ROLE OF INDIGENOUS KNOWLEDGE IN SEASONAL CLIMATE FORECAST FOR AGRICULTURAL PRODUCTION IN BUNGOMA CENTRAL SUB-COUNTY, BUNGOMA COUNTY, KENYA

BARASA CAROLEEN AUMA, B.ED (ARTS)
C50/CE/11315/2008

A THESIS SUBMITTED TO THE SCHOOL OF HUMANITIES AND SOCIAL SCIENCES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ARTS (CLIMATOLOGY) OF KENYATTA UNIVERSITY

SEPTEMBER 2016
DECLARATION

I declare that this thesis is my original work and has not been previously presented for a degree in Kenyatta University, or in any other university. The work presented herein has been carried out by me and all sources of information acknowledged by means of references.

Signature………………………………………Date……………………………………

Caroleen Auma Barasa (C50/CE/11315/2008)
Department of Geography

SUPERVISORS

We confirm that the work reported in this thesis was carried out by the candidate under our supervision.

Signature………………………………………Date……………………………………

Prof. Chris A. Shisanya, PhD
Department of Geography

Signature ………………………………………...Date……………………………

Dr. George L. Makokha, PhD
Department of Geography
DEDICATION

I dedicate this work to my family; Amos, Joshua, Jude, and Benedict who gave me ample time to study and moral support, especially when we were overburdened financially.
ACKNOWLEDGEMENTS

First to God Almighty, who gave me strength and the enthusiasm of going on despite the challenges I had. To my two supervisors, Prof. Shisanya and Dr. Makokha, who tireless assisted in nurturing me in accomplishing this work and were always readily available right from the initial stage of the development of this thesis for advice, guidance and constructive criticism. I am also indebted to the Chwele and Mukuyuni wards residents, agricultural officers and community elders for their support, to the enumerators and analysts who made this work a success. Last but not least, to my husband Amos Wafula Wekesa, who constantly gave me financial, moral and advisory support towards undertaking this study. To all others who offered critical assistance and I have not directed specific acknowledgement remarks, your support are highly esteemed and appreciated.
## TABLE OF CONTENTS

DECLARATION.................................................................................................................. II

DEDICATION..................................................................................................................... III

ACKNOWLEDGEMENTS.................................................................................................... IV

TABLE OF CONTENTS ...................................................................................................... V

LIST OF TABLES ................................................................................................................ VIII

LIST OF FIGURES .............................................................................................................. IX

ABBREVIATIONS USED IN THE STUDY ........................................................................... X

OPERATIONAL DEFINITION OF TERMS ....................................................................... XI

ABSTRACT ......................................................................................................................... XII

CHAPTER ONE: INTRODUCTION ..................................................................................... 1

1.1 BACKGROUND TO THE STUDY ................................................................................. 1
1.2 STATEMENT OF THE PROBLEM .............................................................................. 4
1.3 RESEARCH QUESTIONS ............................................................................................ 6
1.4 STUDY OBJECTIVES.................................................................................................. 6
   1.4.1 General objective ............................................................................................... 6
   1.4.2 Specific objectives ............................................................................................. 6
1.5 HYPOTHESES ........................................................................................................... 6
1.6 JUSTIFICATION AND SIGNIFICANCE OF THE STUDY .......................................... 7
1.7 SCOPE AND LIMITATIONS OF THE STUDY .......................................................... 8

CHAPTER TWO: LITERATURE REVIEW ......................................................................... 9

2.1 INTRODUCTION ......................................................................................................... 9
2.2 INDIGENOUS KNOWLEDGE INDICATORS AND USE OF THE FORECASTS ............... 9
2.3 FARMERS’ PERCEPTION OF BOTH SCIENTIFIC AND IK FORECASTS ...................... 16
   2.3.1 Dissemination .................................................................................................... 17
   2.3.2 Access, Use and Constraints of Scientific Forecasts ......................................... 17
   2.3.3 Reliability and Accuracy .................................................................................. 20
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4 Socio-economic Factors Influencing Forecast Application</td>
<td>22</td>
</tr>
<tr>
<td>2.5 Theoretical Framework</td>
<td>25</td>
</tr>
<tr>
<td>2.6 Conceptual Framework</td>
<td>26</td>
</tr>
<tr>
<td>2.7 Gaps Identified in Literature</td>
<td>29</td>
</tr>
<tr>
<td><strong>CHAPTER THREE: RESEARCH METHODOLOGY</strong></td>
<td>31</td>
</tr>
<tr>
<td>3.1 Introduction</td>
<td>31</td>
</tr>
<tr>
<td>3.2 Research Design and Variables</td>
<td>31</td>
</tr>
<tr>
<td>3.3 Study Area</td>
<td>32</td>
</tr>
<tr>
<td>3.3.1 Geographical Location of the Study Area</td>
<td>32</td>
</tr>
<tr>
<td>3.3.2 Topography</td>
<td>32</td>
</tr>
<tr>
<td>3.3.3 Climate</td>
<td>32</td>
</tr>
<tr>
<td>3.3.4 Human Population</td>
<td>33</td>
</tr>
<tr>
<td>3.3.5 Socio-economic Activities</td>
<td>33</td>
</tr>
<tr>
<td>3.4 Target Population</td>
<td>34</td>
</tr>
<tr>
<td>3.5 Sample Size</td>
<td>37</td>
</tr>
<tr>
<td>3.6 Sampling Procedure</td>
<td>37</td>
</tr>
<tr>
<td>3.6 Research Instruments</td>
<td>40</td>
</tr>
<tr>
<td>3.6.1 Questionnaire</td>
<td>40</td>
</tr>
<tr>
<td>3.6.2 Interview</td>
<td>41</td>
</tr>
<tr>
<td>3.7 Data Collection</td>
<td>41</td>
</tr>
<tr>
<td>3.7.1 Questionnaire</td>
<td>41</td>
</tr>
<tr>
<td>3.7.2 Key Informant Interviews</td>
<td>42</td>
</tr>
<tr>
<td>3.7.3 Focus Group Discussion</td>
<td>42</td>
</tr>
<tr>
<td>3.8 Data Analysis</td>
<td>43</td>
</tr>
<tr>
<td>3.8.1 Chi-square</td>
<td>43</td>
</tr>
<tr>
<td>3.8.2 Factor analysis</td>
<td>45</td>
</tr>
<tr>
<td>3.9 Data Management</td>
<td>46</td>
</tr>
<tr>
<td>3.9.1 Data Coding and Cleaning</td>
<td>46</td>
</tr>
<tr>
<td>3.9.2 Data Confidentiality</td>
<td>47</td>
</tr>
</tbody>
</table>
CHAPTER FOUR: RESULTS AND DISCUSSION ......................................................... 48

4.1 INTRODUCTION .............................................................................................. 48

4.2 INDIGENOUS KNOWLEDGE INDICATORS, DISSEMINATION AND USE OF THE FORECAST .......................... 48

4.2.1 Indigenous Knowledge Indicators .................................................................. 50

4.2.2 Access of IK Forecast Information ................................................................. 57

4.2.3 Use of Indigenous Knowledge Forecasts ....................................................... 59

4.3 FARMER’S PERCEPTION OF BOTH SCIENTIFIC AND IK SEASONAL CLIMATE FORECAST .................. 60

4.3.1 Perception on Reliability of the Indicators ..................................................... 60

4.3.2 Accuracy of the forecast ................................................................................. 63

4.3.3 Access of Forecast ......................................................................................... 64

4.3 Use of the Forecast ............................................................................................ 68

4.3.5 Improving Agricultural Production ............................................................... 70

4.4 SOCIO-ECONOMIC FACTORS THAT INFLUENCE FORECAST USE .............................................. 77

4.4.1 Demographic Characteristics of Respondents ............................................... 78

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS 100

5.1 INTRODUCTION .............................................................................................. 100

5.2 SUMMARY OF THE MAIN FINDINGS ............................................................ 100

5.3 CONCLUSION .................................................................................................. 102

REFERENCES ....................................................................................................... 106

APPENDICES ......................................................................................................... 113

APPENDIX 1: CHI-SQUARE .................................................................................. 113

APPENDIX II ......................................................................................................... 114

APPENDIX III: QUESTIONNAIRE ......................................................................... 115

APPENDIX IV: FACE TO FACE INTERVIEW GUIDE FOR THE ELDERS OF THE COMMUNITY ........... 122

APPENDIX V: FOCUS GROUP DISCUSSION GUIDE .............................................. 123
LIST OF TABLES

TABLE 3.2: SAMPLE SIZE AS PER SUB-LOCATION .......................................................... 40
TABLE 4.1: IK INDICATOR USED TO FORECAST .......................................................... 51
TABLE 4.2: MODES FOR DISSEMINATION OF IK FORECASTS TO THE FARMERS.......... 58
TABLE 4.3: RELIABILITY OF THE IK INDICATORS USED BY THE COMMUNITY ........... 61
TABLE 4.5: RESPONSE STRATEGIES TO THE FORECAST ............................................. 71
TABLE 4.6: THE OUTCOME OF RESPONSE STRATEGIES VARIOUS .............................. 73
TABLE 4.7: RESPONDENTS’ WAY OF LAND ACQUISITION .......................................... 87
TABLE 4.8: CROPS GROWN IN THE STUDY AREA ......................................................... 88
TABLE 4.9: FARM TOOLS OWNED BY FARMERS ......................................................... 89
TABLE 4.10: FACTORS LIMITING USE OF FORECASTS .............................................. 90
TABLE 4.11: TABLE OF COMMUNALITIES ................................................................. 93
LIST OF FIGURES

FIGURE 2.6: CONCEPTUAL FRAMEWORK FOR FORECAST GENERATION, ACCESS & USE ........28
FIGURE 4.1: RELIABILITY RATING FOR INDIGENOUS KNOWLEDGE FORECAST .............62
FIGURE 4.2: RELIABILITY RATING FOR SCIENTIFIC FORECAST ................................63
FIGURE 4.3: MODE OF DISSEMINATING SCIENTIFIC FORECASTS TO THE FARMERS ....65
FIGURE 4.4: COMPARATIVE BAR GRAPH FOR PRECIPITATION IN THE STUDY AREA (2009-2012) ........................................................................................................................................74
FIGURE 4.5: SHOWING THE MAM RAINFALL OF 2013 ................................................77
FIGURE 4.6: DISTRIBUTION OF RESPONDENTS BY AGE ........................................79
FIGURE 4.7: DISTRIBUTION OF THE RESPONDENTS BY GENDER ...........................80
FIG 4.8 FARMERS HOUSEHOLD COMPOSITION BY AGE OF DEPENDANTS ...............81
FIGURE 4.9: MARITAL STATUS OF RESPONDENTS ..................................................83
FIGURE 4.10: EDUCATION LEVEL OF RESPONDENTS .............................................84
FIG 4.11: RESPONDENTS SOURCES OF INCOME .....................................................85
FIGURE 4.12: LAND SIZES OWNED BY RESPONDENTS SOURCE: FIELD, (2013) ........86
# Abbreviations Used in the Study

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBOs</td>
<td>Community Based Organizations</td>
</tr>
<tr>
<td>DMCN</td>
<td>Drought Monitoring Center Nairobi</td>
</tr>
<tr>
<td>FAO</td>
<td>Food Agriculture Organization</td>
</tr>
<tr>
<td>FGDs</td>
<td>Focused Group Discussions</td>
</tr>
<tr>
<td>IGAD</td>
<td>Intergovernmental Authority on Development</td>
</tr>
<tr>
<td>IK</td>
<td>Indigenous Knowledge</td>
</tr>
<tr>
<td>IKS</td>
<td>Indigenous Knowledge Systems</td>
</tr>
<tr>
<td>IKF</td>
<td>Indigenous Knowledge Forecasts</td>
</tr>
<tr>
<td>ISDR</td>
<td>International Strategy for Disaster Reduction</td>
</tr>
<tr>
<td>KBS</td>
<td>Kenya Bureau of Statistics</td>
</tr>
<tr>
<td>KMS</td>
<td>Kenya Meteorological Services</td>
</tr>
<tr>
<td>KIBHS</td>
<td>Kenya Integrated Household Budget Survey</td>
</tr>
<tr>
<td>NMS</td>
<td>National Meteorological Service</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Packages for Social Sciences</td>
</tr>
<tr>
<td>SST</td>
<td>Sea Surface Temperatures</td>
</tr>
<tr>
<td>SCF</td>
<td>Scientific Climate Forecast</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td>UNEP</td>
<td>United National Environment Program</td>
</tr>
<tr>
<td>UNSO</td>
<td>Office to Combat Desertification</td>
</tr>
<tr>
<td>WMO</td>
<td>World Meteorological Organization</td>
</tr>
</tbody>
</table>
Operational definition of terms

**Agricultural production:** Is the science, art, or occupation concerned with cultivating land raising crops

**Indigenous knowledge:** Is a body of knowledge built up by a group of people through generations of living in close contact with nature; it is the knowledge used by local people to make a living in a particular environment.

**Indigenous knowledge forecast:** This is the knowledge system developed by a community to predict weather

**Indigenous knowledge system:** This is human experiences, organized and ordered into accumulated knowledge with the objectives to utilize it to achieve quality of life and to create a livable environment for both human and other forms of life.

**Indigenous knowledge indicators:** Signs in a given environment that occur to indicate the approaching season

**Perception:** Is the way one thinks about or understands something; the ability to understand or notice something

**Scientific forecasts:** This is the application of science and technology to predict weather.

**Seasonal climate forecast:** This is the provision of information about the expected state of regional climate beyond the time frame of long-range weather forecast (10-14) days

**Socio-economic factors:** Are the social and economic experiences and realities that help, mold one's personality, attitude, and lifestyle.

**Climate variability:** This is the deviation of climate statistics over a given period of time for example, a month, season or year when compared to long-term statistics for the same calendar period.

**Livelihood:** These are activities that the community involves in for survival
Indigenous knowledge is the local knowledge unique to a given culture or society. It is the basis of decision making in agriculture, healthcare, food preservation and natural resource management. This study was set to establish the existence of Indigenous knowledge in the community of Chwele and Mukuyuni wards of Bungoma Central Sub-County, Bungoma County and its role in seasonal climate forecast. The general objective of this study was to examine the role of indigenous knowledge in seasonal climate forecast for agricultural production in Chwele and Mukuyuni wards. The specific objectives were: (a) To identify and document IK indicators used in forecasting weather in the study area and how the forecast is received and used by farmers, (b) to evaluate farmers’ perception of both scientific and indigenous knowledge forecast in improving agricultural production and (c) to examine socio-economic factors influencing the use of the forecasts for agricultural production. Data collection was done using questionnaires, key informant interviews and focus group discussions. The study employed a descriptive survey design which involved the use of both quantitative and qualitative techniques. The study was stratified into six sub-locations; each was allocated the number of respondents that were to be drawn from it proportionately; according to its total number of farmer households. A list of all farmer households in all sub-locations was sought and random sampling was executed. Using ballot method all required respondents were drawn. Questionnaires were administered to 100 respondents to achieve the three objectives. 5 key informants were included for the interviews and two focus group discussions of 8 members each gave additional information on these three objectives. Scientific forecast on rainfall in the study area for the last 4 years was assembled from Bungoma water supply station and comparison made with the IK forecast as given by the key informants who use IK to forecast weather, the year of reference was 2013 and their previous experiences. Field survey data was analyzed by SPSS, presented and the hypotheses tested by chi-square and factor analysis. The findings revealed that the community relied on IK for seasonal forecast as shown by chi square test \( p > .05 \). Moreover, farmers’ knowledge of birds, insects, animals, plants, wind and astronomical indicators was used to predict weather. It was also evident that over 70% of the respondents in Chwele and Mukuyuni Wards access scientific forecasts and their main sources are radio and neighbors. Of those who access the scientific forecasts, only 30% have confidence in it. 75% rate forecast to be useful despite their lack of confidence. The farmers perceived that indigenous knowledge indicators were accurate and reliable in their forecast compared to the scientific forecasts which they termed as unreliable and untimely. It was established that uncertainties about seasonal forecasts was one of the critical factors that forced farmers to continue using IK. It was clear that farmers’ socio-economic status may impede or enhance the use of forecasts. Factor analysis was used to reduce the factors mentioned, and only 5 were extracted as having significant influence to forecast use. It is recommended that IK should be used to augment scientific forecast to enhance credibility and usability of these forecasts. Scientific forecast should be downscaled to farmer accompanied with advice on how the forecast should be used to enhance their coping strategies. Farmers should also be provided with farm inputs in order for them to take advantage of a good season or avert risks in a poor season. It is suggested that further research on IK in the study area should be done in all aspects of environmental issues where IK is used, a study to establish the rational of IK indicators used should also be carried out and gender involvement in forecast application should be investigated.
CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Historically and up to date, local communities in different parts of the world have continued to rely on indigenous knowledge (IK) to conserve the environment and deal with natural disasters. This is partly due to lack of accessibility and difficulty in interpreting conventional weather forecast. Traditionally, farmers have used traditional knowledge to understand weather and climate patterns in order to make decisions about crop and irrigation cycles. This knowledge is the sum of facts that are known or learned from experience or acquired through observation and handed down to generations. The knowledge is adapted to local conditions and needs (IGAD, 2006). Indigenous knowledge system is a body of knowledge of indigenous people of a particular geographical area that have survived on for a very long time (Mapara, 2009). Indigenous knowledge, particularly in the African context, had long been ignored and maligned by outsiders.

Today however, there is increasing acknowledgement of the relevance of Indigenous Knowledge as an invaluable and underused knowledge reservoir, which presents developing countries, particularly, Africa with a powerful asset in agriculture, environmental conservation and natural disaster management (UNEP, 2006), as such, recommendation of scientific and Indigenous knowledge to be integrated particularly in the field of environment and development was suggested. In addition, a growing number of African and International development agencies are recognizing that local-level
knowledge and organization provide the foundation for participatory approaches to development, they are both cost effective and sustainable (Warren, 1992).

In Africa, peasant farmers and pastoralists alike, especially those living in dry lands have developed their own forecast schemes based on observation of behavior of surrounding nature (Lucio, 1999; Ngugi, 1999; Shumba, 1999). The importance of integrating both the scientific and indigenous climate forecast information for farm level decision is gaining momentum as documented in Mozambique and Kenya by Lucio (1999) and Ngugi (1999), respectively. This would lead to forecasts and recommendations that are more plausible and useful at local scale and increase the likelihood that the information will be used more to prepare for future. Recent studies of the impact of rainfall forecast in South Africa indicate that there is a considerable gap between the information needed by farmers and that which is provided by the National Meteorological Services (NMS) (Blench, 1999). For example, the NMS gives forecasts that correspond to very large areas, yet rainfall in South Africa can vary considerably over a few kilometers (Kihupi, 2002 and Kihupi 2000). According to this report, most critical information required by farmers is the time when the rainy season begins. The farmers do not have this information in time to adjust their farm decisions because there are too many stages in the delivery system (Ogallo, 1989). These suggest a growing need to compliment modern methods of forecasting with traditional ones. In Zimbabwe for instance, locals have been coping with drought by integrating scientific and IK climate forecasting techniques (Shumba, 1999).
In Kenya, many communities rely on indigenous knowledge for agriculture, food processing and storage, but IK has not been ventured in as an important resource for enhancing agricultural production in most areas. Kenya being an agricultural country that depends on rain-fed agriculture requires maximum use of seasonal climate forecast. The regional nature of seasonal forecast may limit their relevance for planning at national and local level. Finer scale forecast and more fine-tuned early warning systems, accompanied by a rapid delivery of information is needed (Ogallo, 1989). Officially, Kenya Meteorological Services (KMS) is responsible for monitoring and forecasting weather and climate in Kenya, including seasonal forecast. In spite of the slight improvement in forecasting accuracy, the present forecasting accuracy, which is 75%, is still not sufficient as challenges are still numerous due to the strong spatial and temporal variability nature of weather events (Ogallo, 1989; Nyezi et al., 1999; Zorita and Tilya, 2002). These scientific forecasts are formulated at a much larger scale, diverging with local needs.

Indigenous knowledge is still intact among indigenous or local communities in many parts of Africa and the world. These communities have been using IK in their day to day life, but with the coming of modern methods of weather forecasting, these traditional methods have tended to be ignored (Mhita, 2006). This knowledge is under threat of disappearance due to lack of systematic documenting and coordinated research for investigating its relevance and when the old people who are the custodians of the knowledge pass away, the knowledge which has been accumulated for many years is lost (UNEP, 2008). There is therefore need to promote these methods taking cognizance
of climate change which makes modern methods less reliable especially in rural areas where there is inadequate weather forecasting instruments.

1.2 Statement of the Problem

Chwele and Mukuyuni Wards (found in Bungoma Central Sub-County) suffer food poverty of about 42% (GoK, 2010) in spite of the area being agriculturally potential due to rich soils. Agriculture is the main source of livelihood in the area. This region relies on rain-fed agriculture which is susceptible to vagaries of weather. Weather is the only factor over which man has no control hence it has overwhelming dominance over the success or failure of the agricultural enterprise. Therefore use of seasonal climate forecast is not only desirable but also necessary (Phillips et al., 2002 and Phillips, 2003). Although Kenya Meteorological Services issues seasonal climate forecasts (Oduor et al., 2002), climate variability continues to affect life support systems on which small holder farmers depend, severely affecting not only households but also national food security and general social order in Kenya. This information is expected to assist farmers in decision making in order to minimize risks, but due to the large geographical coverage of the forecast there has been cases of poor yield due to crop failure in the region especially of annual crops and users’ complain of inaccurate forecasts especially when the forecasted event does not occur to the expected magnitude. This has degraded the confidence in the forecast (Ogallo, 1989), thereby compromising the livelihoods so much so that despite the region being agriculturally productive, it suffers food poverty. This study critiques channels used by Kenya Meteorological services to disseminate climate forecast and their effectiveness. It also unveils underutilized Indigenous knowledge that is indigenous to the people, acquired through observation of
environmental changes within the farmers’ environment. Meteorological forecast are highly technical in nature such that most small scale farmers cannot understand them hence they derive minimal or no benefits from such forecasts. Beside, these forecasts are available at a cost which the rural people cannot afford. This leaves them vulnerable to vagaries of weather that may lead to poor yield and food insecurity. So the thrust of this research was to find indigenous forecasting solutions to the problem sited above, by taping the indigenous knowledge, which is less technical in nature and inexpensive to the user. It gives location specific forecasts which could be ideal to the area that might not be captured by the large geographical coverage forecast given by the conventional mode. IK forecasts are simple to understand due to the simplicity of the language used and its informal way of dissemination. Modern methods tend to generalize the findings more particularly, with scarcity of forecasting stations in the country. There is need for research in indigenous methods to complement the scientific forecasts so as to produce more reliable and valid information that will enhance forecast application. Furthermore, this knowledge is under threat of disappearance due to lack of documentation and systematic research for its relevancy and when the old people who are the custodians die, the knowledge which was acquired for a long time is lost (Chang’a et al., 2010; UNEP, 2008). Information on IK is not being fully harnessed to help the greater population in Kenya. The study area is basically an agricultural region. It’s development and consequent contribution to that of the nation centers’ upon this sector.
1.3 Research questions

i. What are the IK indicators used in seasonal climate forecast and how is the information received and used by farmers in the study area?

ii. How do farmers perceive scientific and IK forecasting methods?

iii. What relationship is there between socio-economic characteristics of farmers and the use of both scientific and IK seasonal forecasts?

1.4 Study objectives

1.4.1 General objective

The general objective of this study was to examine the role of IK in seasonal climate forecast for agricultural production in Chwele and Mukuyuni wards of Bungoma Central Sub-county, Bungoma County.

1.4.2 Specific objectives

i. To determine and document IK indicators used in seasonal climate forecast in the study area and how the information is received and used by farmers.

ii. To evaluate farmers’ perception of both scientific and indigenous knowledge forecasting methods.

iii. To examine socio-economic factors influencing the use of both scientific and indigenous knowledge seasonal forecast for improving agricultural production.

1.5 Hypotheses

i. \( H_0 \) The community of the study area does not use IK in seasonal climate forecast
ii. H₀ There is no relationship between socio-economic characteristic of farmers and the use of either scientific and IK forecast information for agricultural production.

1.6 Justification and Significance of the study

Study area is in the upper midland ecological zone which is agriculturally productive and therefore depends on agriculture for food and as a means of acquiring finance to sustain their economic needs. Land is a valuable resource, but to due vagaries of weather, the area suffers food poverty of 42%. Agricultural decision making is based on anticipated rainfall weather forecast, and in particular, seasonal rainfall forecasts have limited accessibility. These leaves farmers with no option but to rely on forecast derived from indigenous indicators. Where the meteorological forecasts are accessed, limited understanding of the forecast and poor skills in making appropriate agro-meteorological decisions affect its application. The significance of the study lies in the need to bridge the gap between the climate products given and farmers need to enhance accuracy (Patt and Gwata, 2002) and therefore, farmers are likely to have confidence in the forecast and use it in decision making.

Identifying the indigenous weather forecast indicators and acquiring information on how they are used will not only improve food production in this area, but also be useful to other people living under similar environmental conditions elsewhere. It is also anticipated that knowledge on the interpretation of the behavior or symptoms from the environmental indicator will be documented, so that the indigenous weather forecasting
is improved. Behaviors or signs that are similar should have some weather forecast inferred from them for a particular area. So that it is hoped that the findings from this research will help bring this much needed alignment and thus solve the existing problem where a multitude of differing forecast are derived from same indicators and behaviors. This should add value to the indigenous forecasting systems and also improve its precision. It is anticipated that this research will encourage scholars and readers to undertake similar research on indigenous knowledge forecasting indicators.

1.7 **Scope and limitations of the study**

Only small scale farmers were considered for the study as commercial large scale farmers have enough resources to adequately respond to the forecasts. The study focused on IK in seasonal climate forecast and not all aspects in which IK is used. The study focused on only annual crops were considered as they are the ones mostly affected by weather events. Only rural residents and not urban ones were considered for the study. The limitation of this study was linked to the educational level of the respondents. The researcher mostly used personal interviews as most of the respondents were not able to infill the questionnaire by themselves; hence it was time consuming. Furthermore, there were no original lists of farmers in the villages of the study area. This forced the researcher to go for a reconnaissance visit to generate lists of farmers before random sampling the required number of respondents. This was not an easy task.
CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter divides literature review in four parts. The first section presents literature on indigenous knowledge indicators used for seasonal climate forecast and how the information is received and used for agricultural production in the study area, while the second section focuses on farmers’ perception of both IK and scientific forecast in improving agricultural production. Part three focuses on socio-economic factors influencing the use of indigenous knowledge in weather forecasting as well as use of the forecasts in agricultural production. The fourth section covers the conceptual framework that shows how various variables interact and a summary of selected literature and identified gaps.

2.2 Indigenous Knowledge Indicators and Use of the Forecasts

Indigenous Knowledge (IK) can be defined as a body of knowledge built up by a group of people through generation of living in close contact with the nature; it is knowledge used by local people to make a living in a particular environment (Roncoli et.al. 2002 and Warren, 1992). IK has been used in such areas as biodiversity conservation, disaster prediction and management and in agriculture for seasonal rainfall forecast. IK is learned and identified by farmers within a cultural context and the knowledge base reflects the specific language, beliefs and cultural processes (Shumba, 1999 and Warren, 1991). Many communities in Africa rely on IK for weather forecast for their farmland activities. Each community has its own IK indicators for weather forecast. The rural communities of Ilocos Norte Province of the Philippines rely heavily on Indigenous
weather forecasts to plan and prepare agro forestry activities as well as in disaster prevention (Galacga and Balisakan, 2009). These farmers derive their weather forecasts from observations of the atmosphere and astronomical conditions, plants and the behaviour of organisms such as animals, birds, and mammals. Using these, farmers prepare their upland farmlands in time to ensure that vegetative cover is established before the heavy rainfall season. This helps to prevent soil erosion during the heavy rainfall. While this study entirely focused on disaster prevention and management, the current study focuses on the use of such information for agricultural production (Roncoli et.al, 2005).

Most African communities still rely on traditional forms of climate forecasting by mainly using environmental, meteorological and astronomical indicators. Some even still rely on traditional ‘rainmakers’ (Warren, 1995). Local communities have developed intricate system of gathering, predicting, interpreting and decision making in relation to weather. A study in Nigeria, for example shows that farmers are able to use knowledge of weather systems such as rainfall, thunderstorm, windstorm and sunshine to prepare for future weather (Ajibade and Shokemi, 2003).

Mararike (1999) discusses the use of indigenous knowledge systems in predicting rain or drought seasons. The people try to make meaning out of the environment in which they live. This knowledge is key to any planning process at the lowest level and enables locals to act in a timely way. While there is acknowledgement of the importance of IK, there is no documentation of such knowledge in the study area. Therefore, identification and documentation of effective IK indicators used for seasonal climate forecast in
Chwele and Mukuyuni wards is imperative. According to studies carried out by UNEP (2002), the Hausa of Northern Nigeria, for example, developed a wealth of indigenous knowledge systems to cope with vulnerability to drought and famine in sub-humid to arid regions of the Sahel. People in rural or remote areas rely mostly on indigenous weather forecasting systems to get daily and seasonal weather forecasts. These indicators are derived from the environment and differ from place to place.

Indigenous methods of forecasting are known to complement farmers’ planning activities in Nigeria. Pratt (2001) argues that practitioners of traditional knowledge, perceptive members of the community observe the sky colour, cloud and wind patterns, flowering cycles and fauna movement to determine the imminence of rain. Star pattern provide information on the arrival of seasons and moon crescents and rings of its nature, while historical knowledge indicates which long term cyclical weather pattern is prevailing. Animals grazing and watering behavior are also perceived as indicators of forthcoming meteorological events and pastoralists are not adverse to most mystical indicators such as intestology; studying the intestines of a slaughtered animal could give a clue on the expected season. Pratt’s study did not stress on the use of this forecast knowledge in enhancing agricultural production, an area this study looked at.

Manyatsi (2011) carried out a research in Swaziland on the use of indigenous knowledge to manage hydrological disasters. The study revealed that a variety of methods are used to predict the weather conditions such as environmental cues and the behavior of animals. The nesting position of Ploceus ssp bird is used to predict floods. The cry of cuculus solitaries bird signals the start of the wet season between August and November. On hearing this cry, the farmers assemble their inputs. Manyatsi (2011) also
established that when there is abundance of creatures such as butterflies, locusts and grasshoppers during the farming season then drought would be imminent. Sign of wet conditions approaching makes farmers embark on land preparation in anticipation of the wet rainfall season.

Mawere (2010) carried out a study on the potential of IK to re-establish a moral and virtuous society in selected areas in Zimbabwe and Mozambique and established that indigenous methods of weather forecasting are very useful, especially in summer and immediately after harvesting when crops, like finger millet, would be in need of threshing and winnowing. The current study sought to explore and analyze the uses of indigenous weather forecasts in Chwele and Mukuyuni Wards in Kenya, a region which has a different environment and agronomic practices.

Nyong et al. (2007) carried out a study in the African Sahel on the value of indigenous knowledge in climate change mitigation and adaptation strategies and showed that indigenous knowledge has been applied in this region in climate change mitigation. In the area of adaptation, indigenous weather forecasts have been utilized in the assessment of vulnerability and implementation of adaptation strategies. Nyong et al. (2007) further asserted that although research is gradually recognizing the importance of indigenous knowledge systems in developmental studies, the value of indigenous knowledge in climate change studies has received little attention. This neglected indigenous knowledge included indigenous methods of weather forecasting and their utilization in climate change.
DMCN (2004) carried out a pilot project whose objective was to record traditional weather monitoring prediction indicators (see table 2.1). It was established that among the Banyore community of western Kenya, rainfall prediction is still prevalent and is done by Nganyi elders. According to them the capacity to make rain is inherited in the Nganyi family. Nganyis have an exclusive shrine where a huge snake and particular tall trees aid in monitoring and predicting weather. They have further mastered the winds and associated good or bad rainy seasons with particular wind direction. In addition to indicators, rainfall predictions involve facilities such as 3 stones, a hole, a chicken, a sheep and a pot among others. A report by DMCN (2004) further established that some clan heads use meteorological information to augment traditional forecast before issuing it to the communities. Respondents however complained that meteorological forecast was mostly inaccurate due to the very general nature of the forecast that cover a large geographical area.

Patt and Gwata (2002) argue that probabilistic forecast that cover a wide area can generate confusion and discourage users from incorporating the forecast in decision-making. Respondents therefore recommended for specific forecast that take cognizance of the local needs. Better access to information is mooted as a potential solution to sustainable livelihoods, in an environment where indigenous knowledge, the historical mainstay of survival is diminishing or being under-valued alongside western knowledge that, while valuable, is rarely textured by local experience (Pratt, 2001). This study paid attention to IK as a method of weather forecasting to ensure that it is not eroded away. Thus the current study determined and documented IK indicators used for forecasting weather and how the information is disseminated and used for agricultural production in
the study area. The focus for this research was on identification and analysis of indigenous weather forecasting methods and their utilization by the community in Chwele and Mukuyuni Wards to ensure sustainable livelihood.
Table 2.1: IK indicators used for weather forecasting

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Local/biological name</th>
<th>Sign implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants</td>
<td>• Orembe; shade leaves</td>
<td>• Start of dry season</td>
</tr>
<tr>
<td></td>
<td>• Shading flowers</td>
<td>• Rainy season</td>
</tr>
<tr>
<td></td>
<td>• Fruiting, blooming of trees</td>
<td>• Rainy season</td>
</tr>
<tr>
<td>Animals</td>
<td>• Frogs; absence and seldom crocks</td>
<td>• Beginning of dry season</td>
</tr>
<tr>
<td></td>
<td>• Birds; cry around the river</td>
<td>• Rainy season</td>
</tr>
<tr>
<td></td>
<td>• Move from south to north</td>
<td>• Rain</td>
</tr>
<tr>
<td>Meteorological/astronomical</td>
<td>• Whirlwinds appearance</td>
<td>• Long rains</td>
</tr>
<tr>
<td></td>
<td>• Clouds; thicken at horizon</td>
<td>• Good rains</td>
</tr>
<tr>
<td></td>
<td>• Cluster star in the east</td>
<td>• Short rains</td>
</tr>
<tr>
<td></td>
<td>• In the west</td>
<td>• Long rains</td>
</tr>
</tbody>
</table>

2.3 Farmers’ Perception of Both Scientific and IK Forecasts

Since the inauguration of regional climate outlook forums prior to the 1997/98 El Niño event (WMO, 2010) around the world and Great Horn of Africa climate outlook forums (GHACOF) in Eastern Africa, there has been effort from the climate application community to have farm household (and other sections of the economy) access and utilize climate forecast information (Philips et al. 2002; Oduor et al., 2002). This has been with an aim of reducing weather and climate related risks for sustainable agricultural development. In spite of the effort, application of seasonal climate forecast at the level of an individual farmer remains the greatest challenge to small holder farmers particularly those in Africa. Many a times climate forecast cover a wide geographical area (DMCN, 2004) and fail to take into consideration local factors influencing rainfall. Studies by Patt and Gwata (2002), Philips (2003) and Mwinamo (2001) give evidence that climate forecast predictions do not trickle down to the user, especially resource poor farmer.

If the individual users receive forecast product, are they able to use them? It is important to target farmers in disseminating seasonal climate forecast products since decisions that determine production are made at the scale of the individual. Secondly, for maximum benefits of forecast product a thorough understanding of human social and economic system within which climate forecast is applied is crucial (Kamal and Subbich, 1999).
2.3.1 Dissemination

Previous studies on climate forecast application show that radio is the leading source of forecast information (Philips et al. 2001; Philips et al., 2003; Ngugi, 2002). The question one may ask, how effective is the radio? Do media broadcasts pass forth the message as given by the KMS? According to Oduor et al., (2002) seasonal climate forecast is most useful for agricultural and food security planning yet its access and use remain poor and limited to few farmers. As such they proposed a change in the flow of forecast information. This study argues that IK knowledge when integrated with scientific will bridge this gap.

According to Oduor et al., (2002) KMS should give forecast to stakeholders directly and community radio stations should be set up to provide forecast in vernacular languages. The latter proposal is in agreement with Mwinamo (2001) who argued that the large segment of the rural population in rural areas being illiterate, dissemination of forecasts in local languages has potential to reach a wide audience. It is notable that both the current and proposed information flow lacks a feedback mechanism. Therefore, there is need for the users of forecast information to report back to KMS to verify the information and assess the impact. On the other hand, farmers get IK forecasts on time because of its informal way of dissemination.

2.3.2 Access, Use and Constraints of Scientific Forecasts

Application of scientific climate forecast (SCF) has evolved in conjunction with advances in the accuracy and utility of the climate prediction since the early 1990’s. This had a primary purpose of developing a forecaster-user dialogue and provides an avenue
for information exchange. This section critiques access use and constraints of meteorological forecasts to farmers.

There is evidence that farmers’ have access to climate information but there are mixed signals on how they perceive it; how a farmer perceives the forecast affects the utilization of the forecasts. Studies carried out by Philips et al., (2002), Philips (2003) and Ngugi (2002), show that majority of farmers access forecast information mainly through radio with a good number getting the forecast through word of mouth. While acknowledging importance of media in the dissemination of forecast to the public, the media responds to information with varied degrees; tending to emphasize extreme climate events. For instance, in Zimbabwe where El Niño is associated with drought, the media is said to have exaggerated the 1997/1998 event despite the Zimbabwe NMS having released a conservative and probabilistic forecast. The degree of the media attention received by the El Niño of 1997/1998 contrasted with the La Nina event of 1998/99 despite the latter having potential for good season that would have translated into improved crop yield (Philip et al. 2002). This shows that the media likes communicating negative news which is eye catching to the public.

In addition, Patt and Gwata (2002) observe that forecast disseminators (the media) lacks understanding of the climate forecast concepts such as probabilistic forecast and degree of El Niño or La Niña. The net effect is mis-reporting and mis-trust of climate scientists by the public. It is therefore important to critique media handling of forecast information after release from KMS. It is in this light that the current study seeks to examine the role of IK as a co-issuer of seasonal forecasts and recommend its integration with scientific
forecasts to curb the problem of dissemination of the forecast that may bring misunderstanding and loss of confidence in science by the public.

Whereas the study by Philips et al. 2002 show that farmers in Zimbabwe believe in meteorological forecast, the study by Ngugi (2002) in Machakos was limited to awareness and source of forecast information. Yet belief in the forecast has a positive effect and can enhance decision making at farm level. Do Kenyan small-scale farmers believe in seasonal forecasts? This study sought to investigate the attitude farmers have to the forecast of any source. It also attempted to investigate the other sources of the climate forecast other than the scientific forecast, and farmers’ attitude to it. Applying forecast at individual level especially subsistence farmers of sub-Saharan Africa remains a significant challenge. Ngugi (2002) examined the awareness and usage of the forecast in Machakos County, Kenya. This study showed that majority of farmers receives seasonal forecast information mainly through radio and that a good number of farmers applied it in farm management. The study further established hypothetical responses on how farmers would use the forecasts and several strategies were enlisted. The departing point between Ngugi’s study and the current is that, the current study sought to establish the IK indicators used for forecasting, farmers perception of both IK and scientific forecasts and socio-economic factors that influence the use of forecasts.

The scientific forecast provides the quantitative rainfall in probabilistic mode for seasonal climate and determined amount for medium range weather; of onset of rainfall and the distribution; it does not support farmer’s need in terms location specific forecasts which is one of the significant variables necessary for the farmers to make decisions on
the initial agricultural activities. On the other hand, traditional forecast knowledge is able to help the farmers in terms of its possible onset using indicators such as direction and intensity of the wind during dry season, position of the moon and traditional calendars (including other supportive indicators). This gives an opportunity to blend both systems of the knowledge. The scientific forecasts prepare the farmers in terms of its quantity while the IK prediction helps them to know the possible onset of the rainfall. In this way it is possible to establish a continuum between scientific and IK forecast, which combines the scale, and time of the onset of rainfall.

2.3.3 Reliability and Accuracy

DMCN (2004) carried a pilot project whose objective was to record traditional weather/climate monitoring prediction indicators. Rainfall indicators from the Luo, Basuba, Banyore (of western Kenya) and Akamba (of South Eastern Kenya) communities were recorded. Ngugi (2002), Mwinamo (2001) and Philip et al. (2002) have similarly identified environmental, meteorological and astrological indicators used in traditional rainfall forecasting in different communities. The report by DMCN (2004) further established that some clan leaders use meteorological forecast information to augment traditional forecast before issuing it to the communities. Respondents however complained that meteorological forecast was mostly inaccurate due to the very general nature of the forecast that cover a large geographic area. For instance, respondents from Akamba commonly argued that Makindu is usually the reference point of the forecast for either district of Machakos, Mwingi and Kitui yet many at times the forecasts for
Makindu is likely to drift away from Ukambani towards the Southern County of Kajiado.

Patt and Gwata (2002) argue that probabilistic forecast that cover a wider area can generate confusion and discourage users from incorporating the forecast in decision-making. Respondents recommend for a specific forecast that takes cognizance of farmer’s needs. Although studies by DMCN (2004), Ngugi (2002) and Philips et al., (2001) show that traditional indicators are still used to forecast among African communities they have not addressed socio-economic factors that impede application of the forecast. This study sought to identify socio-economic constraints that impede effective application of both traditional and scientific forecast in agricultural production and food security mitigation. Farmers in different agro-ecological zones are likely to have different needs and, therefore, require specific forecast information. A study by Philips et al. (2001) on the current and potential use of climate forecasts shows a difference in forecast need by agro-ecological zone.

The traditional forecast is highly local specific, mostly at the village level within a radius of 1-2 sq. km derived from an intimate interaction with a micro-environment observed over a period of time. But the scientific forecasts are generated at much larger geographic scale that is 60-300 sq. km that depends on the global meteorological parameters and their dynamics. Also, farmers perceive high rainfall years/season based on locality, onset and distribution instead of the total amount of rain received in that season/year. Though the reliability of the traditional indicators is not definite, it helps the
farmer to prepare for the timing and distribution, while a scientific forecast helps them to prepare for the amount.

A study by Shoko and Shoko (2011) which examined the perception levels of accuracy for indigenous weather forecasts and meteorological forecasts in wards 12 and 13 in Mberengwa, pointed out that 91% of the respondents who had access to both meteorological and indigenous weather forecasts perceived the indigenous weather forecasts as being more reliable than meteorological weather forecasts. The findings clearly illustrate the value attached to indigenous weather forecasts with regards to sustaining livelihoods in this community.

2.4 Socio-Economic Factors Influencing Forecast Application

Social economic factors such as labor credit facilities, draft power and access to certified seeds are determinants in the application of seasonal climate forecast consequently affecting farm management and food security strategies at the household level. According to Kamal and Subbich (1999) socio-economic constraints still form a critical gap between climates forecast information and its application at farm level decision making. In a good rain year, farm households which are limited by labor, may decide to reduce cultivated area, use more manure and focus on weeding to maximize yields while households that have more labor can expand the cultivated area to maximize use of good rainfall conditions. In a drier year the behavior of both sets of households would be different (UNEP, 2006).

According to Philip (2003), a biophysical event such as agro-ecological zone, plays a strong role in delivering crop management decision. The options mainly include change
of area planted, crop or cultivars and planting dates. A case in point is during 1998/99 La Nina event in Zimbabwe where farmers who accessed the forecast in the drier natural zones shifted from planting small grains (like sorghum) to maize given the expectation of the wet season. In a separate study results by Philips et al. (2001) showed that marginal drier zones where long term means are experienced, yield are extremely low and crop failure common, early planting during favorable season has the potential to increase yields. Given that the decision making relies on a variety of socio- economic and geographic factors, the current study attempted to investigate how the said factors affect use of climate forecast information in Chwele and Mukuyuni Wards.

A study by Isabirya et al. (2003) amongst crop farmers, pastoralists and fishermen in two districts in Uganda aiming at establishing methods used in conveying climate forecasts information pointed out that meteorological information is used for planning and scheduling seasonal activities. According to Isabirya et al. (2003) dissemination is the main problem in the forecasts application. Although studies by Philips et al., (2001), Philips (2003), and Patt and Gwatta (2002) show that factors such as labor, credit facilities, animal power and farmers’ perception are key to utilization of forecast, Isabirya et al. (2003) do not explain whether crop farmers, pastoralists and fishermen experience the same problem or not. Whereas dissemination of climate forecast is a challenge to forecast application, it is important to look at other factors such as labor, level of education, income and beliefs in forecast among others.

A study carried out in North West South Africa, Hudson (2001) found out that knowledge of approaching drought is potentially advantageous to all farmers. It helps
them develop better coping strategies, however, farmers without a socio-economic base were found not to respond to an approaching drought or maximize benefits when a good season is expected. 54% of the communal farmers interviewed reported forecast as being valuable but had fewer coping strategies compared to commercial farmers. The study by Hudson (2001) does not examine weather factors such as ownership of animal power, level of education and income among others can affect use of forecast information. The current study attempted to investigate socio-economic constraints in the application of forecast information.

Mwinamo (2001) investigated the influence of weather on farming activities in Kwale County, Kenya. In the study, he identified access to seasonal climate forecast, farmers’ reluctance to plant crop variety resistant to drought and tsetse fly out break as some of the constraints to effective application of the forecast. With most of the farming activities depending on rain, information on onset of the rain must reach farmers in good time and use of modern technology and input would greatly improve production. Majority of the farmers (75%) were found to be illiterate. He argued that lack of understanding of forecast by dissemination agents lead to apathy and lack of the faith of the forecast by people. This could in part be attributed to the low level of literacy. The current study sought to establish understanding of KMS forecast and how level of education affected the understanding of forecasts.
2.5 Theoretical Framework

This study was based on Bob Doppelt theory of the power of sustainable thinking. Doppelt argues that global warming is not, at its core an energy, technology or policy problem. It is the greatest failure of thought in human history. He points out that global warming and today’s other environmental, social and economic problems therefore cannot be resolved merely through more-efficient technologies or cap-and-trade policies. Fundamental change in thinking and perspectives will be needed.

This theory holds that a sustainable development model focuses on economic sustainability, which involves the development of a healthy economy that supports and sustains people and the environment over the long-term. This theory shows that in a market driven economy, cost is a deciding factor in determining whether a project moves forward. To be sustainable, projects must not only provide environmental and social benefits but also offer economic value. This theory relates to this study in such a way that forecast application is highly dependent on how people think about it, the action taken and therefore the outcome. Based on these ideas, farmers’ perception of any forecast is affected by their way of thinking. The actions taken in terms of response strategies to the forecasts are dependent on availability of the resources. This could either enhance forecast use or impede its application. This in turn has a greater effect on the outcome of any agricultural practice, thereby influencing the food security situation in the region and in the country as a whole. This therefore means that forecast application by farmers will be increased if information about how it should be used is downscaled to the poor rural small holder farmer. This could influence how they perceive it and therefore their willingness to use it in their farm level decision making.
The economic value attached to it due to improved production, income and food security could eventually encourage farmers to be more willing to use the forecast in order to improve their productivity, food security and therefore income.

2.6 Conceptual framework

It should be understood that seasonal climate forecast is regarded as important and if agricultural production is to be realized as a sustainable livelihood to the people in the study area, then it should be taken and applied with all seriousness. Over reliance on rain-fed agriculture in the wake of ongoing vagaries of climate variability; where weather patterns have become erratic and unpredictable, planning for farming has become difficult. The framework shows that the seasonal climate forecast in the study could be generated by the scientific methods (SST model) Hansen and Indeje (2002) or indigenous knowledge (IK indicators), these two forecasting methods forms the independent variables in the study and the dependent variables being the response strategies employed by and socio-economic characteristic/factors that influence forecast use. Farmers’ perception of the forecasts stands as intervening variable.

This model shows the interplay of all these variables and therefore the outcome. Indigenous and scientific forecast trickles down to the farmers though own knowledge, chief Barazas, CBOs and radios, television and newspapers respectively. This information is expected to assist farmers in decision making on the response strategies to take in line with the forecast received. However, farmers’ perception of the forecast will always determine how they would use it. Depending on the perception farmers have, response strategies will be employed for maximizing the yield or minimizing risks.
However, the socio-economic characteristic of farmers would either enhance or impede the response strategies taken, for example, a forecast of a rainy season is expected to register good harvest but all these depends on the perception the farmers have to this forecast and their socio-economic base. Finally the interplay of all these variables would lead to high yield and therefore food security and increased income or poor yield, food insecurity/scarcity and low income hence affecting the farmers’ economic status.
Figure 2.1: Conceptual Framework for forecast generation, access and application

Source: Adopted and Modified from (Orodho, 2004)
2.6 Gaps identified in literature

Mawere (2010), used questionnaire, interview and focus group discussion to examine the potential of IK to re-establish moral and virtuous society in selected areas in Mozambique and Zimbabwe. He found out that IK methods of weather forecasting are very useful especially during summer and immediately after harvesting for winnowing. While his study was based in Mozambique and Zimbabwe, the current study was carried out in Chwele and Mukuyuni Wards of Bungoma County, Kenya; a different ecological zone from Mawere’s study area.

Ngugi, (2002), used questionnaire, interview and focus group discussion to examine the awareness and usage of the forecast in Machakos County. He established that majority of farmers’ access forecasts and that a good number of them use it. However, he did not examine the perception and the attitude farmers have towards forecasts of any kind, an aspect that is key to forecast application by farmers. This current study has examined this.

Phillips et al. (2001), used questionnaire, interview and focus group discussion among East African countries to examine the use of IK in forecast generation. He found out that traditional indicators are still used to forecast among African countries; however he did not look at the socio-economic factors impeding application of both scientific and IK forecasts, an area this study has addressed.

In conclusion the chapter examined scientific and IK forecasts, its generation, dissemination and previous studies on forecast use. It is observed that large scale provision of forecasts can limit quality, reduce user confidence hence need to downscale
forecasts at a local level. It is also observed that socio-economic status and farmers’ perception of forecast have a great influence on the choice of farming strategies and response to the forecast of any kind.
CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research design used and study area; it also describes the procedures followed in conducting the study and gives detailed techniques used to collect and analyze data as well as how data was presented.

3.2 Research Design and Variables

The study employed a descriptive survey design which involved the use of both quantitative and qualitative techniques. A descriptive survey as a research design is used to obtain information concerning the current status of the phenomena and to describe ‘what exist’ with respect to the variables or conditions in a situation (Mugenda, 2004). In this study, a descriptive survey was used to get information on the existing indigenous knowledge indicators used for seasonal climate forecast, farmers’ perception of both indigenous and scientific forecasts and the factors that impede or enhance the use of forecasts for agricultural production. The study employed three types of variables; the independent and dependent and intervening variables. The independent variable is one that is varied or manipulated by the researcher. It is a presumed cause whereas a dependent variable is the response that is measured. It is the presumed effect (Mugenda and Mugenda, 1999). Therefore, in this study the independent variable is the seasonal climate forecast; IK or scientific and the dependent variable are; response strategies to the forecast and factors that impede the use of forecast. Farmers’ perception of the forecast encompasses the intervening variables.
3.3 Study Area

3.3.1 Geographical Location of the Study Area

The study was carried out in Chwele and Mukuyuni Wards located in Bungoma Central Sub-County, Bungoma County. The area lies within latitude 0°35’00’’ North and 0°50’00’’ North and longitude 34°20’00’’ East and 34°40’00’’ East (Figure 3.1). It covers an area of 81.9km² with a population density of 692 (GoK, 2008). Field study for this study was conducted here. The study area and setting was appropriate for testing the hypotheses on an ethnically homogenous farming population.

3.3.2 Topography

The altitude of the Sub-County ranges between 1200m and 2000m above sea level. The land surface is gentle in slope and is well drained by rivers originating from Mount Elgon water catchment area. The rivers found in Chwele and Mukuyuni Wards of the Sub –County include Kuywa and Kibisi. It has several hills, such as Kibichori and soils vary in fertility and drainage properties. These soils are well drained, deep and vary from dark-red notrosols to dark-brown acrisols. This permits a wide range of crops to be grown in the area. Such crops include: maize, beans, millet, sorghum, cassava, potatoes, coffee, bananas and horticultural crops.

3.3.3 Climate

The rainfall in the area is bimodal. The long rains start from March to July, while the short rains are expected from August and continue up to October (GoK, 2008). Annual rainfall ranges from 430mm (lowest amount) to 1800mm (highest amount), most farming activities take place during the long rains. The annual temperature varies
between 16\(^0\)C to 32\(^0\)C due to differences in altitude. The period between April and July tends to have lower temperatures while December to February tends to have higher temperatures sometimes reaching 32\(^0\)C (GOK, 2008).

### 3.3.4 Human Population

According to Kenya National Bureau of statistics, in 2009, the population of the study areas was 27,406 male and 29,287 female thus a total of 56,693 compounding to 11,574 households (GoK, 2010). The area is dominated by the Bukusu community. The other tribes found in the area due to intermarriages include Kalenjin-Sabaoti sub-tribe. The area supports one of the densely populated rural communities in Bungoma County. The area has agricultural potential but registers food poverty of 42%. This has affected the economic growth of the region.

### 3.3.5 Socio-economic Activities

Some of the economic engagements that occupy people in the study area include farming, small business, quarrying, brick making and tree nurseries. According to KIHBS (2005/2006), a large proportion of the Sub-county is involved in agriculture (88.8%) as the main economic activity. Generally, land use in the Sub-county is below optimum, out of 373 hectares of arable land, only 70% is utilized because of the overreliance on rain fed agriculture. The main food crops include maize, beans and sweet potatoes. The main cash crops include coffee and sunflower but the performance is below par. The livestock sector is very productive with 60% of the farmers preferring to keep indigenous animals mainly for milk and beef production. However, the potential has not been fully exploited. Despite the Sub-county being an agricultural area, it has
food poverty rate of 42% and most farmers’ plant food crops once per year. Very few grow food crops during the second short rain season because of high cost of farm inputs (GoK, 2008).

### 3.4 Target Population

This is the entire group a researcher is interested in, the group about which the researcher wishes to draw conclusions (Mugenda, 2004). The target populations in this study were all small-scale farmers in Chwele and Mukuyuni ward between ages 25-80. This population was ideal because indigenous knowledge is inherent to people according to age and because age is a socio-economic factor, it was important to note how the age of a farmer can influence forecast application. The study areas being a peri-urban area, not all household population are farmer households and therefore the target population was to take the following in to consideration. The targeted farmers were to fall under the criteria of inclusion below.

i. The farmers to be included in the study must have stayed in the area for the last 20yrs from the year study (2013). This meant that they had a vast knowledge on indicators used for seasonal climate forecast.

ii. Farmers who do farming both for food security and source of family income were to be considered.

iii. The whole household was considered as a study participant but only the head of the household participated in the study.

iv. Provided one is the head of the household and is above 25 years can participate in the study. Age was important because IK is a function of age with the elderly having more knowledge than the young.
v. Known community indigenous knowledge talented persons or predicators were considered as key informants in the selected areas.

vi. Head of NGO’s, CBO’s and opinion leaders are selected as FGD and key informants for the study.

One thousand (1000) farmer households were reached at as the target population using this criteria and the sample size was drawn from here.
Figure 3.1: Location of the Study Area

Source: International Livestock Research Institute (ILRI, Nairobi)
3.5 Sample size

The sample size was determined using the formula and descriptions in Yamane, (1967).

Thus Using Yamane’s formula, \[ n = \frac{N}{1 + N(e^2)} \]  
(Equation 1)

Where:

n is sample size

N is study population

e is desired level of precision at 90% confidence level.

Therefore the sample size is: \[ n = \frac{11574}{1 + 11574(0.1^2)} = 99.99382 \approx 100 \text{ respondents} \]

A sample size of 100 household was reached which formed 10% of the farmers household who were targeted in the study.

3.6 Sampling procedure

Purposive sampling of Chwele and Mukuyuni wards was based on ecological zoning. The area lies within the upper midlands (UM) 2 & 3 where the soils range from red dark to red nitosols, ferrasols and brown to dark brown acrisols. This soil type can support crops like maize, beans, coffee, sunflower and other minor varieties of crops like ground nuts, Irish and Sweet potatoes, Cassavas and Bananas that are the main stay of the people living in the study area.
In this study the observational units were farm households, in effect a sample survey was necessary to ensure adequate coverage of the area. The administrative units (Tables 3.2) were found to be a more convenient ground on which to develop a sample frame. The sampling procedure entailed two interdependent phases. Phase one encompassed the following; first the area was stratified into sub-locations. This gave rise to six sub-locations namely Mukuyuni, Sichei, Sikulu, Kibichori, Kuywa and Chwele. A proportionate sample of a given number of households in each sub-location (Table 3.2) was reached at in accordance with their total number of household population. A list of all farmer household in all sub-locations formed a sample frame from which the respondents were drawn. (Table 3.2).

Under phase two of the sampling procedure, the farm household were selected at the sub-location level. However, lists for the number of farm households in each sub-location were not available. A reconnaissance survey was therefore carried out by the researcher to generate original lists. It involved going to each of the villages in the sub-location and the village headsmen (Bakasa; Luhya) were very helpful in this activity. They provided lists of names of all farmers in the areas under their jurisdiction. A random sampling process was applied on the generated lists to select sample population covered in the area. This was done by writing all the names of farmers in each sub-location on ballot papers. The ballot papers were then folded, mixed well and put in separate containers according to sub-locations. The number of respondents allocated for each sub-location was reached at by picking the ballots from the containers. This procedure was applied to all the six sub-locations. Where the respondent had no idea on
IK a replacement was made. A total of 100 farm households were selected from pre-enumerated lists (Table 3.2).

In addition to 100 respondents, five Key Informants were included for interviews they included: two village elders, two prominent farmers who had vast knowledge on IK; one male and one female. This was purposively done by the researcher in order to have information on gender involvement in forecasting and in farming. One CBO leader and one person from one NGO that deals with agriculture (One acre fund); by offering credit facilities to farmers were considered. Furthermore, two focus group discussions with 8 members each were also included for the study, in addition to key informant interviews (KII) and 100 respondents. They were to give information that could augment that of questionnaire and KII. This gave rise to fourteen (22) more people in addition to the 100 respondents. The two focus group discussions were based on age, interest and knowledge on IK. Both groups had members of mixed gender; both male and female were represented. Purposively, the researcher ensured that the number of male and female in the focus group discussion were equal.
Table 3.2: Sample Size as per sub-location

<table>
<thead>
<tr>
<th>Sub-location</th>
<th>Population</th>
<th>Households</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chwele</td>
<td>18,705</td>
<td>4,198</td>
<td>36</td>
</tr>
<tr>
<td>Sichei</td>
<td>9,818</td>
<td>1,913</td>
<td>17</td>
</tr>
<tr>
<td>Sikulu</td>
<td>4,460</td>
<td>845</td>
<td>7</td>
</tr>
<tr>
<td>Kuywa</td>
<td>11,094</td>
<td>2,107</td>
<td>18</td>
</tr>
<tr>
<td>Kibichori</td>
<td>6,568</td>
<td>1,305</td>
<td>11</td>
</tr>
<tr>
<td>Mukuyuni</td>
<td>6,048</td>
<td>1,206</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>56,693</td>
<td>11,574</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: GoK (2010)

3.6 Research Instruments

According to Kothari (2004), a research instrument is a survey, questionnaire, scale rating or tool designed to measure the variable(s) characteristic(s) or information of interest. Instruments that were used in this study to collect data were questionnaires, interviews and focus group discussion (Appendix 111,1V and V).

3.6.1 Questionnaire

Questionnaires were very instrumental for collecting primary data from farmers. Questionnaires were pre-tested in March. The pre- test involved questionnaires being given to 10 farmers. The pre-test was useful in adjustment and clarification of some questions that were not clear to farmers. Household survey was accomplished with the help of 4 enumerators from the Bukusu community. Primary data provided information on IK indicators used for seasonal climate forecast, farmers’ perception of both IK and
scientific forecast as well as the socio-economic factors that influence forecast use. Questionnaire was used as a method of data collection because of its characteristics of being able to collect a large amount of information from a large number of people in a short period of time in a cost effective manner.

3.6.2 Interview

An interview schedule was used to collect qualitative data from farmers and elders of the community. It was appropriate because of its flexibility as an interactive tool that explores meaning and in depth understanding. As a qualitative tool, it allowed the researcher and respondents some freedom to negotiate.

3.7 Data collection

This study used both primary and secondary data sources in collecting data. Secondary data were gathered from published and unpublished materials about IK and scientific seasonal forecast and its use as well as rainfall data of the study area from KMS for the last four years (from 2009 to 2012). The primary data were collected from the field using questionnaire, key informant interviews and FGDs.

3.7.1 Questionnaire

A structured questionnaire (Appendix 111) with both closed ended and open ended questions was administered to 100 households. The questionnaires were used to collect data on IK indicators used for seasonal climate forecast in the study area, farmers’ perception of both IK and scientific forecasts and the socio-economic factors influencing the use of forecasts. The questionnaires were administered by the researcher with the
help of 4 research assistants to farmers across the area of study especially those who had knowledge on indigenous knowledge for seasonal climate forecast.

3.7.2 Key Informant Interviews

A key informant interview guide (Appendix iv) was used to establish the responses from elders of the community, prominent farmers and local N.G.O leaders. Interviews with village elders and local NGO leaders were conducted at Alpha quest home; Chwele market where information on IK indicators used for seasonal climate forecast in the study area, farmers’ perception of both IK and scientific forecasts and the socio-economic factors influencing the use of forecasts was sought. The interviews with prominent farmers were done in their homesteads and information on the response strategies to forecasts as a way of forecast application were solicited. This method was ideal because the researcher needed to understand interpretations and responses given by the respondents. The researcher personally took notes during the interview.

3.7.3 Focus Group Discussion

A focus group discussion is a special interview composed of 8-12 participants. The researcher had held two focus group discussions at different times in the course of the survey. These two groups were based on age. Starting with the old and ending with the younger group. Each FGD held comprised of 8 participants. The first group comprised of farmers of ages 25-50, and the second one 50 years and above. These categories were also based on farmers’ interest and knowledge on IK indicators used for forecasting. This was facilitated by the principal investigator using prescribed interview guide attached appendix v. The FGD participants were purely farmers. The farmers were
selected across the breadth of each Sub-location with the assistance of local administrators and the meeting venues were left for the researcher’s discretion and accessibility by the farmers. Each discussant group comprised farmers of mixed gender. Although it was desirable to have equal number of men and women in each group, this was not achieved. Where a farmer did not show up, a suitable replacement was found.

FGD was used to give additional information regarding all the three objectives. This tool was important because it was a way through which the researcher could establish some clarity of thought about the information given in questionnaires and during interviews.

3.8 Data Analysis

Both qualitative and quantitative data were used. Qualitative data were edited, paraphrased and summarized for better understanding. It was organized into various themes as per the research objectives. The researcher then presented the data in narrative form which formed a basic component of the thesis. These helped to compliment findings from the quantitative data. For quantitative data, the researcher used both descriptive and inferential statistics. Descriptive statistics such as percentages, frequencies tables, charts, graphs were used to summarize and present findings. The inferential statistics were used to make inferences and to draw conclusions. The inferential statistics used in this study were Chi-square, and factor analysis.

3.8.1 Chi-square

According to Kothari (2004) chi square is a statistical method used as a test for comparing variance and a non-parametric test. It was used to test the independence of attributes. To apply chi-square, the following consideration must be taken into account.
i. The data must be in the form of frequencies counted in each of the numbers of categories (percentages cannot be used).

ii. The total number of observed frequencies must exceed 20

iii. The expected frequency under H₀ in any one fraction must not normally be less than 5

iv. The observations must be independent (one observation must not influence the other)

v. Kothari, 2004

This study uses $\chi^2$ formula that applies to two or more independent variables;

Formula is expressed as

$$X^2 = \sum_{r} \sum_{k} \frac{(O-E)^2}{E}$$

(Equation 2)

Where $x^2=\text{chi-square value}$

$\sum_{r} \sum_{k} =$ sum over all rows and columns (that is sum all the cells in the table)

$O = \text{Observed frequencies}$

$E = \text{expected frequencies};$ this requires a bit of calculation. The calculation being;

$E = \text{row total} \times \text{columns total}/n;$ that is multiplying the sum of rows by the sum of columns in which the observed frequencies occur and dividing by $N$

Where $N=$ the total number of observations or the sum of the observed frequencies

Degree of freedom has to be determined.
Degree of freedom (df) is calculated using formula \((r-1)(k-1)\) that is number of rows less 1 multiplied by number of column less 1, \(r\) stands for row and \(k\) stands for column.

This gives the required \(x^2\) value. Thereafter, compare the calculated and the critical table chi-square for the required degree of freedom and probability. If chi-square is less than the critical table value at a given level of significance (in this case 5%) for a given degree of freedom, it is concluded that the null hypothesis \(H_0\) is true and therefore no difference between the variables. The null hypothesis does not hold giving room to acceptance of the alternative hypothesis and confirmation that there exists a difference between variable under investigation. The ages of the farmers and their use of IK for seasonal climate forecast were subjected to chi square test.

### 3.8.2 Factor analysis

Factor analysis was done to single out those factors that had significant influence. Socio-economic characteristics of farmers were then correlated with forecast use to establish the relationship. This is a means by which regularity and order in a phenomenon can be discerned. The analysis resolves observations into distinct patterns of occurrence. The technique can reduce a large data set down to a small number of factors which can then be easily characterized and explained and also determine whether some underlying patterns of relationships exist to facilitate the reducing of the data to a smaller set of factors or components. The SPSS was used to generate factor analysis results. The procedure used involved the following steps:

i. Computation of Eigen value and scree plot

ii. Generating list of communalities from principle component analysis
iii. Extraction of the factors

Factor analysis proved to be suitable in testing the hypothesis 3 in order to explain the factors determining the use of climate forecast information in agricultural production. This analysis produces a resolution of a set of descriptive variables in terms of small numbers of categories or factors. Five factors were observed. The choice of factors was based on the use of Eigen values and scree slope technique at the cut off levels (Fig 4.14). In this case only five factors were identified, only those factors with Eigen values above one would be considered. A communality analysis (principal component analysis was ran to identify which factors are among the five to extract (Table 4.11). To examine socio-economic factors influencing the use of forecast information for agricultural production, only a factor with the value >.4 is significant and was extracted. Therefore the extracted factors included age, level of education, belief, labor and storage facilities. All tests of significance were computed at 0.01 and 0.05. The statistical package for social sciences (SPSS) version 20 was used to analyze the data.

3.9 Data Management

3.9.1 Data Coding and Cleaning

The data collected from the field was cleaned, coded and arranged in categories before being key punched in to the computer for analysis. The narrative data was arranged in various themes according to their relatedness and objectives. This was to form narrative notes for this thesis.
3.9.2 Data Confidentiality

All respondents were fully informed about the purpose of the study and were made aware of the implications of their participation in the study. Their identity was kept confidential by the researcher and the information they gave was used for the research and not any other purpose. All sources reviewed were acknowledged. Permission and authorization was sort from all authorities before data was collected.
4.1 Introduction

This chapter presents the findings of the research. It gives clear information about the indigenous knowledge indicators used in the study area for seasonal climate forecast, farmers’ perception of both scientific and indigenous knowledge forecasts as well as the socio-economic factors that influence the use of forecasts.

4.2 Indigenous Knowledge Indicators, Dissemination and Use of the Forecast

Indigenous knowledge in the study area has been regarded as an important tool in seasonal climate forecast and has been used since time immemorial for their farm level decision making. This information is in line with Phillips et al. (2001) who pointed out that traditional indicators are still used to forecast among African communities. It was also echoed by Mawere (2010), who pointed out that IK methods of weather forecasting are very useful in summer and immediately after harvesting for winnowing of grains. The study showed that (98%) of the respondents were aware of IK indicators used for seasonal climate forecast and 90% of the respondents believed in IK system of forecasts. A majority (80%) of these respondents acknowledged its use in seasonal climate forecast. These results demonstrate that local strategies are considered as a trusted source of information and of importance to this community. Results further indicate a significant difference between levels of awareness of Indigenous knowledge indicators used for seasonal climate forecast, with the elderly being more aware of them than the younger generation especially in terms of interpretation of the indicators. This supports the observation made by UNEP (2008), the report concluded that IK is under threat of disappearance due to lack of systematic documenting and coordinated research for
investigating its relevance and when the old people who are the custodians of the knowledge pass away, the knowledge which has been accumulated for many years is lost. There is therefore need to document these indicators in order for the future generations to benefit from it.

Discussions with the focus groups further revealed that majority of the young people did not have a good command of indigenous knowledge (IK). This could be attributed to their inexperience or not being old enough to gather all indigenous knowledge indicators. This did not seem to bother them because they argued that IK was outdated and there were better and more modern methods of predicting weather. Although these findings match those of Bhatta (1999), who acknowledges that local knowledge lacks accountability within communities themselves, especially with the younger generations; the dominant belief being that conventional or scientific knowledge is ‘superior’ to local knowledge, but it must be noted that indigenous knowledge is intrinsic and almost everybody uses it in his day to day life. One could feel the heat and anticipate for a rainy afternoon or by observing clouds, one could carry an umbrella in anticipation of rainfall. This is IK, the only challenge is, it not being precise and not being documented, an issue that the current study has addressed.

As regards the current official scientific systems, participants were generally not satisfied because the information received from the local administrators was considered common knowledge. The information concentrated on distribution and the type of rainy season but not what to expect in terms of onset and cessation of rain, the information that farmers look forward to. They also acknowledged that it was difficult to accurately
predict weather on a location specific scale using scientific method which always give larger coverage forecasts and that is why they relied more on indigenous knowledge. More so, meteorological forecasts are highly technical in nature, such that most people cannot understand them hence they derive minimal or no benefits from such forecast. Besides, these forecasts are available at a cost; newspapers have to be bought, radios have to use power which the rural people cannot afford. This may minimize media attention and hence less forecast access by the farmers. This leaves them vulnerable to all the vagaries of weather that may lead to poor yields and food insecurity. So the indigenous forecasting methods has offered solutions to the problem cited above, by tapping indigenous forecasting knowledge, which is less technical in nature and inexpensive to the user.

4.2.1 Indigenous Knowledge Indicators

People of Chwele and Mukuyuni wards relied on the observation of certain physical phenomena in order to make reasonable and sometimes almost accurate weather forecasts. They relied on the study of certain phenomenon such as trees, birds, frogs, animals, insects, grass, wind, sun, moon and lightening, among others. Table 4.1 is an exposition of some of these phenomena.
Table 4.1: IK indicator used to forecast

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Frequency n=100</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal behaviour</td>
<td>89</td>
<td>23.5%</td>
</tr>
<tr>
<td>Plant behaviour</td>
<td>67</td>
<td>17.7%</td>
</tr>
<tr>
<td>Wind direction</td>
<td>54</td>
<td>14.2%</td>
</tr>
<tr>
<td>Temperature</td>
<td>65</td>
<td>17.1%</td>
</tr>
<tr>
<td>Astrological information</td>
<td>25</td>
<td>6.6%</td>
</tr>
<tr>
<td>Cloud</td>
<td>78</td>
<td>20.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>378</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Source: Field, (2013)

Due to double responses; most farmers acknowledging the use of more than two indicators, the frequency totals were 378 instead of 100 corresponding to the number of respondents. The study results show that 23.5 %, 20.6 %, 17.7 %, 17.1 %, 14.2 % and 6.6% of the respondents acknowledge animal behavior, cloud, plant behavior, temperature, wind direction and astronomical information respectively to be indicators used to forecast weather by the community. It was clear that the community does not rely a lot on astronomical information in their weather prediction, this could be due to the high belief they had in observation of other named indicators.

4.2.1.1 Behavior of Animals

The study revealed that behavior of certain animals was key to IK as an indicator of seasonal climate forecast. 23.5% of the respondents were of the opinion that behavior of animals was an indicator that could be relied upon in seasonal climate forecast.
4.2.1.1 Reproductive Behavior

The study revealed that observation of rampant reproduction of animals, especially wild animals was an indication of the approaching rainy season. Animals have their own life cycle and coping strategies that are intrinsically related to cycles of rain. Animals have evolved (or been created) to reproduce when environmental conditions best favor the survival of their offsprings (Pratt, 2001). For most, this coincides with the arrival of rain as water is available. Rain supports plant growth, providing enough fodder and hence milk production for grazing mammals. Rain also means increased insects which are good for nesting birds. If rain marks the best time for reproduction, then it should be no surprise that animals are sensitive to changes in climate that indicate rain is likely to occur. Many of strongest indicators for rains appear to be animals’ behavior that is related to reproduction for instance the nesting of birds. By extension, the absence of these behaviors in the months before the rain season is an indicator of dry spell or delayed rains.

4.2.1.1.2 Non Domesticated Animal Behavior

Animals may also indicate rain through behavior other than reproduction. If rain generally occurs in highlands before the lowlands, then rivers and water table are likely to rise before the arrival of rain in the lowlands. Thus, if ants are seen moving en masse, or snakes observed climbing trees to avoid rising water levels, it seems logical concluding that rain is on the way. On that note, other animals may initiate seasonal migration to enjoy conditions in one area or another based on rainfall patterns. What is unlikely is that animals behavior predict dry spell per se. Rather, it is the absence of normal behavior associated with rain that signals a season of below average rainfall.
Animals like snakes, migrating from upland to river side to look for water was a clear indication of dry spell approaching. Frogs make chorus noises late in the evening and early in the morning showing that the rains are near.

4.2.1.1.3  Human Population

Another observed behavior before rain failure among the community of Chwele and Mukuyuni wards is that despite plenty of food available to a household through the previous season’s production, people find that they are not satisfied after eating. This feeling may be a manifestation of concerns for future food security; or may simply be part of the natural cycle in food security as the less productive dry season comes to a close.

4.2.1.1.4  Domesticated Animals

Cattle will stand and make for pasture when the coming season is favorable. With a dry spell coming, they will return to sitting after milking and only reluctantly leave the confines of the boma when forced. Cattle are eager to return to the boma in the evening when the coming season is favorable. With coming of dry spell, they are unsettled and will disappear in pairs to the bush and are in the bush around sunset. With coming of dry spell milk production declines despite adequate levels of fodder or pasture. At the watering place cattle are quick to drink and leave water points when the coming season is good, happy to return to grazing. With coming of dry spell cattle at water points appear very lazy, sitting, feigning, drinking and are reluctant to leave these points. This has been considered to be strong sign in the community of the study area.
4.2.1.5 Birds

Sighting of soaring hawks and eagles are regarded as good signs of rain. This behavior may be encouraged by updraft that results when low-pressure (indicative of rain) centre push into the area. Birds singing very early in the morning shows the coming of the dry spell. If normal rains are expected however, it is heard in early evening (around 7pm). This behavior is noted as you approach the rainy season and is expected to continue for a couple of weeks, at which time the rains should begin. Certain behavior of birds can also be a helpful barometer in predicting the arrival and intensity of a particular rainy season.

On one hand, once the migratory birds like kamakhuyi (luhya), begin to surface in a particular environment, then the rain season is said to be imminent. For instance when they are spotted moving from east to west then that is an indication that rains are near, almost within one month the community would be expecting rain. Birds such as Namwetwitwi (black and brown birds) sing melodious songs. The continuous singing, by the day and by the night, indicates the commencement of the rainy season. People could also foretell whether rains are going to fall in the next hour or two if they hear the sound of Namwetwitwi (rain bird).

On the other hand, however, when the migratory birds vanish from a particular area or region, it signals the decrease of rain and eventually its departure. When birds like Wambundo (they regard a bat as a bird because it flies) are seen flying past a certain area it is a pointer that rainfall is erratic. If these bats fly around and occasionally land on the ground, especially as a swarm, it means that the rainfall pattern is good in that particular growing season. The study observed that even the ordinary chicken (Engokho) reared in homes, can be used to predict the nature of rainfall patterns. Normally, chickens do not
wonder around when it is raining. Informants argue that through observing their fowls and other birds, people can tell whether the rains are going to stop or not. If the birds and chickens venture out to feed when it is raining, people can foretell that for at least the next few days there would be a Munyekenye (drizzle). If the birds and poultry do not venture out to feed, the significance was that the rains would not last the whole day. It was further noted that on those rare occasions that birds and chicken move around when it is raining, people regard that rarity as an indicator of plentiful rains in that particular season.

4.2.1.2 Behavior of Plants

The behavior of trees in general and fruit trees in particular plays a significant role in determining weather patterns. Fruit trees like Mangoes (*mangifera indica*), Mkuyu (*ficus sycomorus*) are frequently used to predict the imminence of the rain season and the quantities of rainfall in any given agricultural season.

It is interesting to note that the Bukusu people have even been able to harness the behavior of exotic trees like the Mango trees in their extrapolation. According to one of the informants, if for instance, there is an abundance of fruits towards the encroachment of the rain season, people would know that the season was likely to experience low rainfall patterns. Presence of many fruits, flowers and leaves in some tree species such as Mkuyu and Mango trees, is an indication of good rains in the coming season. Shedding of leaves by some trees for example Mkuyu tree implies poor rains.
4.2.1.3 Meteorological indicators

These are indicators that are considered elements of weather, with which the weather of a place is described. Ajibade and Shokemi, (2003) pointed out that in Nigeria farmers use meteorological indicators such as thunderstorms, windstorm and sunshine to prepare for future weather. In the study area however, the meteorological indicators used included:

4.2.1.3.1 Temperature

Rising temperatures especially during night time was a clear indication that the rain season could start soon. A very high temperature during the day and night is an indication that the rain season is nearing. The community of the study area perceived the rising temperature in terms of too much heat and the sweating that they felt. Blankets would not be used at night because of that heat.

4.2.1.3.2 Wind Direction

The arrival of rain is announced by the arrival of sisiafusho (a type of wind that is vigorous and in circular motion). It happens at day time. It is a conspicuous wind and is neither hot, cold, wet nor dry; but has a ‘rumbling sound’. This type of wind is expected in the last month of the dry season. There is also change in wind direction, the cold consistent wind found in the latter parts of the dry season die, replaced by hot humid and erratic winds. Movement of wind from West to East denoted the approach of a dry spell, and therefore hunger is expected. This alerted the farmers to start preparing on how they would cope with the situation. They say that the winds had gone to bring rain. Once the wind is observed moving towards East, it would automatically come back with rain.
4.2.1.3.3 Clouds

Clouds during the days of dry season play an important role in helping to determine whether the coming wet season can be expected to hold rain. If heavy cloud cover is observed through the long rains season, then the rains will be normal or good. If there are clear skies however, the long rains are likely to be poor. In general, clouds at night are an indication of rain to come. Regardless of cloud cover seen during the day, if no clouds are observed at night, the chance of rains is said to be unlikely. Generally, when rains are far, white clouds could be seen dominating the sky or the sky could be cloudless. With heavy dark clouds, rains are expected.

4.2.1.3.4 Lightning

Around the rainy season, lightening from the eastern sky at night means moving rain. This sign is regarded with high confidence. If lightening is seen at night people expect rain the following morning. However, if there are many thunderstorms through the dry season, it is said that the rainy season to come is likely to be poor. In general, lightening at night in the west, that is Lake Victoria side, shows the approaching rainy season.

4.2.1.4 Astronomical Indicators

These are indicators that have to do with the shape and size of the moon and stars; however the respondents acknowledged their existence and opined that they did not use them as much as other indicators.

4.2.2 Access of IK Forecast Information

One of the ways in which the persistent food insecurity problem may be addressed is through enhanced use of seasonal forecasts to anticipate and manage climate related
risks. Farmers informed and forewarned of expected seasonal conditions can minimize risks during poor seasons and maximize on the opportunities during the favorable seasons. But for this to occur, there must be mechanisms and policies that support the generation, dissemination and use of seasonal forecasts. Major forecast communication/dissemination channels identified in the study area included; word of mouth especially for advice coming from elders, chief’s meetings (barazas), and own knowledge as shown in table 4.2. The role of indigenous knowledge was found to be important at the community level. Most people respect these institutions despite the fact that formal governance institutions do not recognize the role played by these institutions.

### Table 4.2: Modes for dissemination of IK forecasts to the farmers

<table>
<thead>
<tr>
<th>Response</th>
<th>Own knowledge</th>
<th>Village Elder</th>
<th>CBO ‘s Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>%</td>
<td>F</td>
</tr>
<tr>
<td>Yes</td>
<td>12</td>
<td>12</td>
<td>70</td>
</tr>
</tbody>
</table>

**Source:** Field, (2013)

Table 4.2 shows that the most reliable mode of getting IK forecast information is by village elders (70%), own knowledge (12%) and CBO (6%). Since this information is indigenous to the people, radio and other telecommunication modes were not part of the ways through which the forecast information is disseminated. 88% of the respondents acknowledged receiving IK forecast information which helps them to plan for their farming activities. The fact that only a few people have the knowledge on interpretation of the indicators used for forecast, most of the farmers get such information through
village elders and community based organizations. Some farmers start preparing their farms after seeing their neighbors doing it.

4.2.3 Use of Indigenous Knowledge Forecasts

As noted earlier 80% of the respondents acknowledged using IK forecast for their farm activities. They use the information for preparing land, agricultural equipment and seeds; most of the people start assembling farm equipment and farm inputs after seeing the likelihood of the approaching rainy season. This is through the indigenous knowledge indicators. Making any decision on choice of crop cultivar, planting and harvesting dates is highly depends on the forecast information of the expected weather. This is important because it helps farmers to minimize weather related risks. Seasonal forecast information is important in deciding on modes of agricultural produce, processing, storage as well as choice of appropriate days for winnowing and thrashing small grains.

The planning of these activities based on indigenous weather forecasts concurs with Galacga and Balisakan (2009) who pointed out that farmers in the Philippines rely heavily on indigenous weather forecasts to plan and prepare agro-forestry activities.

With the knowledge of the expected season farmers engage in various farming practices. For a good season for example, farmers could enlarge the area under cultivation, use a lot of fertilizers in anticipation of good harvest. They would also adjust planting dates in relation to the likelihood of the onset of rains. Farmers also decide on crop mix and variety of the crops grown especially during the second season; early maturing crops are grown if the season is not promising. For the expected poor season, food rationing is done and most of them buy food storing the one harvested in the previous season for the future (table 4.5, 4.6).
4.3 Farmer’s Perception of both Scientific and IK Seasonal Climate Forecast

In the study area, seasonal forecast was regarded not only as important but also necessary for any meaningful decisions to be made in terms of agriculture productivity. This means that timely access to this information is vital to all farmers; therefore there is need for well-developed mechanisms of dissemination to enhance its usability by the farmers. Both IK and scientific forecast are evident in the study area. While scientific forecast uses the known methodology of study of sea surfaces temperatures, wind patterns and past weather events to predict the state of the atmosphere, IK forecasts is given in line with experience of living in close contact with the environment and nature. Scientific forecasts are disseminated in a formal way. There are hierarchical channels of dissemination which makes the forecasts not to reach farmers on time for them to make timely decisions. IK forecasts on the other hand are disseminated in an informal way through chief’s barazas thereby accessible to farmers.

4.3.1 Perception on Reliability of the Indicators

Comparative ratings of the accuracy of indigenous weather forecasts to meteorological weather forecasts showed that 86\% (Figure 4.1) of the respondents who had access to both meteorological and indigenous weather forecasts perceived the indigenous weather forecasts as being more reliable than meteorological weather forecasts (Figure 4.2). The findings clearly illustrate the value attached to indigenous weather forecasts with regards to sustaining livelihoods in this community. Once they are observed then the forecasted weather event would be expected to take place. People would start preparing their farms in line with the expected weather. Most communities regard indigenous climate forecast with high value as pointed out in the study by Shoko and Shoko (2011).
The results show excellent rating for cloud 49%, animal behavior 44%, plant behavior 41%, temperature changes 34% and direction of wind 30% respectively. These are the most reliable IK indicators used by the respondents in seasonal climate forecasting.

In general, table 4.3 shows the reliability rating for cloud as an indicator at 80%, animal behavior rating 91%, plant behavior at 66%, temperature changes at 66% and direction of wind at 60% respectively. Astronomic information was the least rated IK indicators and hence the frequency of respective respondents’ show that they are not regarded as reliable signs for seasonal climate forecasting in the community. These could be attributed to the fact that most farmers in the community do not study astronomical patterns since the other indicators suit their needs. Nevertheless, they acknowledge the existence of such indicators as size and shape of the moon that could give information on the arrival of rain or cessation of it. The assessment of perception on reliability
between the scientific and IK forecasts, the respondents regarded the IK forecast as being more reliable (86%) due to its location specific nature of the forecasts, while scientific forecasts was rated slightly lower (59%) because of the general nature of the forecasts that covers a wider area (Figure 4.1 and 4.2). To validate the responses given by farmers, code of numbers were allocated according to the nature of the response, for instance, 1 for reliable, 2 for somehow reliable, 3 for not reliable and 4 for not sure.

Figure 4.1: reliability rating for indigenous knowledge forecast

Source: Author, (2013)
4.3.2 Accuracy of the forecast

A majority (80%) of the respondents indicated that indigenous weather forecasts’ accuracy fell in the ‘excellent’ to ‘good’ rating while 69% indicated that they rated meteorological weather forecasts as ‘average’ to ‘good’. As noted earlier, community perceives IK forecast as being accurate and that it gives them the information they need for their farm level decision making. The scientific forecasts are sometimes regarded inaccurate due to the large geographical coverage. Moreover, once the forecast is made and the event does not occur to the expected magnitude, farmers lose confidence and therefore the use of the forecast is compromised. There is no question about accuracy of the IK indicators in the study area (Table 4.11). The results concur with Patt and Gwatta (2002) who argued that probabilistic forecast that cover a wider area can generate confusion and discourage users from incorporating the forecast in decision making. This
explains why the community in the study area rate IK forecast as more accurate than the scientific forecasts.

### 4.3.3 Access of Forecast

The study showed that 75% of the respondents received scientific weather forecast information while 25% did not (table 4.4). 30% of those who received scientific forecasts occasionally use it for planning farming activities but 70% lack confidence in the forecast, Nevertheless, despite their lack of confidence in the forecast they regard the forecast as important for farming activities. Patt and Gwatta (2002); Phillips (2003) and Mwinamo (2001), give evidence that climate forecast predictions do not trickle down to the user, especially resource poor farmers. This has played a role in making farmers to lack confidence in such forecasts.

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency (n=100)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>75</td>
<td>75.0</td>
</tr>
<tr>
<td>NO</td>
<td>25</td>
<td>25.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Source: Field, (2013)**

From the above data, it is clear that farmers in the community do receive scientific forecast and the main mode of dissemination of scientific forecast were; Radio,
Newspaper and Television (Figure 4.3). However, they regarded this as expensive to access and difficult to understand to enable them make use of it. Majority also lack confidence in it, they do not believe it, as depicted by 70% who opined that they believed in IK forecasts. Only 30% acknowledged that they believe KMS forecasts although they rarely use it for farm level decision making. According to FitzGerald (1994), people make decisions in the light of what is perceived and not what actually is. Farmers who do not believe in Meteorological forecast attribute it to inaccuracy, a fact that could emanate from errors due to generating forecasts of large geographical area coverage.

![Figure 4.3: Mode for disseminating scientific forecast to the farmers](image)

Source: Author, (2013)
Figure 4.3 show that 80% of the respondents received scientific weather forecast information through radio, 66% through TV and 34% through Newspapers. The least used modes for receiving scientific weather forecast information are village elders and CBOs. The three major modes of disseminating scientific forecasts have affected maximum access of the forecasts by vulnerable groups and language barrier brings about misunderstanding of the expected seasons. The current nature of scientific forecast terminologies of normal and above normal may not assist much a small scale farmer who has limited resources to cope with the eventualities of extreme weather events (Oduor et al. 2002).

This information concurs with the findings of Phillip et al., (2001); Phillip et al., (2003); Ngugi (2002) which showed that radio is the leading source of scientific forecast information. The question is that, how effective is radio to a small holder farmer? When they get the information are they able to understand? According to Isabirya et al., (2003), dissemination is the main problem in forecast application.

The jargons used in the communication of seasonal forecast are a stalemate to the end users of the information. This has highly compromised the use of such forecasts for any meaningful farm decisions in the area. This information concurs with Gigerenzer and Hoffrage (1995) who pointed out that, the communication of uncertainty constitutes a related problem of quality. Forecasts are presented in the language of probabilities, but are often not perceived as such. Probabilistic information is difficult to assimilate because people do not think probabilistically nor do they interpret probabilities easily (Gigerenzer and Hoffrage, 1995, cited by Stern and Easterling, 1999; Nicholls, 1999).
From a purely technical or statistical perspective, an unlikely event, one with a low probability of occurrence, can in fact occur. But for farmers and policy makers to use forecast information as a risk-reducing tool, they must have an appropriate understanding of the meaning of a probabilistic forecast (Gigerenzer and Hoffrage, 1995). This is lacking.

While progress is being made in the generation of more detailed forecasts, a lot still needs to be done to promote wider dissemination and use by vulnerable groups. It is imperative that those responsible for the generation and dissemination of seasonal forecasts collaborate and pursue strategies to remove barriers associated with access and application of climate information to ensure food security for the area and the country as a whole. Specific barriers to wider use of climate forecasts need to be addressed, including lack of clarity on how climate information can contribute to better development practice, variable usability of the available climate information, misconceptions about the demands and needs of users of climate information, and, finally, the failure to integrate local knowledge into seasonal forecasts (Blench, 1999).

Combining indigenous and modern seasonal forecasting is one of the ways of dealing with challenges faced in the development, communication and use of seasonal forecasts. Many farmers already make use of indigenous forecasts for their farm level decision making and may only need certain information to complement what they already know. It is therefore important that forecasters target existing gaps if they are to add value to communities working on the ground. Participatory approaches offer opportunities through which indigenous and modern approaches to seasonal forecasting can be
harmonized and user needs integrated. Indeed, participatory dissemination of forecasts has shown positive impacts on farmers’ response but as Roncoli et al. (2006) observed, focusing exclusively on how climate forecasts affect yield misses out on the contextual interaction that shapes how farmers understand and use climate forecasts. It is also worth noting that participatory processes are not necessarily equitable and all inclusive. O’Brien and Vogel (2003), caution against over reliance on official networks for forecast dissemination, as they may lead to intentional or unintentional exclusion of some groups from receiving information. This strengthens the case for using informal systems (local/indigenous) of dissemination even where formal institutions seem to be working well.

The effectiveness of seasonal forecasts as a supportive decision-making tool for small-scale African farmers remains subject to debate given the fact that deterministic forecasts are still not available for farmers several months in advance as ideally required. In this regard indigenous knowledge when harnessed may assist farmers a great deal.

4.3.4 Use of the Forecast

25% of the respondents in the study area do not access seasonal and daily weather forecasts from the Meteorological services. Where Meteorological forecasts are received through the radio, lack of skill in interpretation and application of these forecasts becomes a hurdle as this requires Meteorological and Agricultural Extension officers. Therefore, people need simple and easy language to apply agro- meteorological products which are not readily available. Hence these residents are then left with no choice but to use their indigenous weather forecasts as decision making tools in planning their
livelihoods. This concurs with Shoko and Shoko (2011) who pointed out that while farmer did not have the scientific forecasts in time, when asked about the expected season as observed by IK indicators almost everybody had the idea. More than 80% of the respondents relied on IK for seasonal climate forecast; this is because the IK forecast gives location specific forecasts that farmers need. The information is well understood and from which all farm decisions are made. Majority claimed that they do not believe in scientific forecasts because it comes after they already have the idea on the expected weather.

Farmers opined that the most vital information they needed was access to timely and accurate forecast, to them more specific information about the length of the rainy season (beginning and ending dates), short range forecasts and medium rage forecasts are vital in making tactful and strategic decisions with regards to productivity. This was also echoed in the UNDP/UNSO,(2000) report which stated that farmers needed more specific forecast information, for instance within 24hours or 5-10 days that would enable them make decisions on farm management practices. Majority of the farmers did not make use of meteorological forecast due to their level of literacy. The language used in packaging and dissemination of the forecast is difficult for them to understand. For example they cannot interpret or understand what above normal or depressed rainfall means. These terminologies are common in packaging and disseminating scientific forecasts. In addition to this, the language used is too technical and at times in the dialects they do not understand. The farmers attributed this to their lack of training in interpreting and applying climate information. Majority of the farmers (about 70%) who access meteorological forecasts have no confidence in it because of these short comings.
These makes IK forecasts to be perceived reliable, accurate and used by most farmers because of its simplicity. They rated forecasts as important in averting agricultural risks. Roncoli et. al. (2001) argue that quality of the information is the level of confidence placed in it by the receiver, and affects acceptance and use. Thus until KMS down scales forecasts at a reduced geographical scale as a way of improving accuracy it is unlikely that farmers will believe and use meteorological forecast. Cases of farmers rating meteorological forecasts useful and not using it concurs with the findings of Hudson (2001) and Mwinamo (2001).

Despite the prevalent application and use of indigenous knowledge by indigenous local communities, it has not been harnessed to fit into the current scientific framework for environmental conservation and natural disaster management in Kenya. As a result, there is a general lack of information and understanding of the need to integrate or mainstream IK into scientific knowledge systems for sustainable development in the country.

4.3.5 Improving Agricultural Production

IK has always enabled this community to improve on their agricultural output. By relying on IK farmers know what to plant, where and when. FGD’s findings revealed that there were years with extreme weather as forecasted by IK such as 1997/1998, 2009 and 2012. They believed that rains failed in 1997/1998 because of the curse. This concurs with the El Niño event of the same year as was scientifically forecasted. In 1998 there was no food because wind that brings rainfall failed in 1997 and hence there was no rain. Whenever there were signs of poor rains, they tried to store the food by buying and
leaving the harvested one for future. They also tried to ration food and embarked on planting other supplement foods like sweet potatoes, cassava, yams, millet and sorghum. Once they took cognizance of signs of a better season they could start farm preparation, seeds and fertilizers are bought in time hence with the onset of rain everything is ready. During the second season, whenever there is rain, farmers plant short-season crop that mature early to ensure they take advantage of the favorable season. Table 4.5 shows some of the response strategies farmers employ after receiving the forecasts of any kind.

**Table 4.5: Response strategies to the forecast**

<table>
<thead>
<tr>
<th>Response strategy</th>
<th>Frequency(F)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change of crop area</td>
<td>70</td>
<td>30.1</td>
</tr>
<tr>
<td>Change of planting date</td>
<td>66</td>
<td>28.4</td>
</tr>
<tr>
<td>Use of fertilizer</td>
<td>74</td>
<td>31.8</td>
</tr>
<tr>
<td>Change of cultivar</td>
<td>8</td>
<td>3.4</td>
</tr>
<tr>
<td>Alternative activity</td>
<td>14</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: Field, (2013)

From table 4.5, farmers could respond to the forecast positively, especially if the expected season is promising. For a good season, change of the planting area was an ideal response; 70% of farmers could put more land under cultivation and the result is good harvest due to improved yields. This would eventually translate to increased income as shown in table 4.6. However, for those farmers who have small pieces of land; taking advantage of good season using this strategy would not be possible. 66% of farmers do alter the planting dates depending on the forecast. Some could even practice
dry planting after seeing the indicators that showed the imminence of rainfall. This was found to be an appropriate strategy because farmers would use it to avert risks. 74% of farmers would use fertilizer if the expected season was good to ensure maximum yield. This would not be the case if the expected season was poor; use of fertilizers in such a case would increase losses. Change of cultivar was found to be a poor response strategy in the study area. This could be attributed to the fact that people in the area are used to their specific crops they grow, changing to a totally different crop regardless of the suit season was not an easy undertaking. This explains why only 8% of respondents do consider this option. Alternative activity as a response strategy registered only 14% of the respondents; because the area is agricultural and people do not consider other forms of livelihoods as an important way of ensuring food security. The only sure way is by farming. It was also established that adding crops to those they always plant was a strategy which they seldom used in the area especially during the second season.

Table 4.6 shows the outcome of using different response strategies to the forecast and it is clear that any response strategy that farmers engaged in bore positive results except for the alternative activity. The study results show better response strategy for any expected season; by changing cultivar resulted in increase in yield, and therefore, income as cited by 64 respondents, use of fertilizer increased yield, income and surplus in food as acknowledged by 68 respondents, change of crop area resulted in increased yield as acknowledged by 68 respondents, change of planting dates as shown by 62 led to increased yield. However, use of other alternative activities is not a good response strategy. 21% of the respondents attributed reduction in income to this response activity.
Table 4.6: The outcome of response strategies various

<table>
<thead>
<tr>
<th>Response strategy</th>
<th>Outcome</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change of crop area</td>
<td>Surplus</td>
<td>68</td>
<td>20.4</td>
</tr>
<tr>
<td>Change of planting dates</td>
<td>Increased yield</td>
<td>62</td>
<td>18.6</td>
</tr>
<tr>
<td>Use of fertilizer</td>
<td>Increased yield/ income</td>
<td>68</td>
<td>20.4</td>
</tr>
<tr>
<td>Change of cultivar</td>
<td>Increased yield</td>
<td>64</td>
<td>19.2</td>
</tr>
<tr>
<td>Alternative activity</td>
<td>Reduced yield</td>
<td>70</td>
<td>21.0</td>
</tr>
</tbody>
</table>

Source: Field, (2013)

This study found evidence that farmers do vary both crop and variety selections as a function of the expected season. For example, an increase in the number of farmers intending to plant maize and no other crops in their second season as opposed to their normal trend in planting was noted in 1998/99 and 2012, given expectations of a good year. The percentage of farmers intending to add maize to their crop mix was even higher due to the good weather expected. In 2012/2013, the number of people who reported as having heard the official forecast dropped by over 25% as a result of the lack of media attention. Nevertheless, given the prevalence of traditional forecasting schemes, which are based on IK indicators such as winds and flowering of trees and forecasts delivered through village spirit media, almost all farmers interviewed had some expectation of conditions for the season.

In both 1997/98 and 1998/99, the majority of accounts of the traditional forecast were in agreement with the official forecast although the events did not occur to the expected magnitude. The same applies to 2009 and 2012 as shown in figure 4.4. This shows that
IKF and SCF give similar climatic forecast and therefore when integrated could enhance credibility and usability of the forecast.

Figure 4.4: Comparative bar graph for precipitation in the study area (2009-2012)  
Source: Author, (2013)

Figure 4.4 shows abundant rainfall in 2012 and less abundant in 2009 during the second season. This affected the onset of long rains in 2010 as it delayed and thus affected farmers. The findings revealed that during the year of extreme weather events as in the case of 2009 and 2012, farmers employ various coping strategies for them to avert the risks involved. Those who were noted to have received climate forecast information through radio for scientific forecasts and those who used IK forecast information employed similar coping strategies ranging from change of cultivar, use of fertilizer,
pesticides, changing planting dates and food storage to alternative dietary feeds (Table 4.5). Some even planted early maturing crops where the expected weather is of little amount of rainfall. For instance, in 2012 where the area registered a high amount of rainfall in the short season, most farmers used fertilizers, pesticides, herbicides for limiting the effect of too much water on beans and other legume crops. 2009/2010 conventional forecast predicted that sea surface temperature (SST) would be enhanced and persistent up to April 2010 implying that El Niño conditions will be there. However, El Niño condition was not associated with heavy rains as that of 1997/1998. The area was predicted to have normal to above normal rainfall (KMS, 2009). IK forecasts for 2009/2010 concurred with that of the scientific forecasts as most of the environmental indicators that are frequently used for seasonal rainfall prediction by elders of the community pointed towards a good 2009/2010 rainfall season. Since July, flowering of trees were observed in the area which signaled good rains in the upcoming season. The October, November and December (OND) 2009 short-rain season coincided with weak El Niño condition. This continued up to early 2010 when near normal and above normal rainfall was enhanced.

According to the farmers as pointed out during the FGDs, all these events did not happen to the expected magnitude as forecasted by KMS but what they expected in IK came to pass; for example the KMS forecast of 2012 October, November and December (OND) and 2013 March, April, May (MAM) rainfall did not occur to the expected magnitude (Figure 4.5 and Figure 4.6). The rainfall data from the study area stations was not available for the whole year but the most crucial months the MAM and OND
were available. The predicted time of onset though differed in a week’s time range with IK; this has an effect on the decisions made by farmers.

The outlook for 2013 forecast showed that the western region would receive near normal to above normal enhanced in March and April but depressed in July (KMS, 2013). This concurred with early onset and poor distribution as depicted by IK indicators. However, the language used in dissemination here presents a major challenge to the use of such forecast. Farmers have no idea of what normal, above normal or depressed rainfall means. Furthermore, the information is too general and specific locations may experience some uncertainties. By late February of the same year IK indicators had given an indication of the eminence of the rain season, which was expected to be earlier than the normal season. Any slight difference in the commencement of the season as forecasted by KMS makes farmers not to have confidence with it and therefore its application. The IK had shown early on set and therefore those who shifted their planting dates evaded the vagaries of too much rainfall that affected the beans in May and June and less rainfall that affected maize in July and August during fruiting and ripening. These had a severe effect on the yield as most farmers did not harvest much (Field, 2013).
The chi square test revealed that the community indeed uses IK for seasonal climate forecast as p value is greater than .05 (p>.05). In this case, therefore, we reject the null hypothesis, because the community indeed uses IK for seasonal climate forecast. Although those who were found to use scientific forecasts also highly depend on IK forecast information.

4.4 Socio-economic Factors that Influence Forecast Use

While this local community has for years relied on their indigenous forecasting methods for planning agricultural activities, there has been an increasing use of modern seasonal forecasts over time. Successful use of forecasts requires on one hand a deeper understanding of the characteristics and needs of specific user groups and a clear
understanding of what the forecasts mean on the other hand. However, studies carried out in West and Southern Africa show limited adoption of forecasts by farmers due to serious resource limitations such as lack of land, labor, inputs, credit, market access and limited exposure to the use of forecasts. It is therefore important that the needs and concerns of users, in particular vulnerable groups, also inform the content and forecast dissemination approaches. The fact that many small scale farmers are unable to take advantage of forecasts due to resource constraints necessitates that socio-economic and political needs are also addressed along with climate information needs in adaption and planning. Access of the forecast does not necessarily translate to forecast application. There are quite a number of factors that determine forecast use by farmers for their farm management.

4.4.1 Demographic Characteristics of Respondents

The socio-economic status of farmers can influence their use of seasonal forecast in crop management decisions. This section examines household characteristics and assets that can influence use of climate forecast information.

4.4.1.1 Age

Respondents of all ages (through 30-80) were represented, with slightly larger numbers in the highest age bracket (40-80) category accounting for 75 (75%) and below 40 were 25 (25%) of the respondents, respectively. The oldest bracket was 60 and above years and this accounted for 28 (28%) of the respondents as shown in figure 4.6. This indicates that the data was collected from different age groups hence giving the general understanding of every age group as far as the study was concerned.
Most of the farmers are in their productive ages and, therefore, use of forecasts can significantly contribute to improved agricultural productivity.

![Bar chart showing distribution of respondents by age](image)

**Figure 4.6: Distribution of respondents by age**  
*Source: Field, (2013)*

### 4.4.1.2 Gender

To establish the distribution of respondents by gender, it was found that male were more than female. The number of male interviewed was slightly larger at 54 (54%) compared to females at 46 (46%) as shown in figure 4.7. This indicates a well-mixed perspective of the subject as far as data collection was concerned. Although it was desirable to have the equal number of male and female farmers represented in the study, this was not achieved. This could be attributed to the fact that farming activities for a long time were
issues that would be tackled by men. Women are rarely organized into agricultural cooperative societies or other functional associations while agricultural extension programmes and other supporting services have traditionally concentrated more on educating male farmers; hence, women still largely depend on their husbands for farm related information (Raffety, 2012). This is so ironical because the implementation of all farm activities is done by women. For instance, weeding, harvesting, winnowing and threshing. There is therefore for need for women to be fully involved in all stages of decision making regarding farm management.

Most men engage in outdoor activities and thus paved way for their wives to take care of farm activities hence the number of women. This gives a total of 100 farmer respondents who were included in the study.

Figure 4.7: Distribution of the respondents by gender
Source: Field, (2013)
4.4.1.3 Household composition

Most of the farmers have a household composition of persons below 15 years as shown in figure 4.8 this accounts for 60%. 30% of farmers have ages 15-19 as their household composition and only 10 have 20-25 adults in their families.

![Household composition by age of dependants](image)

**Fig 4.8 Farmers household composition by age of dependants**  
*Source: Author, (2013)*

The number of household members has an implication on food security and farm labor. Use of forecast influences plans to improve food security and decision on when and by how much farm labour is required. For instance, a large family is always hunger stricken in case of low harvest but at the same time it offers a good source of labor in the promising season. Large family coupled with small pieces of land and the vagaries of weather are a challenge to food production and security.
4.4.1.4 Marital status

The findings of this study showed that most of the respondents (91%) were married and living with their spouses. A further (4%) were divorced and (5%) were single (figure 4.9). Marital status was perceived to be vital as far as access and use of seasonal forecast was concerned, be it indigenous or scientific forecasts. Marital status has an influence on decision making with regards to the response strategies to be taken after any weather forecast is made. Men were rated as the heads of the households who were responsible for all farm decisions on when to prepare land, what to plant and where. The head of the household was to decide on when to harvest, the mode of storage and all that appertains farming. Women were viewed as helpers and implementers of what their husbands decided. Female headed households and their children were generally perceived to be more vulnerable to the risks of weather on agricultural productivity than their counterparts’ households with both spouses. Single or divorced women could manage their own farm but financial constraints were noted as setbacks to maximum use of the forecasts.
4.4.1.5 Level of Education

From figure 4.10, it is clear that a big number of respondents have primary and secondary education. 18% of respondents were totally illiterate, 26% having primary level education, 39% having secondary education and 17% had post-secondary education. No respondent had special training of any kind in agriculture; which is a big challenge. Farmers’ level of education and personal characteristics influence the way he/she acts upon information received. Patt and Gwatta, (2002) argue that young and educated farmers are more prepared to take risks in order to try new ideas than elderly farmers.

Education level is important to understand basic concepts in forecasting and making choices of what and when to plant. It was also clear that those who are illiterate and who
have primary education have more confidence in IK forecast than the scientific forecasts, a situation that could arise from their inability to understand the scientific forecast concepts. Even those with secondary education had a problem with understanding and interpreting the forecast concepts such as above normal and depressed rainfall.

![Figure 4.10: Education level of respondents](Image)

Source: Author, (2013)

### 4.4.1.6 Income

As shown in figure 4.11 the major source of income in the study area is farming; both crop farming and livestock keeping, this accounts for 70%. The other sources of income included employment at 2%, wages at 7% and business at 21%, although the businesses engaged in accrue from farming and, therefore, this means that farming is the biggest source of income. In order for these people to realize livelihood sustainability then, use
of forecasts is inevitable. KMS issues forecasts one month earlier, giving time for preparation in terms of finances from CBO’s, NGO’s and other credit facilities institutions. It gives advance information on the outlook of the expected season so that farmers can decide on whether to borrow money to invest in farming or not. One acre fund; an NGO that gives credit facilities in terms of farm inputs could bridge this problem by solving the farmer’s income problem but most farmers do not dare borrowing for fear of defaulting, as a result they end up lacking capital to purchase farm inputs and hire labor hence underutilizing the forecasts.

![Fig 4.11: Respondents sources of income](source: Field, (2013))

### 4.4.1.7 Land Size and Tenure

Land is a big resource in Chwele and Mukuyuni wards because from the earlier sections it is clear that most of the people’s livelihood depends on this natural resource. Most of
the respondents have land less than 5 acres as represented by 84% of the respondents, 13% have between 5-10 acres and 3% have more than 10 acres. Land size and tenure are major factors in deciding on the use of forecasts (Fig 4.12). Given that majority of the respondents acquired land through inheritance (Table 4.7), land fragmentation could be the reason why most of them have small land sizes. Small land inhibits increase in area in case of a good forecast in order to take advantage of the season and maximize the yield. Therefore, intensified farming should be encouraged to optimize the yield.

![Figure 4.12: Land sizes owned by respondents](source: Field, (2013))
From table 4.7 most of the land owned by people was acquired through inheritance as represented by 79% of the respondents, 9% of the land owned by farmers was bought and some farmers do rent the land for farming purposes as depicted by 12% of the respondents.

### 4.4.1.8 Farming Practices

Table 4.8 shows that the annual crops grown in the study area included maize, which accounted for 23.6%, beans, (23.6%), sorghum, (11.5%), millet (11.1%) and groundnuts (19.1%), and other crops accounted for 10.8%. Maize, beans and groundnuts are the main annual crops grown in the study area with few people growing sorghum, millet and other seasonal crops like sunflower as shown in table 4.8. It is clear that farmers plant more than one crop. This is important in minimizing risks of weather, pests and diseases, when one crop fails a farmer does not incur total loss. Crops do very well in the area but clear seasonal climate forecast are inevitable since any slight weather anomaly greatly affects the yield, exposing the population to food insecurity stresses. For instance, in 2013 beans were affected by too much rain during the long rains and maize affected by
poor distribution of rain during the fruiting stage. Data collected from the field showed that the area registered very poor yield in 2013 compared to other years that did not have extreme weather.

Table 4.8: Crops grown in the study area

<table>
<thead>
<tr>
<th>Crop</th>
<th>Frequency (n=100)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>100</td>
<td>23.6</td>
</tr>
<tr>
<td>Beans</td>
<td>100</td>
<td>23.6</td>
</tr>
<tr>
<td>Sorghum</td>
<td>49</td>
<td>11.5</td>
</tr>
<tr>
<td>Millet</td>
<td>47</td>
<td>11.1</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>81</td>
<td>19.1</td>
</tr>
<tr>
<td>Others</td>
<td>46</td>
<td>10.8</td>
</tr>
<tr>
<td>Total</td>
<td>425</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Field, (2013)

Due to double responses; one farmer planting more than one crop, the frequency went beyond the exact number of respondents. The types of crops grown in the area have an influence on the response to seasonal climate forecast in such a way that most farmers would not wish to have change of cultivar as a response strategy, because of the tradition of planting specific crops in that area. Even if the season is not promising for maize and beans, they would still plant these very crops because they are not used to other crops which would do well with little rainfall.
4.4.1.9. Farm Equipment

From table 4.9, it is clear that most farmers do not own their own farm equipment. Regardless of whether the forecast of any kind is given in advance, response to the forecast may be limited by draft. Most farmers have to wait for those with animal power to finish on their farms before they have mercy on them. Inadequate income also inhibits their ability to hire farm machinery on time thereby exposing them to food insecurity.

Table 4.9: Farm tools owned by farmers

<table>
<thead>
<tr>
<th>Farm tools</th>
<th>Frequency (n=100)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal plough</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Ox-cut</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Sprayer</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Oxen</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Other</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Field, (2013)

4.4.2. Factors Influencing the Use of IK and Scientific Forecasts

Agricultural decision makers currently fail to optimally use available climate information and forecasts (Changnon et al. 1995); suggesting that increased accuracy of forecasts and other climate information will not translate automatically into increased
influence on farmer decisions. Factors other than the accuracy and reliability of forecasts influence farmer choices regarding the use of forecasts in their decisions. The question is, “What other factors?” The factors under study that influenced the use of IK and scientific climate forecast in improving agricultural production in Mukuyuni Ward included: age, educational level, belief system, income, labor, land size, animal power, storage facilities and interpretation of IK indicators as shown in table 4.10.

Table 4.10: Factors limiting the use of forecasts for agricultural production

<table>
<thead>
<tr>
<th>Limiting factor</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54</td>
<td>13.2</td>
<td>3</td>
</tr>
<tr>
<td>Level of education</td>
<td>53</td>
<td>12.9</td>
<td>4</td>
</tr>
<tr>
<td>Income</td>
<td>83</td>
<td>20.2</td>
<td>1</td>
</tr>
<tr>
<td>Belief system</td>
<td>47</td>
<td>11.5</td>
<td>5</td>
</tr>
<tr>
<td>Interpretation</td>
<td>73</td>
<td>17.8</td>
<td>2</td>
</tr>
<tr>
<td>Labour</td>
<td>22</td>
<td>5.4</td>
<td>8</td>
</tr>
<tr>
<td>Land</td>
<td>23</td>
<td>5.6</td>
<td>7</td>
</tr>
<tr>
<td>Storage facilities</td>
<td>15</td>
<td>3.7</td>
<td>9</td>
</tr>
<tr>
<td>Animal power</td>
<td>40</td>
<td>9.7</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: Field, (2013)

Table 4.10 shows that the major factors that limit the use of seasonal climate forecast in improving agriculture are age (13.2%), level of education (12.9%), income (20.2%), belief system at (11.4%), interpretation (17.8%) , land (5.6%), labor (5.4%), animal power (9.7%) and storage facilities at 3.7%. Land storage facilities and animal power are factors are underlain by income. Out of the 15 factors that the researcher had anticipated,
only 9 were mentioned by respondent as factors that influence the use of forecasts. The 9 factors initially analyzed were reduced to 5 main ones.

These five factors were observed and chosen for discussion. The choice of factors was based on the use of Eigen values and Scree slope technique at the cut off levels (Figure 4.13). In this case only five factors were identified, only those factors with Eigen values above one were considered. A communality analysis (principal component analysis was ran to identify which factors are among the five to extract (Table 4.11). To examine socio-economic factors influencing the use of forecast information for agricultural production, only factors with the value >.4 is significant and was extracted. Therefore, the extracted factors included age, level of education, belief, labor and storage facilities.
Figure 4.14: Scree plot
Source: Author, (2013)
### 4.11: Table of Communalities

<table>
<thead>
<tr>
<th>Question</th>
<th>Initial</th>
<th>Extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is age a factor that influences the use of forecast information to improve agricultural production?</td>
<td>1.000</td>
<td>.423</td>
</tr>
<tr>
<td>Is the level of education a factor that influences the use of forecast information to improve agricultural production?</td>
<td>1.000</td>
<td>.539</td>
</tr>
<tr>
<td>Is income a factor that influences the use of forecast information to improve agricultural production?</td>
<td>1.000</td>
<td>.099</td>
</tr>
<tr>
<td>Is belief a factor that influences the use of forecast information to improve agricultural production?</td>
<td>1.000</td>
<td>.515</td>
</tr>
<tr>
<td>Is interpretation a factor that influences the use of forecast information to improve agricultural production?</td>
<td>1.000</td>
<td>.108</td>
</tr>
<tr>
<td>Is labor a factor that influences the use of forecast information to improve agricultural production?</td>
<td>1.000</td>
<td>.582</td>
</tr>
<tr>
<td>Is size of land a factor that influences the use of forecast information to improve agricultural production?</td>
<td>1.000</td>
<td>.219</td>
</tr>
<tr>
<td>Are storage facilities a factor that influences the use of forecast information to improve agricultural production?</td>
<td>1.000</td>
<td>.415</td>
</tr>
</tbody>
</table>

**Method of extraction:** Principle Component Analysis  
**Source:** Author, (2013)
From table 4.11 it is clear that age is a factor that influences the use of forecast as shown by the values greater than 4. Age registered .423 from the communality table. This concurs with the information given during the FGD interview. The FGDs revealed that most people who use IK in seasonal forecast are elderly and therefore age was concluded as a factor that could influence forecast use. This is attributed to the fact that most young people regard scientific knowledge as paramount and that IK is outdated and the old way before technology come by. This was echoed in the UNEP (2008) report, which pointed out that IK has not been documented and may be lost when the old people who are custodians of the knowledge pass away. Most young people do not have the interpretation of a particular indicator much. This greatly affected the levels of agricultural production, although they have interest in the use of IK forecasts. Their farm decisions are made depending on what the neighbours do in terms of land preparation, planting time and so forth. Moreover, those who have high level of education could be inclined to the use of scientific forecasts and only seek IK where the scientific forecasts seem inaccurate. There should be a way through which young people acquire IK and this is where documentation of such information is key. On the other hand, the young give more attention to scientific forecast but which they say they still have no confidence in.

Lack of animal power is another hindrance to response to forecasts, as farmers fail to take advantage of the planting opportunities waiting for their turn to plough. The research showed that out of 100 farmers interviewed only 53% had their own animal power that is meaningful in crop farming that means, 47% had to wait until their fellow farmers are through with ploughing before they start ploughing (Table 4.9).
From Table 4.10 it is clear that 5.4% of the respondents considered labor as one of the factors that influence the use of forecast. This corresponds to what it registered in Table 4.11, the value being .582. Most famers use family labor, and where it is not enough they have to supplement it with hired labor. The challenge is still income and this could be a hindrance to any response to the forecasts. This is in line with the UNCEF / UNEP report (2006), the report pointed out that socio-economic factor such as labor could affect use of forecasts by farmers. For example, in a good rain year farm households which are limited by labor, may decide to reduce the cultivated area, use more manure and focus on weeding to maximize yield while households that have more labor can expand the cultivated area to maximum use of good rainfall conditions. In a drier year the behavior of both sets of households would be different. This information concurs with the findings of Kamal and Subbiah (1999). They argued that socio-economic constraints form a critical gap between climate forecast information and its application at farm level decision making.

Belief as a factor registered .515 (Table 4.11), this means that how people perceive the forecasts greatly determines the response they put to it. The biggest challenge in the use of scientific forecast is the fact that famers view it as unreliable and always untimely. Patt and Gwata (2002) have argued that access and use of climate forecast remain the greatest challenge to climate scientists. Many a time climate forecast have suffered a credibility problem and people have shown mistrust for it (Hobbs, 1980) an attitude that comes from the previous forecasts being perceived as inaccurate, as a result, users end up ignoring the forecast. The study revealed that farmers had accessed forecasts; IK over
90% and scientific 70, when farmers were asked whether they believe in forecasts, only 30% of those who access both IK and scientific believe KMS forecast and 80% believe IK forecast. According to FitzGerald (1974), people make decisions in line with what they perceive as opposed to what actually is. Farmers who do not believe in Meteorological forecasts attribute it to inaccuracy that perhaps stems from generating large geographical area forecasts.

Contrary to the many respondents who claimed to receive the scientific forecasts as it is in the table, they do not put it to use. Most of the respondents had faith in the traditional forecasts which they use. Farmers should be educated on the benefits of forecasts and how to use it. Farmers using own knowledge to determine rainfall on set to plant are most likely dependent on indigenous rainfall indicators (Ngugi, 2001; DMCN, 2004). IK can predict onset but not distribution and cessation.

Forecasts are important in averting agricultural risks. Patt and Gwatta (2002) argue that quality of the information is the level of confidence placed in it by receivers and affects its acceptance and use. Therefore, KMS should downscale forecasts at a reduced geographical area as a way of improving accuracy, before this is done, it is unlikely that a farmer will believe and use meteorological.

Cases of farmers rating Meteorological forecasts as useful but not using it are also reported in Hudson (2001) and Mwinamo (2003).
The level of education as a factor that influences forecast use registered .539 (Table 4.11) People who are educated; post primary regard IK as old, an outdated form, backward way of forecasting and therefore embarking on it for seasonal forecasts could be minimal. Whereas those with primary and non-literate levels rely more on this (IK) because they cannot access scientific knowledge, they consider it expensive to access and at the same time, the presentation of the forecast and its mode of communication to policymakers and farmers are critical to application success. While much attention has been paid to the science of climate forecasting and its application for drought mitigation, there is limited understanding of the socio-political environment through which climate forecasts are channeled and interpreted. Once in the hands of policymakers, the science product loses in a very critical sense, its desired objectivity and becomes woven into a complex mesh of social, economic, and cultural realities that influence how information is in fact used. To them IK forecasts is the only forecast they know and rely on. IK should be integrated into the scientific system of forecasting to enhance access and usability of the forecasts (Ingram, 2002). These findings are in line with those pointed out by Mwinamo (2001). He argued that lack of understanding of forecasts by dissemination agents lead to apathy and lack of faith of the forecast by the people. He also pointed out that a large segment of rural people are illiterate. This is a challenge to understanding scientific forecasts

Lack of income registered .099 will go a long way in affecting farmers’ response to forecasts especially if one does not have his own machinery. Those with their draft will quickly employ a response strategy but those who do not have will wait until their counterparts finish on their farms before they have mercy on them. This highly
exacerbates their vulnerability to hunger, because they may delay to take advantage of a good season or to respond to a bad season. This information is in agreement with the findings of Phillips et al. (2001). The Research carried out in Zimbabwe has shown that just under 58% of communal farmers own their own animal power implying that 42% have to wait for their turn to have their fields ploughed (Phillips, et al. 2001). Although forecasting information may be readily available to communal farmers, lack of draft power and resources limit its effective use. Planting opportunities are missed as farmers wait for their turn to plough. They therefore recommended that communal farmers should have access to inputs and draft power in order to capture the benefits of seasonal forecast information by making timely and appropriate decisions.

Lack of capital is a big challenge to forecast application as depicted by 20.2% (Table 4.10). They considered forecasts very important for their farm decisions but most farmers fail to take advantage of the favorable season since they have limited resources, therefore, even when the forecast is given in advance still they may not employ the expected strategy to avert the risks or maximize their yields.

Land size and storage facilities were factors that least influenced how people respond to the forecasts. Many of them use family labor, and those who cannot are forced to contract people to work on their farms. Many of them still cannot afford this and therefore are forced to till only a small portion. Therefore, the size of land is intertwined with labor availability.
To examine the socio-economic factors influencing the use of forecast information for agricultural production, all factors that were extracted were transformed into one variable called socio-economic by SPSS. These factors were correlated with forecast use (Transformed from response strategies engaged in by farmers). The results showed that the correlation is significant at $p>0.05$ and therefore we rejected the null hypothesis and accept the alternative one that supports that indeed there is a relationship between socio-economic characteristics of a farmer and the use of forecasts for agricultural production. Taking the coefficient of determinant, socio-economic factors contributes 47.6% in the variability to the use of forecast for agricultural production. The remaining variability is contributed by other factors other than socio-economic factors.
CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction
This chapter deals with summary of the main finding, conclusion and recommendations of this study and areas of further research. The main objective of this study was to examine the role of indigenous knowledge in seasonal climate forecast for agricultural production. The summary of the findings, conclusion and recommendations outlined in this chapter were based on these primary objectives.

5.2 Summary of the Main Findings
It was found that IK plays a major role in seasonal climate forecasts. This study clearly brought out the vast indigenous knowledge of farmers on rainfall prediction and their understanding on reliability through their observation, experience and practice in the field. Majority of farmers have the knowledge about indicators used for seasonal weather forecasts and that a good number use it in agricultural planning.

The first objective was to identify and document IK indicator used for seasonal climate forecast in Chwele and Mukuyuni wards, how information is received and used by farmers. The study results have shown that indeed there are indicators used for seasonal climate forecast such as animal behaviour (23.5%), plant behaviour (17.7%), clouds (20.6%), temperature (17.1%) wind (14.2%) and astronomical (6.6%).
The study also revealed that skill in the interpretation of IK indicators was a function of age. The elderly contributed a lot of valuable knowledge while the young tended to look down upon the indigenous weather forecasting systems.

It was noted that this information is received by own knowledge (12%) that is people see indicators and make interpretation of the expected weather, C.B.O (6%) and by village elders in chiefs Barazas (70%). The information received was used in making farm decisions such as (when, where and what to plant). Decisions like changing crop cultivar, change of crop area, use of fertilizer, or alternative activity were made after receiving the forecast of the expected weather. This has enabled them to reclaim good yield in a good season and cover risks in poor seasons. The chi-square analysis applied to verify the null hypothesis that the community in the study does not use IK was rejected. Because it was found out that indeed IK is used for seasonal forecast.

The second objective of the study was to examine farmer’s perception of both IK and scientific forecasting methods. Farmers regarded forecasts as being important for agricultural productivity, the study results showed that the community have access to both IK and scientific forecasts, but for those respondents who had access of scientific and IK forecast, (70%) do not have confidence in scientific forecast due to its inaccuracy that stems from its large geographical coverage, and access; a problem emanating from its formal channels of dissemination. IK forecast was rated reliable at (86%) while scientific forecast reliability fell at 59%. Access of scientific forecast was mostly through radio (80%), television (66%) and newspaper (34%), lack of media attention and limited understanding of the forecast affects its application. On the other hand IK
forecast dissemination is informal and therefore reaches a wide population. It was clear that people make decisions based on what they perceive and not what really is the case. These highly compromises forecast application.

The third objective was to examine socio-economic factors enhancing or impeding forecast use. Seasonal climate forecast access does not necessarily translate to forecast application or use. There are other socio-economic factors which influence forecast application in agricultural productivity. It is therefore important to look at the socio-economic base of the society when dealing with the question of forecast application. The socio-economic status of a farmer can either impede or enhance forecast use. The results showed that socio-economic characteristics of a farmer play an important role as far as forecast use is concerned. A number of factors noted to have influence on forecast use were; age (13.2%), income (20.2%), interpretation (17.8%), belief system (11.4%), animal power (9.7%), land size (5.6%), labor (5.4%), and storage facilities (3.7%). These have an effect on the general outcome in terms of yields and therefore food security of the region. Correlation analysis to test the hypothesis that stated; there is no relationship between socio-economic characteristics of farmers and use of either scientific or IK forecasts for agricultural production showed that indeed there is a significant relationship and therefore the null hypothesis was rejected and the alternative one upheld.

5.3 Conclusion

In the light of findings above, it can be concluded that the small holder farmers of Chwele and Mukuyuni wards rely heavily on IK as opposed to meteorological forecast.
The finding from this study confirms the finding by Shako and Shako (2011). It was also noted that there is need to utilize the IK forecast to augment the scientific weather forecast from meteorological services.

Local residents in most cases do not understand the meteorological forecast, so immense benefit can be realized if this type of forecasting system which (IK) is better understood by the majority of the resident is improved. It was clear that despite modernization and global change, IK systems used to predict weather still play an important role in decision making in rural livelihoods.

The study also concluded that farmers’ perception of the forecast has an influence on how they would use these forecasts. Majority of the farmers rely on indigenous knowledge in weather prediction because of how they perceive it. They perceive IK forecasting methods to be more reliable than the scientific ones.

Furthermore, the study revealed that socio-economic status of a farmer may impede or enhance the use of climate forecast information.

5.4 Recommendations

The findings from this research reveal that there is need to utilize the Indigenous weather forecasting systems to augment the conventional weather forecasts from the Meteorological services. In view of this, the following recommendations are made:

i. IK forecasts given by traditional forecast experts should be recorded and disseminated to farmers through chief’s barazas and CBOs in order for farmers to make use of the forecast to enhance their agricultural productivity. Since it was noted that interpretation of the IK forecasting indicators is a function of age,
there is need to document and impart the knowledge on the use of this indicators to derive weather forecast to younger people so as to ensure that the forecasting methods are available for the present and future generations.

ii. Indigenous weather forecasting systems should be used to augment scientific forecast in order to restore credibility and enhance its application by farmers. This is to say that scientific forecasts should be blended with IK and be disseminated through right channels. Experts in the field such as field extension officers should be involved in forecast dissemination to ensure that the information reaches the farmers on time, this should be accompanied by the advice on how to use these forecast. For instance, this crops to grow in a particular season to enhance agricultural productivity.

iii. (a) Farmers should have access to farming inputs and animal power in order to capture the benefits of seasonal forecast information by making timely and appropriate decisions. There is also need to teach people how the indigenous weather forecasts and Meteorological forecasts can be used for planning purposes. For example choice of a crop to grow in that season. This should be done for both seasonal and short period forecast.

(b) Sustainable land management practices should be adopted by farmers, for example intensification in farming could enhance productivity in the wake of land fragmentation in the region.
(c) Young people should be encouraged to take up farming as an occupation as an enterprise. They are more likely to employ modern techniques of farming and therefore enhance agricultural productivity. This will boost the food security situation in the region and improve farmers’ living standards as well as improving the economy of the country.

5.5 Areas of further research.

It is also suggested that further research should focus on

i. The rational of indigenous knowledge indicators and their prediction of rainfall.

ii. Focus should also be paid on other areas where IK is used in the study area and not only in seasonal climate forecast as is in this study.

iii. Further research should also investigate gender involvement in forecast application. Since they are the chief implementers of farm activities yet rarely textured in decision making after forecast access.
REFERENCES


Kenya Metrological Services, (2009). Seasonal climate outlook

Kenya Metrological Services, (2013). Seasonal climate outlook

Lucio FDF (1999). Use of contemporary and indigenous forecast information for farm level decision making in Mozambique. Consultancy Report UNDP/UNSO P.72


Patt, C. (2001): Traditional early warning systems and coping strategies for drought among pastrol communities. Flencher School of Law and diplomacy, Tuff University, Medford, United States


Phillips, S.G; Makaudze, E; Dean, D; Unganal, L and Chimeli, A. (2002). *Implication on farm level Response to Seasonal Climate forecast for aggregate grain production in Zimbabwe Agricultural system* 74:351-396


Pratt, C. (2001): *Traditional early warning system and coping Strategies for drought among pastoral communities.* Fletcher School of Law and diplomacy. Tuff University, Medford, United States

Raffety, R. Fremeth, A and Branzei, O. (2012). The environmental consequences of shared ownership, the alliance on research on corporate sustainability (ARCS) annual conference, New Haven, connection

Republic of Kenya (2004). National Policy on Disaster Management (Revised draft) P.4, Nairobi Kenya


United Nation Environment Programme (UNEP, 2002). Africa Environment Outlook, past present and future perspectives. Earth Print Ltd. UK


### APPENDICES

#### APPENDIX 1: Chi-Square

Table 4.9: chi-square test

<table>
<thead>
<tr>
<th></th>
<th>Chi-Square Tests value</th>
<th>df</th>
<th>Asymp. Sig. (2 sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>.581*</td>
<td>2</td>
<td>.748</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>1.041</td>
<td>2</td>
<td>.594</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.522</td>
<td>1</td>
<td>.470</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 4 cells (66.7%) have expected count greater than 5. The minimum expected count is .05.
**APPENDIX 11**: Table of correlation between social economic factor and use of both IK and scientific forecasts

Table 4.17: Table of correlation

<table>
<thead>
<tr>
<th>Social economic factors that influence agricultural productivity. use of IK forecast information for agricultural production</th>
<th>Social economic factor that influences agricultural productivity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation Sig. (1-tailed) N</td>
<td>1</td>
</tr>
<tr>
<td>Pearson Correlation Sig. (1-tailed) N</td>
<td>0.690 .053 11</td>
</tr>
</tbody>
</table>
Appendix III: Questionnaire

This questionnaire is administered to assess the role of indigenous knowledge in seasonal climate forecast for agricultural production in Chwele division of Bungoma County, Kenya.

Introduction

Good morning/afternoon. My name is Carolyne Barasa and Iam here to conduct research on indigenous knowledge on behalf of Kenyatta University. The information you will provide is completely confidential and will be used only for research purposes. I therefore request for your participation in this study.

Name of enumerator Date
Start time Stop time

SECTION A: Respondent’s personal data

Name………………………………………………………………………………………………………. Age………………..Gender □ male □ Female
Marital status………………………………Level of education…………………

□ Primary □ Secondary □ Post-secondary □ Illiterate
Level of agricultural training……………………………………………………………...

II Household composition

Name(s)1…………………………………………..age……………………………….sex……

2
3
4
5
Relationship with the head of family………………………..resident/out of………………

III  Land tenure and use

a)  Total land area in acre

☐ < 2,  ☐ 5,  ☐ 10,  ☐ >10

b)  Which economic activity do you engage in

☐ Crop farming,  ☐ Livestock keeping  ☐ Trading  ☐ Other

c)  For each above specify:

Crop farming: which crop

☐ Beans  ☐ Maize  ☐ Ground nuts  ☐ Sorghum  ☐ Millet  ☐ Other

D)  Do you own this land? if yes how did you acquire

☐ Inherited  ☐ Bought  ☐ Rented  ☐ other

e)  How many acres do you intend to farm this year in acreage

☐ 1-5

☐ 5-10

☐ >10
B I Climate forecast information

a) Are you aware of IK forecast? If yes which of the indicator listed below have you used

<table>
<thead>
<tr>
<th>Signs/ indicators</th>
<th>indication</th>
<th>Time of occurrence</th>
<th>Reliability of the indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal behavior</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant behavior</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind direction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astronomic indicator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sky colour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clouds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other(Specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


b) How do you get the forecast information of IK system? (Tick where appropriate and if more than one please show by ticking against them)
<table>
<thead>
<tr>
<th>Mode of dissemination</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
<td></td>
</tr>
<tr>
<td>Television</td>
<td></td>
</tr>
<tr>
<td>Extension</td>
<td></td>
</tr>
<tr>
<td>Village elders</td>
<td></td>
</tr>
<tr>
<td>Rain makers</td>
<td></td>
</tr>
<tr>
<td>Own knowledge</td>
<td></td>
</tr>
<tr>
<td>Other (Specify)</td>
<td></td>
</tr>
</tbody>
</table>

c) Do you remember (years) when these indicators were observed and people advised on the expected weather?

   Yes_________/No______
   If yes complete the tables bellow

<table>
<thead>
<tr>
<th>Year</th>
<th>Indicator</th>
<th>Interpretation/probable effect</th>
<th>Expected weather</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

 d) What response activities did you engage in for particular weather event and what was the outcome? Please indicate in the table below
Response strategy | Tick | Out come | Tick
---|---|---|---
Change of area | | Increased yield | 
Cultivar change | | Reduced yield | 
Fertilizer use | | Increased income | 
Food storage | | Reduced income | 
Alternative activit | | Surplus | 
Other( Specify) | | Other(Specify) | 

e) Are there years when IK indicators forecasted weather to be unusual and you did not engage in response activities?

Yes…………/no…………

f) If yes, what were the effects?

**Effects**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop failure</td>
<td></td>
</tr>
<tr>
<td>Poor yield</td>
<td></td>
</tr>
<tr>
<td>Famine</td>
<td></td>
</tr>
<tr>
<td>Low income</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

II Information on Scientific knowledge systems in weather forecasting

a) Do you receive scientific weather forecast information in this area?

Yes…………/no…………

b) If yes, what are the sources? Please complete the table below.

<table>
<thead>
<tr>
<th>Mode of dissemination</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Radio</td>
<td></td>
</tr>
<tr>
<td>2  News paper</td>
<td></td>
</tr>
</tbody>
</table>
3 Television
4 Extension officers and village elders
5 CBO’s
6 KMS bulletin
7 Other

c) Do you believe in the forecast?
Yes………… / no…………
d) If no, why? □ Not accurate □ not timely □ other
e) Do you understand the forecast? Yes……… /no…………
f) If no, why? □ Language □ not detailed □ very general □ others
g) How would you rate seasonal climate forecast?
□ Fair □ Very useful □ Not useful □ Other
h) Which is the most useful forecast information you need?
□ Rainfall distribution
□ When to start planting
□ When the season begins
□ Adequacy of rain
□ Crop cultivar to be planted

C Factors influencing the use of both IK and scientific forecasts agricultural production
   a) Which of these factors
   b) enhance or impede your response to seasonal climate forecasts

Limiting factors
   Tick
   Age
   Level of education
   Income
   Belief
Interpretation
Labor
Size of land
Storage facilities
Draft
Accuracy
Fertilizer
Other (Specify)

a) Do you use seasonal climate forecast information in planning for food security status in your family? 

Yes……… /no…………………….

b) How do you respond to forecasts to ensure food security for your family?

- Reduce/ increase number of meals
- Change diet
- Buy in case of deficiency
- Seek off farm employment
- Other (Specify)
APPENDIX IV: Face to Face Interview Guide for the Elders of the Community

1. Do you have any reasons as to why a particular weather event occurs after a certain indicator has been seen?

2. Do you remember years when particular indicators were seen and the weather scenario expected failed to materialize?

3. What response strategy do you engage in for extreme weather scenarios?

4. How effective is the use of IK in seasonal climate forecast?

5. Has IK forecast been able to improve agricultural production in the study area?

6. Are the IK indicators known by all members of the community or are they only known by specific people (elderly people)?

7. How would you ensure that IK is not lost for future generations?

8. What limits the use of IK in seasonal climate forecast?

9. What limits the use of IK seasonal climate forecast information for agricultural production?

10. What is your opinion on both scientific and IK seasonal climate forecast systems?
APPENDIX V: Focus Group Discussion Guide

1. Do you have IK of any kind in this community?

2. Do you use it in seasonal climate forecast?

3. What are some of the indicators that you use?

4. Is the knowledge inherent to all or are there specific people who do it? Does age affect the IK knowledge?

5. How do you rate scientific forecast and IK in terms of accuracy, reliability and dissemination?

6. Do you use the forecast?

7. What response strategies do you use after receiving the forecasts

8. Has the forecast been important in improving agricultural productivity?

9. What are the hindrances to forecast use?

10. How would you like the forecasts to be?