 to 25 years) to the elderly (at least 65 years). The younger age groups may not have made observations as they would have spent some time attending school but were included to get to know whether they were observant as well as getting their perceptions. The questionnaires were administered in order to get following key information:

- whether the particular individual has any knowledge on IKS on weather forecasting

- the type of forecast they find more reliable and why
- perceptions on climate change

The semi structured questionnaire had both qualitative and quantitative information.

(iv) Rainfall data

Rainfall data for the years 1988-2013 for Kanyemba station was collected from the Meteorological Services Department (MSD), daily rainfall data for the years 2007-2013 were collected from the AGRITEX office at Mushumbi business centre. Seasonal forecast information for the 2012/13 season was also collected from MSD. The update for the 2012/13 rainfall season was also obtained from the MSD.

3.3 Data analysis and presentation

Quantitative data from questionnaires was analyzed for frequencies, relationships and levels of significance using the Statistical Package for Social Science (SPSS). Qualitative data was analyzed using the thematic approach method. The MS excel spreadsheet was used to

a. simulate the long term rainfall pattern at Mushumbi; regression analysis was done using rainfall data for Kanyemba station and calculating the rainfall trend.

b. calculate long term rainfall mean (1988/89 to 2012/13) and the number days without rain for the 2012/13 rainfall season.

Seasonal forecast for the 2012/13 rainfall season was compared with IKS indicators to determine reliability of the indicators.

3.4 Challenges faced

Data collection was done in a period when it had been announced that harmonized elections where going to be held. With this background, some respondents, for example a certain village head in Mushumbi, refused to be interviewed because he feared his life would be in danger unless other village heads were around to witness the interview. The other village heads were not at their homes that day so the interview was not done. As the time for elections got closer, respondents were uneasy and would not answer any questions without being satisfied that the researcher’s agenda was not political.

Some respondents thought they were being assessed in order to get food aid, and upon hearing that I was a student at the University of Zimbabwe, they would want to give excuses not to be interviewed because they were not going to get something after all. However, the village head/ward secretaries told the respondents that we were students and the findings from the researches will help them in future. Respondents complained that students were always coming to ask them for information and queried what the information was being used for because they were not seeing any improvement in their lives. The challenges faced by the researcher would not be complete without mentioning the issue of accessibility. The district has about 5 km of tarred roads, with the rest of the roads being in various degrees of disrepair. It was difficult to get transport into the villages especially in Ward 10 and 12.

3.5 Ethical issues and protocol

The data collection process was done in conformity to ethics in research. Researchers commonly assure participants that anything discussed between them will be kept in strict confidence (Kumekpor, 2002). Respondents' confidentiality and anonymity was assured. Respondents were also assured that the information they were giving was going to be used for academic purposes only and no names were going to be made public in any form of media. Upon entering villages, the researcher would inform the ward councilors, ward secretaries as well as village headmen before doing the interviews. It was important to provide participants with a high degree of confidentiality.

4. RESULTS AND DISCUSSIONS

4.1 Presentation approach

This chapter presents the findings of the study. The results are presented per objective and follow the order of objectives as presented in Chapter 1. Findings on identification of indigenous weather indicators for both drought and normal seasons are presented first. A comparison between seasonal climate forecasts (SCFs) and IKS for the 2012/13 season are presented second and finally the role of indigenous knowledge in food security.

4.2 Indigenous weather indicators

4.2.1 Plant indicators

From the interviews carried out, the appearance of new leaves on all trees is an indicator that the rainy season is approaching. The time the leaves appear is an indicator itself, early appearance of leaves means rains will be early and late appearance means the rains will be late. Not every tree is used as an indicator for drought or abundant rains. Certain trees like wild mango/*mutondo (cordlya africana), hakwa (strychnos innocu), musiga, baobab (adansonia digitata), and chenje/shuma (dyspros mespiliformis), nhunguru (flacourtia indica)* were pointed out as very good indicators.

Figure 4.1. Shuma, nhunguru, hakwa trees

The *mutondo (cordlya africana)* tree is regarded as sacred and no one is allowed to cut it. These trees are not found in abundance in the area. The wild mango tree produces reddish fruits and when these fruits ripen and start falling; rains are expected within a week or less. The fruits are edible but no one is allowed to eat them before the rains fall because they are believed to cause diseases. Abundance of *hakwa (strychnos innocu), musiga and baobab* *fruits* (Figure 4.1) and *shuma* is a sign of drought and if the fruits are few, it means that rains will be good. Elsewhere, unusual production of baobab (*adansonia digitata*) fruits, *mazhanje (Uapaca kirkiana)* and *hacha (Parinari curatellifolia)* and *shuma (dyspros mespiliformis)* fruits (Speranza *et al.*, 2009; Risiro *et al.*, 2012). A common interpretation of why trees bear so much fruit in a drought season is said to be God's way of ensuring people's survival in periods of food scarcity.

Figure 4.2. Nests hanging on a muzunga (acacia) tree on the edge of a river and a baobab tree

When the acacia nicolita tree produces dense white flowers, lots of rains are expected and the rains usually fall within a few days, and this correspond with findings from Speranza *et al.* (2009) in the Makueni district, Kenya. Speranza *et al.* (2009) also found out that late flowering of the acacia tree is an indicator of drought conditions. Falling rain causes the flowers to fall.

Table 4.1.Plant indicators and their predictions (IKS) as applied in the Mbire District

Tree type	***Description***	***Weather condition***
Mopane *(colosphermum mopane)*	Trees foliaging	Indicates that the rainy season is approaching.
Acacia *(acacia nicolita)/* mizunga	Dense white/yellowish flowers sprouting	Abundant rains within 1-2 weeks. The rain will cause the flowers to fall. The flowers appear before the first rains and will also appear during the rainy season, usually indicating the end of a dry spell. The amount of flowers can tell the amount of rain. The more dense the flowers, the more the rain..
	Few flowers	Little rains expected
Baobab tree	An abundance of *mauyu* fruit	Indicates that there won't be enough rains

(adansonia digitata) /muuyu		(drought).
Hakwa *(strychnos innocu)*, nhunguru *(flacourtia indica)*	An abundance of fruit	Indicates a bad rainfall season
Chenje / Shuma *(dyspros mespiliformis)*	An abundance of *chenje* fruits	Indicates drought conditions
	Late foliaging of trees	Indicates low rains that season/ drought conditions.
Wild mango *(cordlya africana)*/*mutondo*	Ripening of *mutondo* fruits	When the fruits begin to ripen and fall down, rains are near; rains usually fall within a week. The fruits are not eaten until the first rains have fallen.
Musiga	Abundance of fruit	An indication of poor rains that season
All trees	Time of foliaging	Generally, when tree start growing new leaves it means the rains are near. Early sprouting of new leaves means the rains will come early that particular year and late foliaging indicates late rains, which usually translate to a bad rainfall season which is short.

4.2.2 Animal indicators

Animals and insects display certain behaviors on the onset of the rainy season and during the rainy season. Mbire District has an abundance of wild animals namely baboons, impala, elephants, buffalo and hippopotamus though they are not found in some areas because of human settlement. In the study area, only Ward 12 is close to a wildlife conservancy causing humans and animals to interact and it's only in the Chikafa area where behavior of elephants was mentioned. The chirping of insects like cicadas (*cryptotympana postulata*) and crickets *(gryllus sp)* was associated with high temperatures (around 40^{o}C) at the beginning of the rainy season in November. Mosquitoes will be most active and their biting activity increases during this hot period. The sun spiders/jerrymunglum start moving around in large numbers and termites collecting grass and closing their holes indicate imminent rains (Makwara, 2013). It was noted that at the beginning of the rainy season people prefer sleeping outside due to the high temperatures. Appearance of migratory birds

(Abdims stork) is a sign that the rains can fall in a day or two and their continued presence especially at the start of the rainy season indicates that there are still more rains to come.

The rain cuckoo is another important indicator, when it starts singing; rains are known to be near and can fall within a week or days. This corresponds with a study done by Shoko, (2012) in Mberengwa District ranking the rain cuckoo number one and Abdims stork number three in rainfall prediction. Some respondents thought the way it sings indicate the amount of rainfall. If it sings like *kowe, kowe, tsvo tsvo,* above average rains will fall but if it just sings, *kowe, kowe* the rains will just be normal.

Table 4.2. Insects and their predictions as applied in Mbire District

Indicator	***Description***	***Weather condition***
Armoured cricket/ *mamunye*	Presence in large numbers	Indication of drought conditions
Crickets *(gryllus sp)*	Chirping the whole day and night	An indication of high temperatures and rains are expected in a week or two.
Mosquitoes *(plasmodium sp.)*	Biting activity increases	Indicates that the temperatures are high. Rains expected to fall with a day or two
Toads *(xenopus laevis)*	Croaking a lot	Rains expected within a day or two
Cicadas (*cryptotympana postulata*) /nyenze	Chirping the whole day and night	Indicates that temperatures are high and rains are near. They only appear when the trees have foliaged
Sun spiders/jerrymunglum *(arachnida sp.)*	Spiders moving around in large numbers Spiders closing their webs	Indicates beginning of rainy season Rains are near
Butterflies *(charaxespollux)*	Presence of butterflies	Rainy season has begun. A large number of butterflies means there will be lots of worms
Termites *(isoptera sp.)*	Increased activity, cutting grass plants (collecting food) during a dry spell	Rains can fall within a week on less

Table 4.3. Birds and animal indicators as applied to the Mbire District

Indicator	***Description***	***Weather condition***
Weaver birds (*Ploceus intermedius)* /Jesa	Building of nests high on the trees indicate	Rains will be normal/ above normal
	Nests are low on trees along the river bed	Indication of a drought
Abdim's stork *(ciconia adminii*) /Shuramurove	Their presence	Rainy season has began because they only appear when it has rained
	Flying in circles at low altitude	Rains will fall within a day or two
Elephants *(loxodotna africana)*	Migrating to higher ground	Above normal rains expected, with the possibility of flooding
Rain cuckoo *(clamator glandarius)/* haya	Singing	Rains are near and may fall within 3-4 days

4.2.3. Astronomic and meteorological indicators

Temperature, humidity and wind direction before or during the rainy season can indicate the timing and intensity of rains that are expected to fall. These meteorological weather parameters are common in both IKS and SFCs (IDRC, 2010). The respondents alluded to the fact that incessant chirping of cicadas and crickets, the biting activity of mosquitoes are all linked to very high temperatures. Though no thermometers are used to measure how hot it is, people can tell the intensity by the amount of sweat, breathlessness and the heat in the soil when one steps on the soil without shoes.

As the rainy season approaches, the wind direction can be used to tell the nature of the coming season. The period from end of October up to early November, light winds blow from almost all directions, causing whirlwind like activity. Light rains can fall but usually the quantity is very little to start any agricultural activities. Towards the end of November, easterly winds from Mozambique bring abundant rains, and this is usually a sign of a good season. If winds blow from south/ southwest (Guruve) direction, the rains will be light and is a sign of a bad season. The time the Milky Way (*urimira*) is seen in the sky is used to tell whether rains would be early or late. If the stars are seen early in the night towards end of

October/ beginning of November, the rains will come early. The study of constellation of the stars is specialized to very few old people and is almost non-existent in the younger age groups (Risiro *et al.*, 2012).

The appearance of a hallo around the moon and the stars, giving them a dim appearance was also noted to indicate that the rains are imminent. The respondents noted that the hallo does not indicate how soon the rains are going to fall, but is merely a sign of impending rains. Dry spells can occur while the hallo phenomenon is on. The new and old moon phases are associated with more rain, whereas the full moon phase is associated with little or no rains (Makwara, 2013).

Table 4.4. Astronomic and meteorological indicators and their predictions as applied in Mbire District

Indicator	***Description***	***Weather condition***
Moon and stars	A hallo/ *dziva* around the moon and the stars and the sun	An indication that the rainy season is about to start
	New and old moon	Wet conditions expected (during the rainy season)
	Full moon during the rainy season	Dry conditions expected.
Urimira/ milky way	Early rising of the stars (beginning of November)	Early onset of the rainy season
Temperatures	Very high temperatures, causing breathlessness and sweating, even at night, sparks/ mirages during the day.	Rains can fall within hours up to day or two
Temperatures	Very cold winters	Indicates below normal rains
Wind	Wind blowing from the Mozambican/ Zambian direction (i.e. winds blowing from the east/ north east direction)	When the wind blows consistently from that direction rains fall within a week
	Continual blowing of the wind from the southern direction (from the mountains bordering Guruve and Mbire Districts until late November)	An indication of below normal rains
	Dark clouds accompanied by very strong winds	A storm is imminent, lots of rains expected.
Rainbow	Appearance of rainbow during a rain event	An indication that the rains will stop

4.3 Comparison of SCF and IKS for the 2012/13 season

4.3.1 The 2012/2013 seasonal climatic forecast

Zimbabwe was divided into three meteorological regions for the 2012/13 rainfall season, each region having the same probabilities of rainfall occurrences. Region 1 comprised of all Mashonaland, Manicaland province and Northern Midlands whilst Region 2 comprised of Matabeleland North and small part of Mashonaland West and Midlands. Region 3 was made up of Matabeleland South, southern Midlands and Masvingo. Figure 4.2 shows the three regions and the amount of rains expected for the forecast issued in August 2012. For the 2012/13 rainfall season, Regions 1 and 2 were expected to have normal to above normal rainfall for both OND (October November December) and JFM (January February March) while Region 3 was expected to have below normal rainfall for both OND and JFM.

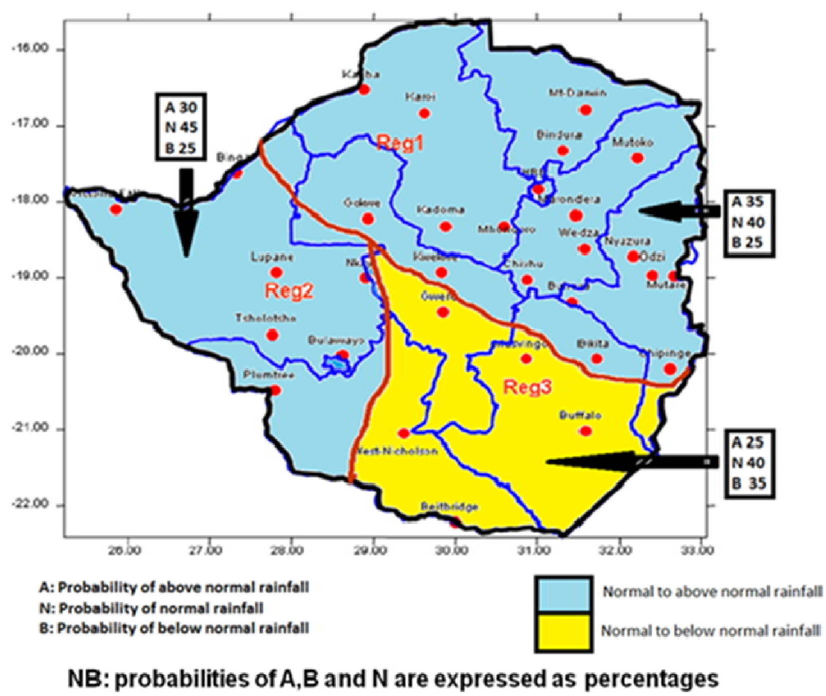

Figure 4.3. Rainfall outlook for October-December 2012 showing normal to above normal rainfall over the northern parts of the country

Source (MSD, 2012)

4.3.2 Updates on the seasonal forecast

Following the August (2012) forecast for the 2012/2013 season with a lead time of 6 months, an update was issued in December 2012 for the January February March 2013 period. Ideally the shorter the lead time the higher the accuracy hence the need to update using the October Sea surface temperatures for the Indian Ocean. Figure 4.3 shows an expected improvement in the expected amounts compared to the forecast issued for the same period in August 2012.

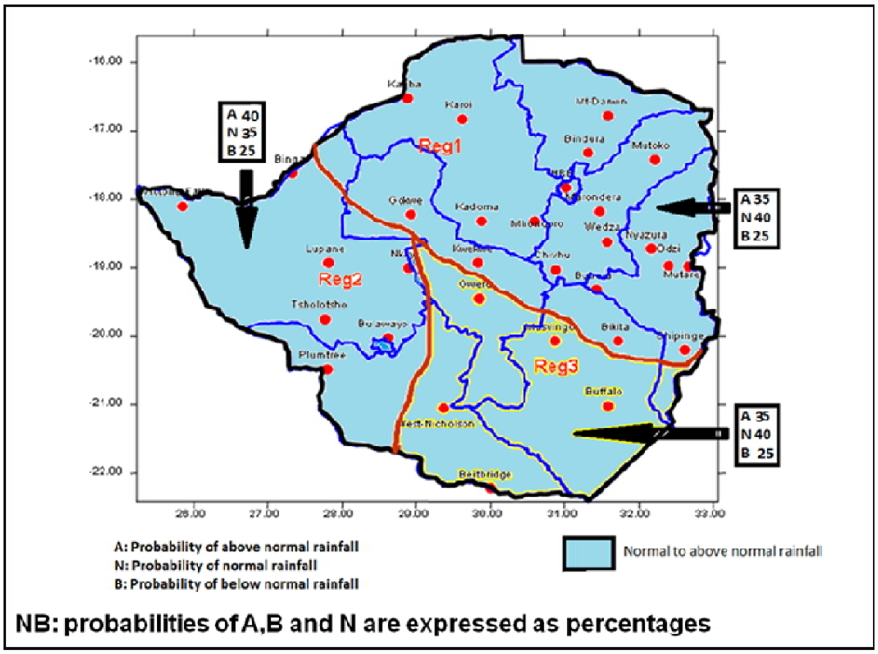

Figure 4.4. Rainfall outlook for January- December 2013 showing normal to above normal rainfall over the northern parts of the country

Source (MSD, 2012)

4.3.3 Mean onset, cessation and length of the season in the Mbire District

Rains were expected to start between 1 and 7 December 2012 in Region 1. The length of the season was expected to be between 115 to 135 days and the cessation dates were from 3 to 8 April 2013. The first rain event recorded at Mushumbi was on 26 November 2013 and the last rain event was on 16 March 2013. From the first to the last rain event, there were 109 days. For the past 6 rainfall seasons (2007/2008 to 20012/2013), the average length of the season is 117 days. The length was calculated by numbering the days between the first rain events to the last rain event. Taking into account that seasonal climate forecasts do not take intra-seasonal variability into consideration, both the August 2012 and the December updated forecast for the JFM were correct.

4.3.4 Forecast for the 2012/2013 season using IKS

For the 2012/13 season, of all the respondents who participated in the interviews, 53% percent of the respondents did not observe or did not remember taking notice of any IKS indicators. From Table 4.5, 42% responded that they had observed that this was going to be a normal or above normal rainfall season because the *chenje (dysporios mespiliformis)* and *musiga* trees did not produce lots of fruits and that was an indicator of a good/normal rainy season. Wind was also stated as another indicator in the 2012/13 rainfall season that showed there will be good rains by the direction from which it blew.

Winds that blow from Mozambique continuously (up to two weeks before the rains fall) normally indicate good rains. About 2% of the respondents said that the winds that blew almost exclusively from the Mozambique side at the end of December 2012 and beginning of January 2013 showed the rains would be above normal. However, 3 % of the respondents said the indicators meant drought. This response could be because some of the farmers in the district generally associate poor harvests to drought conditions. The positions of bird's nests indicated that there would be normal rains in the 2012/13 rainfall season because they were not on the lower branches of trees.

Table 4.5. Indicators for the 2012/13

% of respondents	***Indicators observed***	***Prediction***
53%	Did not observe/ did not remember	None
42%	The chenje *(dysporios mespiliformis)* and musiga trees did not have much fruit Wind was blowing from Mozambique/ Zambia.	Normal rains
2%	The chenje *(dysporios mespiliformis)* and musiga trees did not have much fruit Wind was blowing from	Above normal

	Mozambique	
3%	The chenje *(dysporios mespiliformis)* and musiga trees did not have much fruit Wind was blowing from Mozambique	Below normal

For the 2012/13 rainfall season, the IKS indicators did correctly predict that there was going to be good rains and a total of 899 mm, which was above the normal long term average of 660 mm.

4.3.5 Similarities and differences for IKS and SCFs for the 2012/13 season

SCFs give precise dates as to when the season is expected to begin and end, whereas IKS cannot give precise times. In terms of quantities, IKS can differentiate between good rainfall years from drought years but cannot differentiate between a normal and above normal rainfall season. Both IKS and SCFs could not predict intra-seasonal variability. The SCFs gives weekly and monthly updates, whereas for IKS, there is no regular update but observations from the environment are used as forecasts, for example flowering of trees and position of the moon (Table 4.6).

Table 4.6. Summary of similarities and differences for IKS and SCFs for the 2012/13 season

Parameter	***SCFs***	***IKS***
Rainfall quantity	Normal to above normal rainfall	Normal rainfall
Seasonal length	Rains were expected to start from 1 to 7 December and cease between 3 to 8 April	No precise dates from IKS for beginning and end of season
Intra seasonal variability	No prediction from the onset	No be prediction from the onset
Updates	Weekly and monthly updates from the MSD	Position of the moon, flowering of the acacia (*mizunga*) and termites collecting food and closing their holes were used as indicators
Rainfall intensity	The MSD predicted that	IKS could not tell the length of the

	there will be lots of rain the whole of January	January wet spell, but the winds blowing from Mozambique/Zambia indicated good rains

4.3.6 Impacts of rainfall distribution on crops

(i)Yearly Rainfall variability

The year on year variation of seasonal rainfall ranges from 500 mm to just over 900 mm at Mushumbi over a six year period (Figure 4.5).

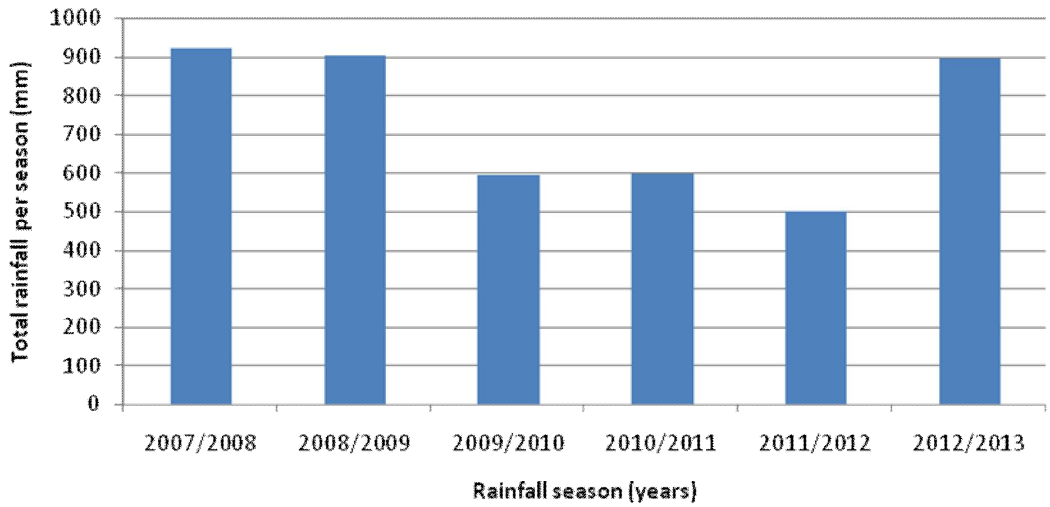

Figure 4.5. Yearly rainfall variation from 2007/08 to2012/2013 seasons at Mushumbi Pools

Source: AGRITEX

Despite the rainfall being highly variable from year to year, there is an increase in the total amount of rainfall received for the period 1988/89 to 2012/13 (Figure 4.6), with a regression coefficient of R^2=0.036. Rainfall for Mushumbi Pools was simulated using the Kanyemba rainfall data from 1988/89 to 2012/13 season. The available rainfall information for Mushumbi Pools for the period 2007/08 to 2012/13 was correlated with the Kanyemba rainfall data for the same period. The relationships between these two stations are fairly strong, with Pearson's R being 0.68. The relationship is given by Equation 1.

Y = 0.981X-1.924

Where **Y**=simulated rainfall for Mushumbi, mm

X=Kanyemba rainfall, mm

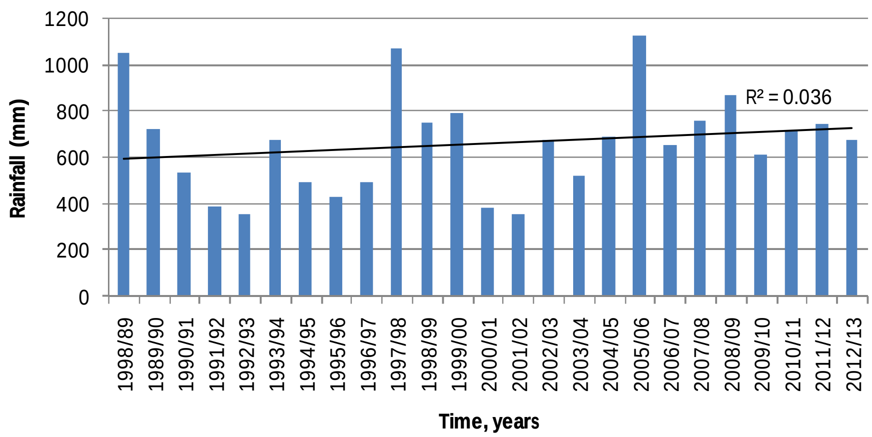

Figure 4.6. Yearly rainfall variation at Mushumbi Pools from 1988 to 2012/2013

Source: Meteorological Services Department

The rainfall for the 2012/2013 season was described as a bad agricultural season by the majority of the farmers (99%). The long term average rainfall of 660 mm was surpassed in the 2012/13 season at Mushumbi, having recorded 899 mm.

(ii) Seasonal rainfall variability

The rainfall distribution could not support healthy plant growth. Rains continued to fall throughout January 2013 and a total of 494mm of rain was received in January alone, which was more than half of the total seasonal rainfall. This resulted in the soil being water logged and plants not growing well. From the 22nd of February 2013, a 15 day dry spell followed, causing crops to suffer from moisture stress. The last significant rains fell on the 11 March, with only 1mm recorded on 16 March 2013. Most of the dry-land maize crop did not reach maturity (Figure 4.7).

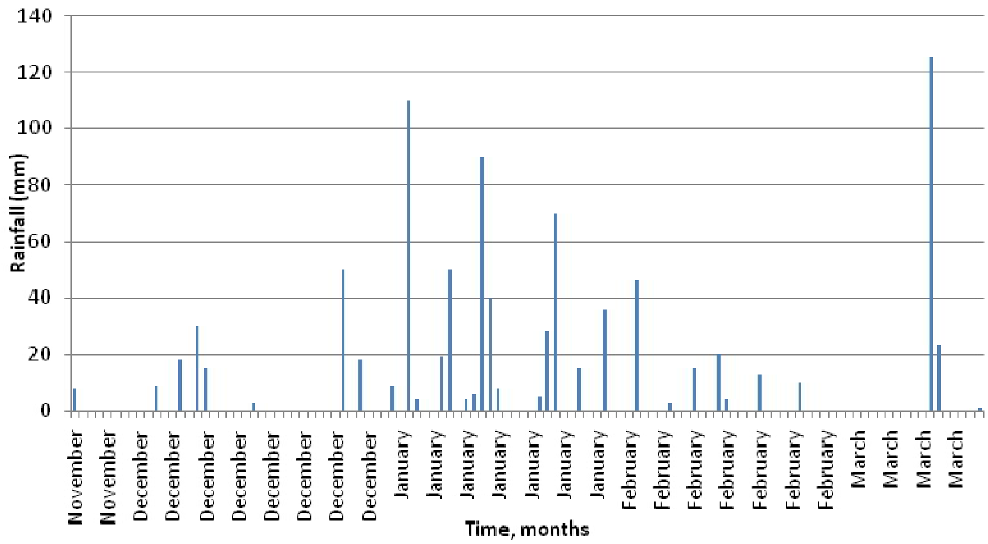

Figure 4.7. Daily rainfall variation for the 2012/13 season at Mushumbi Pools

According (FAO, 2013) , grain maize take between 125 to 180 days to mature, depending on the variety. The distribution of rains also affected recession farming because floods, which used to occur in February/March, came in January and washed away the crops and the farmers had to replant when the water levels had gone down.

(iii) Maize crop water requirements

Figure 4.8 shows the different amounts of water required by the maize crop at different stages. Between 2.5-3.5 months from planting, the maize crop has the highest water requirements. Comparing with the rainfall distribution for the 2012/13 season, there is a mismatch between the available rainfall and the requirements per stage, most critically at the maturing stages. In Mbire District, most crops were planted mid to end of December, and lots of rain fell in January stunting growth at a stage where crops did not require a lot of water. By the time the crops reached the flowering stage, the rains where waning and the crops were affected by hot, dry spells and reached permanent wilting point at the grain filling stage.

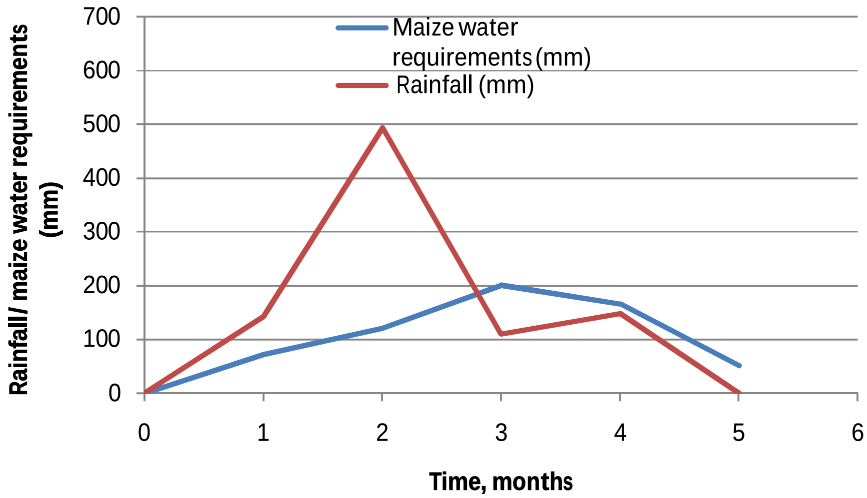

Figure 4.8. Crop water requirements at various growth stages for maize at a maximum temperature of 31^{O}

Source

For the 2012/13 season the total number of days without rain was 78, out of a total 109 days in the season. This rainfall pattern cannot support adequate plant growth, Figure 4.7. From the (Figure 4.9) it can be seen that the months of February and March, during which the plants are reaching the crucial stages, were mostly without rain. There are more days without rain, and the average length of dry spells is 14 days and this, coupled with high temperatures resulted in crops failing.

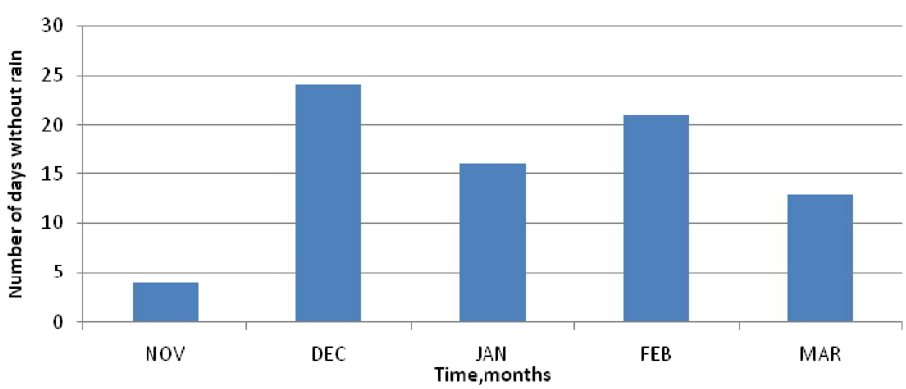

Figure 4.9. Days without rain for the 2012/13 season at Mushumbi Pools

All crops were affected by dry spells, but the impact was more pronounced on the maize crop which is more sensitive to moisture stresses.

4.3.7 Perceptions on rainfall trends

Of the respondents interviewed, 81% cited that the amount of rainfall received is becoming less, 13% thought that there is no change and 6% thought that amount of rainfall is increasing (Figure 4.10).

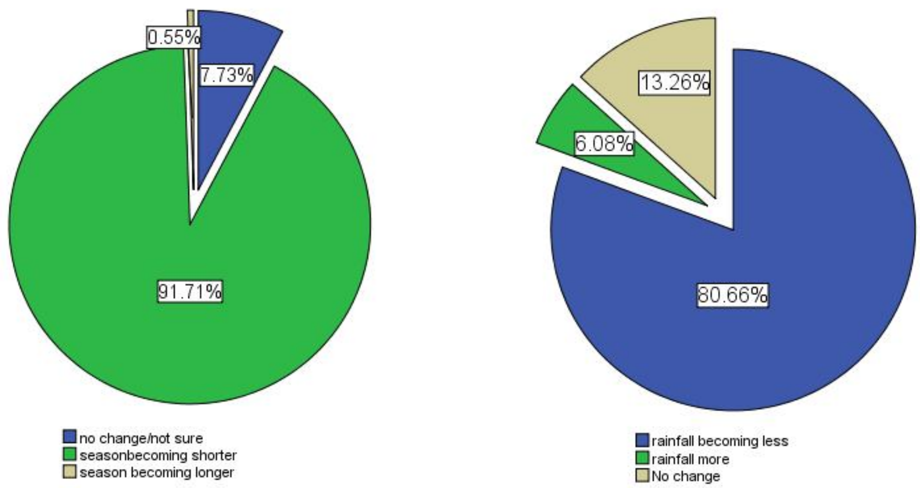

Figure 4.10. Perceptions on rainfall patterns

From analysing rainfall trend from 1988 to 2012/13 at Mushumbi using regression analysis, there is an increase (R^2=0.036) (Figure 4.6), but the increase is small. The perception that rainfall is decreasing could be due to accrediting poor harvests to drought only. On timing and ending of rains, 92% think that there season has become shorter and 8% were not sure or thought that there was any change in length. From the available rainfall data for the past 6 years, rains started in November, but these were usually small quantities which do not enable planting. Rainfall ends around mid March and from the available data at Mushumbi, it cannot be concluded that length of season has significantly changed.

4.4 Role of IKS in ensuring food security

4.4.1 IKS and its reliability

Of all respondents interviewed, 93% were familiar with IKS. This knowledge varies with age and length of stay in the area. All respondents above 55 years knew about IKS. The younger age groups (18-34 years) mentioned that though they may not be very observant of the environment in which they live, they hear it from the elders.

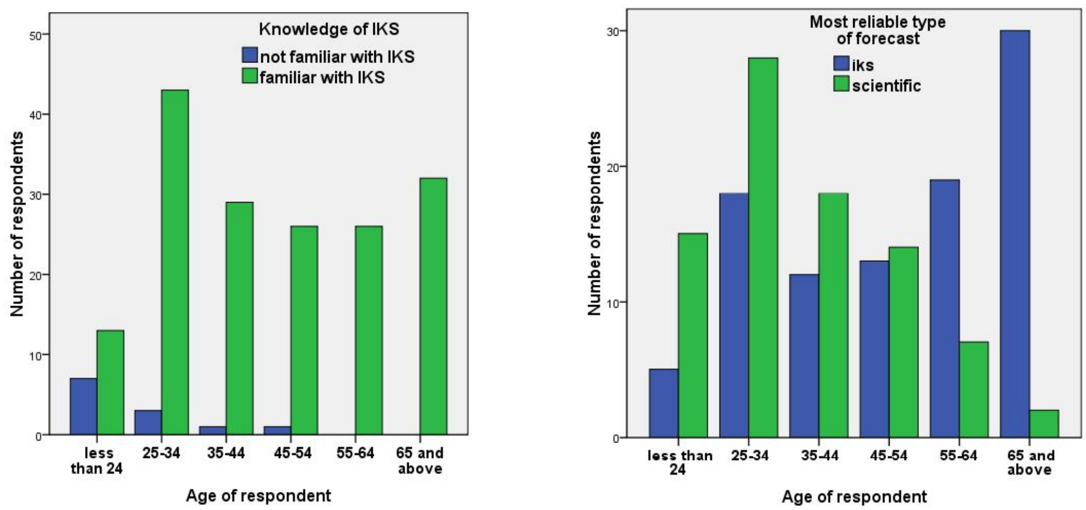

Figure 4. 11. Relationships between age, knowledge of IKS and reliable form of forecast

4.4.2 Relationship between length of residence and reliable form of forecast

Only 7% of the respondents who have resided in Mbire District for a period of less than 20 years are not familiar with IKS. There is a relationship between length of residence and form of forecast most trusted but the strength of the relationship is weak ($p = 0.01$, $p<0.05$ and a Pearson's coefficient of -0.254). IKS is not general knowledge but is related to the length of time a person has been living in an area, direct experience and the socio-cultural embedment of the persons (Speranza *et al.*, 2009). From Figure 4.12 it can be seen that those that have stayed in the area for at least 30 years rate IKS as their most reliable form of forecasting.

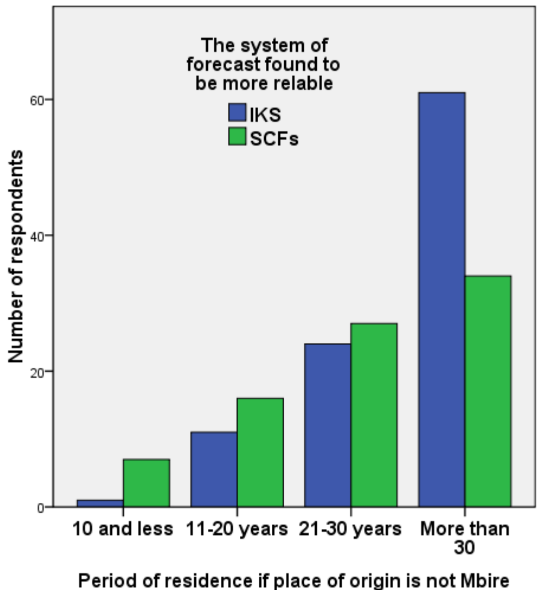

Figure 4.12. Relationship between length of residence and type of forecasting found to be more reliable

4.4.3 Level of education and reliability

There is a relationship between level of education and reliability, although it not a very strong one (p<0.05, Pearman's R=0.341). The levels of education in the Mbire District are generally low, for the surveyed sample 23% had never been to school, 50% had primary education only, 26% had been to secondary school and only 1% had achieved tertiary education. The number of respondents who find IKS more reliable decrease with increase in time spent at school; 83% (age 65 years and above) of those that have never been to school, 52 % of respondents with only primary education and 32% of those that attained secondary school education, respectively, (Figure 4.13). The 50% of those with tertiary education arises from the fact that only two respondents were interviewed. The decreasing trend of IKS reliability can be attributed to scientific observations and solutions being promoted as the best explanation to most phenomena, not only weather forecasting.

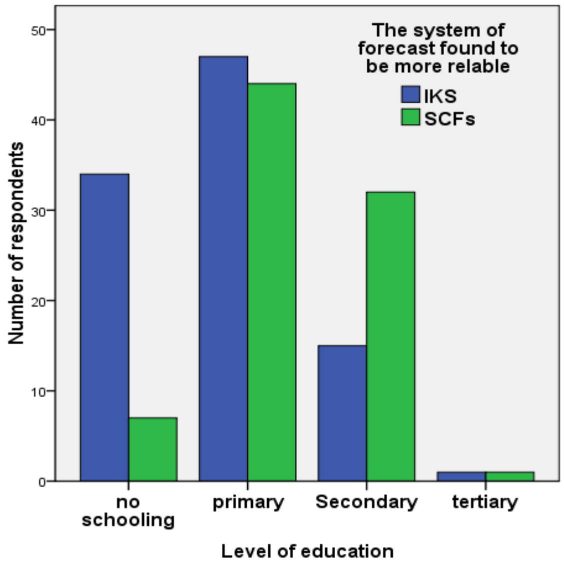

Figure 4.13. Relationship between levels of education and most reliable type of forecast

The school curriculum does not incorporate IKS and as a result, it's treated as backward myth. Scientific forecasts have replaced observations of the environment that was practiced by the elderly.

4.4.4 Rainfall intensity

Of all the respondents interviewed, 53% of them were able to predict the intensity (amount of rainfall) of a rainfall event. Very high temperatures which cause bodies to sweat profusely, even at night; increased mosquito biting activity, wind direction and type of clouds were the most commonly used indicators. The clouds that bring lots of rain are usually grey and are at low altitudes. The darker clouds that are whitish at the top and go high into the sky (cumulonimbus) also bring lots of rain accompanied by thunder/hail/lightning.

4.4.5 Role of IKS in agricultural planning

Accurate weather forecasts are indispensable to farmers because they allow the farmer to make decisions on how to manage crops and livestock. Use of IKS in planning agricultural activities is very low, with only 14% of the farmers using it in the 2012/13 rainfall season. Farmers tend not to exclusively follow the any form of forecast, but if they hear of an increased risk of flooding via radios, they become cautious in the flood plains.

"*We inform farmers we work with about the forecast, but very few of them do as we advise. They still plant early even if you warn then that the season has not begun in earnest. However, if you warn them about an impending flood, they all get out of the flood plain.*" AGRITEX official

This could be because of the issue of climate change and variability. Respondents said that in the past they used to know when indicators predicted a good season they would harvest well, but these days things have change. The respondents who found IKS reliable mentioned that they use IKS to plan cropping patterns and not livestock because in case of a poor season, they sell animals to buy food. The intention is to keep as much livestock as is possible so that one can always sell when the need arises.

"We just plant crops because we can see that the rainfall pattern has changed. In the past we used to have good harvests, now the harvests are poor. When enough rains fall we plant because the rainy season is now short and we fear that our crops might not reach maturity." 60 year old lady. Chikwama Village, Mushumbi.

If the outlook for a particular season does not indicate much rain or if the rains are late, the hectarage of drought resistant food crops like sorghum and millet and short season crops like cowpeas is increased and dryland maize acreage is reduced. In the flood plains there is no reduction in hectarage for maize because farmers do take advantage of the residual moisture and try to maximize the yields.

"We plant cotton as usual irrespective of what the forecasts tell because it is drought tolerant and it's our major source of cash. The money we get we use to buy grain….these past few years, however, the price of cotton was very low and we could hardly pay the seed companies what we owe them." Farmer, Chitsungo Village, Ward 10.

4.4.6 Food security

Following the 2012/13 agricultural season, the communities in Mbire are not food secure. Empty granaries and food queues could be seen during harvest period, Figure 4.14.

Figure 4.14. An empty granary at a homestead in Ward 9, people queuing for food aid at Mushumbi Primary School, April 2013

The average yield for maize was 0.2 t/ha, 0.5 t/ha for cotton, 0.4 t/ha for sorghum, 0.4 t/ha for groundnuts and 0.3 t/ha for cowpeas for the three wards in which the study was carried out. For food crops, maize has the highest area under cultivation, followed by sorghum, groundnuts and cowpeas respectively. Cotton has the highest area under cultivation (Table 4.7) because it is the major income earner and also drought resistant. Profits realized from cotton are used to buy grain among other things.

Table 4.7. Area under crops for the 2012/13 season

Area under crops (Hectare)	*Ward 9*	*Ward 10*	*Ward 12*
Maize	507	676	614
Sorghum	124	185	429
Cotton	1769	2347	1111
Groundnut	77	297	89
Cowpeas	225	88	148

Source: AGRITEX

The average yield of maize per household is 80 kg for the three wards; with the highest being 90 kg for Ward 9 and lowest being 68 kg for Ward 10. Averages for sorghum, groundnuts, cowpeas and cotton were 70 kg, 40 kg, 40 kg and 550 kg respectively (Figure 4.15) The district has an average of 5 members per household (ZimStat, 2012) and these yields cannot adequately cover the food needs for a single family until the next harvest.

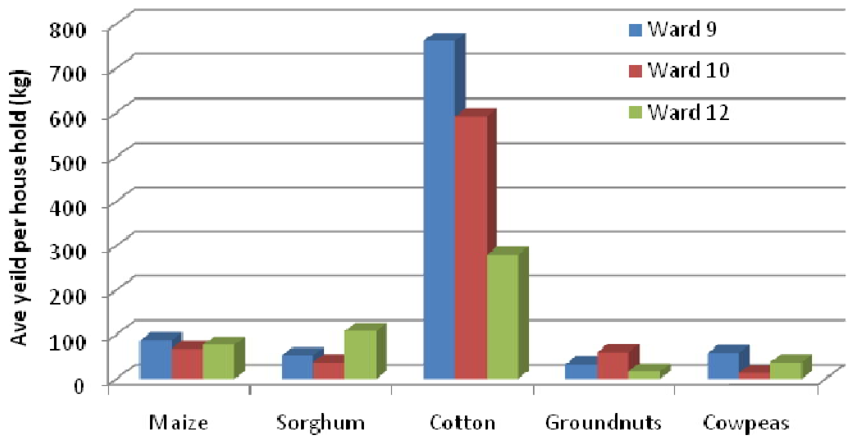

Figure 4.15. Average yields (kg) for the 2012/13 season

Source: AGRITEX

Recession farming in the floodplains is widely practiced and it's an important contributor to the food security situation. From the interviews carried out, 62% of the respondents have a field in the flood plain, and the average size of the field being 0.7 hectares. Yield of maize crop from the flood plain is estimated to be 0.8 tonnes per hectare (AGRITEX estimates). Average harvests for this field size is 10 x 50 kg bags, which is not enough to last the whole year for average family of 5 members. This type of agriculture has been practised for a long time but the sizes of the fields are getting smaller due to increasing populations. Early floods (January) are also reducing yields because they wash away crops, leaving farmers with the only option of having to replant after the water has receded. The crops at the far end of the flood plain might not do well due to lack of moisture if replanting is done.

4.4.7 Factors impacting food security

The main factors affecting food security in the Mbire District are rainfall amounts and distribution. Wildlife and pests also contribute to food security issues.

i) Case study

Key informant Interview with Headman X

Headmen X came with his family to Mbire District in the 1970s to settle because of the fertile soils in the area. Then, rains used to be good and reliable and he used to have bumper harvests. He used to till about 12 acres of his dry-land field, mostly growing maize, groundnuts and cotton, harvesting between 4 to 5 tonnes of maize, 100 bales of cotton and did not grow sorghum because generally, maize is preferred over sorghum. Because he is not originally from the area, he does not own a field in the flood plains. He used to own a tractor and was well known in the area for his farming prowess.

Rains used to start in October, but nowadays rains start falling in November, but quantities are usually small that planting of crops starts between middle to end of December. One cannot tell what the pattern is like these days because some years, inadequate rains are received throughout the season and crops fail but some years rains can fall continuously for up to 3 or 4 weeks, causing flooding and damaging the crops. Weather information comes in the form of radio broadcasts and this year they said the rains were going to be good, even the indigenous indicators like wind and wild fruits showed there was going to be good rains, but he won't get enough food to eat because of dry spells. Headman X does not use any form of forecasting because he does not find any type of forecast very reliable and he just plants and hopes for the best. The headman has since sold his tractor because the poor harvest makes it difficult for him to service it. This year he won't harvest any maize because though rains fell, the distribution was not good resulting in crops failing due to long dry spells. He expected to harvest 4 bales of cotton, 200 kg of sorghum and 150 kg of cowpeas. Pests however are a challenge, especially birds and armored crickets which can destroy an entire harvest if not controlled.

(ii) Wildlife and pests

During the focus group discussions, it was apparent that it is not only rainfall patterns that were to blame for the poor harvests, but pests and wildlife were a threat as well. Wildlife is a problem in communities that are close to wildlife conservancies like Chikafa, where elephants, baboons and impalas have been known to destroy entire fields to the point that farmers have relocated their fields close to the flood plains close to where their homes are. In the floodplains, temporary shelters have to be built for people to stay in order to chase hippopotamuses at night (Bosongo, 2011). Pests like armored crickets and birds are also a major problem and farmers thought they have been increasing over the years. As one farmer puts it,' *if one is not able to chase the birds away, there is no point in planting sorghum in the first place'*. Solutions to problems of pests were to use insecticides but farmers do not always have money to buy these.

5. CONCLUSIONS AND RECOMMENDATIONS

From the results of this research, the following conclusions and recommendations were made.

Objective 1: To identify indigenous knowledge indicators used in Mbire District

Conclusion

In the Mbire district, wild fruits trees like *shuma (dyspros mespiliformis), hakwa* (*strychnos innocu)* and *nhunguru (flacourtia indica)* indicate drought or normal season by the amount of fruit they bear. A lot of fruit is a drought indicator and few fruits are a normal rainfall indicator. When the wild mango (*mutondo*) fruits ripen the rains are imminent. Indicators like singing of the cicadas, crickets, rain cuckoo and appearance of migratory birds are time indicators, and are only noticed around the time the first rains fall. Old and new moon phases are associated with wet spells. Wind direction is an important indicator of amount of rains expected in the district.

Recommendation

Thorough documentation of all indigenous knowledge indicators is needed as well as educating the community about IKS is needed so as to encourage younger subsistence farmers to be aware of the environment and use forecasts to plan on which crops to plant and when to plant in order to improve food security in the district. Further studies on the impacts of climate change on the animal and vegetation indicators needs to be done.

Objective 2: To compare traditional and scientific forecasting methods for the 2012/13 season

Conclusion

Both the SCFs given by the Meteorological Services Department and indicators of IKS predicted that normal rains in terms of quantity were going to be received in the Mbire district. IKS and SCFs could not forecast from the onset the variability during the season.

IKS, though localized, did not give an approximate length of the season; differentiation of a normal season from an above normal rainy season is still a question for further research. SCFs issues weekly and monthly forecasts via radios and newspapers and detailed forecasts can be obtained from meteorological stations. IKS indicators can tell the beginning or end of wet and dry spells but the time is not clearly outlined as the SCF forecasts.

Recommendation

Further studies are needed to validate indigenous knowledge indicators against seasonal climate forecasts for both good/normal rainfall seasons and drought seasons to determine their reliability taking climate change into consideration, and then the two forms of knowledge can be integrated for the benefit of the community.

Objective 3: To establish the role of indigenous knowledge systems in food security under changing climate conditions

Conclusion

The community knows about IKS but mostly the older (>55 years) find it more reliable and it can be concluded that the level of reliability of IKS is related to age as well as the level of schooling one has been exposed to. IKS is not only limited to rainfall forecasting, but also knowledge of moisture fluctuations in the flood plains. Recession farming has a long history in the district and has helped in complementing dryland agriculture which is affected by drought. More than half of the households have a field in the flood plain but the size of fields are getting smaller due to increase in population. In normal or dry season, yields are high in the floodplains that in the upland fields. The use of IKS for planning purposes is not widespread in the Mbire District and this can be attributed to the strong perception the community has about changing rainfall patterns. Farmers are aware that climate change is happening because harvests are poor most of the years. For the 2012/13 the community is not food secure and the problem of food insecurity is becoming a perennial one.

Recommendation

The Mbire District community needs to be taught about IKS in weather forecasting, targeting youths and school children in order to make them aware that it's not a myth, so that they can start observing the environment and use predictions from traditional indicators to plan agricultural activities.

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APPENDICES

APPENDIX 1: Semi structured questionnaires

Personal Details

1 Gender. Female ☐ Male ☐

2 Age

Less than 24	25-34	35-44	45-54	55-64	65-74	Above 75

3 Marital status. Single ☐ Married ☐ Divorced ☐

Widowed ☐

4 Size of household

No of family members	1-3	4-6	7-10	More than 10

5 Level of education

Never been to school	Primary	Secondary	Tertiary

What is your source of income?

6 Are you originally from this area? Yes ☐ No ☐

7 How long have you resided in Mbire?

Less than 5	6-10	11-20	21-30	More than 30

Section B : Weather information

8 Have you noticed any changes in rainfall patterns?

Rainfall amount is becoming less	Rainfall amount is increasing	It has remained the same	Season is beginning latter

9 Have you noticed any change in temperatures?

It's becoming hotter	it's becoming cooler	There is no change

10 How have the weather changes affected farming?

11 Do you know about indigenous ways of weather forecasting? Yes ☐ No ☐

12 How do you get to hear about weather information?

13 What do you find as the most reliable method of weather forecasting?

a. Indigenous ☐ Scientific ☐

Why?

14 Which indigenous indicators do you base your predictions on?

Vegetation	Animal behavior	Temperatures	Moon and stars/ wind

15 Which indigenous indicators did you observe before the

a) 1982 drought?

b) 1992 drought?

c) Cyclone Eline (2000)

16 For the current season, which indicators did you observe?

17 What did they predict and did it come true? Yes ☐ No ☐

18 Nowadays, with the changes in weather patterns, are these indigenous indicators still reliable? Yes ☐ No ☐

19 Are you able to tell how long the season is going to be from indigenous knowledge?

Yes ☐ No ☐

20 Are you able to tell the intensity of a rain event from indigenous knowledge?

Yes ☐ No ☐

If yes, what are the signs/ indicators?...

21 Do indigenous ways of weather forecasting sometimes coincide with scientific forecasting?

Yes ☐ No ☐

If yes, how often?

Very often	Less often	Not at all

23. Do you use IKS for agricultural planning? Yes .☐..............No ☐

Section C :Livelihoods

22 Do you have a field in the flood plain (*gova*)? Yes ☐ No ☐

If yes, what's the size of the field?...

23 How do you prepare your land for planting? Plough ☐ Hoe ☐

24 How long have you been practicing recession farming? ....

25 Is there any change in the crops you grow now and in the past? Yes ☐ No ☐

If yes, which are the crops and why have you changed the type of crops? …………..

26 In the past, did you use any methods of conserve moisture (hunyoro)?

27 Do you own livestock? Yes ☐ No ☐

28 Which livestock do you own?

Cattle	Goats	Sheep	Pigs	Poultry

29 What is the most common disaster that affects you? Drought ☐ Floods ☐

30 How did you cope with food shortages in times of drought in the past?...

31 How do you cope in times of food shortage these days?..

32 Traditionally, how did you cope with floods?..

APPENDIX 2: Focus group discussions

Date of discussion_________________

Ward___________

1 Do you know about indigenous ways of seasonal weather forecasting?
2 How timely do you receive information about weather forecasts for the Meteorology department? If at all?
3 Which method of forecasting is more reliable?
4 Which indicators do you base your forecasting on?
5 Are the indicators (plants animals) still in abundance these days?
6 Does indigenous knowledge and science give the same forecast?
7 Do you use weather forecasts to plan agricultural activities?
8 Are you noticing any change in rainfall patterns and temperatures? How have they changed?
9 Between rainfed and flood plain agriculture, which gives you better yields?
10 Which crops did you grow in the past?
11 Which severe droughts/ floods do you remember?
12 What did you notice prior to their coming?
13 Since the construction of the dams, did you have to move permanently from your homes or it seasonal?
14 What are your coping strategies in times of drought and floods?
15 What’s the communities’ perception on traditional knowledge?
16 In the past, how did you cope with drought and floods?

APPENDIX 3 Key informant interviews

Interviewer; ………………………………………………………………........................

Date of interview; …………...

1 What are your social standing/ occupation?
2 What is your age?
3 How long have you resided / worked in Mbire?
4 Do you know about indigenous ways of seasonal weather forecasting?
5 How timely do you receive information about weather forecasts?
6 Which method of forecasting do you find more reliable?
7 Does indigenous knowledge and science give the same forecast?
8 Do you use weather forecasts to plan agricultural activities?
9 How many people have fields in the flood plains and do they get sustainable harvests from them?
10 Between rainfed and flood plain agriculture, which gives you better yields?
11 What are your coping strategies in times of drought and floods?
12 What's the communities' perception on traditional knowledge?
13 Do you think rainfall patterns and temperatures have changed? Yes/ No. If yes how and when did you start noticing change?