ACCESS AND UTILIZATION OF AGRO METEOROLOGICAL INFORMATION BY SMALLHOLDER FARMERS IN PERKERRA AND LARI-WENDANI IRRIGATION SCHEMES, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Award of Master of Science Degree in Agricultural Information and Communication Management of Egerton University

EGERTON UNIVERSITY

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DECLARATION AND APPROVAL

DECLARATION

I hereby declare that this is my original work and has not been submitted or published for any award of a degree or diploma in this University or any other University.

Signature______________________________ ______________________________

Willard Zendera Date

APPROVAL

This thesis has been presented with our approval as University supervisors.

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DEDICATION

To my late father William Zendera and my mother Kesiah Zendera, for their sacrifice in sending me to school.

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ABSTRACT

Weather and climate variability are the major production risks and uncertainties impacting agricultural systems performance and management. This study investigated the access and factors that influence the utility of agro meteorological information by smallholder irrigation farmers in Lari Wendani and Perkerra irrigation schemes in Kenya. A systematic random sampling procedure was employed to select 255 farmers from a total population of 776 farmers. In Lari Wendani 33 farmers were interviewed and 222 farmers were interviewed in Perkerra irrigation scheme. These interviews were conducted after a pretest was done in Lari Wendani on 15 farmers who were attending a horticultural and marketing course. Structured questionnaires were used to elicit responses from the households. The units of measurements were farmers, irrigation and extension staff. Data were analyzed using descriptive statistics such as mean, percentage, ranking, standard deviation, χ^2-test, and Spearman Correlation Coefficient. A multiple regression analysis model was used to analyze the influence of several independent variables on access to and utilization of agro meteorological information. Results indicated that 98% of the farmers were able to access agro meteorological information through radio. More than 60% indicated that they could not access meteorological information from bulletins, mobile, internet, extension, and barazas. Inadequate extension (72%) was cited as a major factor affecting farmers' access to weather forecasts. More than 50% of the respondents made decisions always in the event that they received seasonal forecasts, onset date of the main rains and information on the expected amount of rainfall. The factors affecting farmers' adoption of agro meteorological information were related to the inaccuracy of forecasts; inadequate weather forecasts information for meaningful decisions and the delay in releasing seasonal forecasts giving farmers less time to make preparations. It was concluded that socio-economic factors affect the level of adoption of agro meteorological innovations. The study emphasizes the need for training in extension in relation to dissemination of agro meteorological innovations and the use of feasible demonstrations to enhance the adoption of agro meteorological products.

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LIST OF ABBREVIATIONS

ALIN	: Arid Lands Information Network
ASAL	: Arid and Semi Arid Lands
AWS	: Automatic Weather Stations
CBOs	: Community Based Organization
CBS	: Central Bureau of Statistics
DEOs	: District Extension Officers
ICT	: Information and Communication Technology
ITCZ	: Inter-tropical Convergence Zone
KMD	: Kenya Meteorological Department
KNBS	: Kenya National Bureau of Statistics
LBNR	: Lake Bogoria National Reserve
NGOs	: Non-governmental Organization
NIB	: National Irrigation Board
NMHS	: National Meteorological and Hydrological Services
RANET	: Radio and Internet Communication System
SADC	: Southern Africa Development Community
SPSS	: Statistical Package for Social Scientists
SSTs	: Sea Surface Temperature

CHAPTER ONE

INTRODUCTION

1.1. Background of Study

Kenya comprises of 60, 000,000 ha with a population of 38,610,097 people; her growth rate stands at 2.7% (KNBS, 2010). The total land area in Kenya is 58,037,000 ha. Approximately 5,162,000 ha is arable land while 103,203 ha is land under irrigated agriculture (CBS, 2007, AQUASTAT, 2005). It has one of the most developed and diversified economies in the Sub-Saharan Africa region based largely on agriculture (UN, 2008).

Kenya is a major exporter of coffee and tea, for which she has a reputation for her high quality, as well as fruit, flowers and vegetables. Many exports emanate from plantation farms, although smallholder exports are also important. Agricultural products account for 65% of exports, with tea and coffee accounting for 42%. Approximately 75% of Kenya's population is engaged in agriculture. Despite being a major exporter of cash crops, Kenya is also a large recipient of food aid in Africa. The emphasis of the government agricultural extension services is primarily to meet food security needs, with export promotion and trade as a secondary priority (Kimenia and Oyare, 2006).

Agriculture is highly vulnerable to seasonal climate variability. Climatic variability is often devastating to agriculture because of its associated seasonal uncertainties (Bert *et al.*, 2006, Awuor, 2008). Farmers incorporate weather and climate factors into their management processes to a significant extent. Farmers and other decision makers in agriculture are ill prepared for the variations in weather conditions. They often make decisions based on their general understanding of climatic patterns for their regions (Bert *et al.*, 2006, Gommes *et al.,* 2007). Climatic uncertainty and variability often leads to conservative strategies that sacrifice productivity to reduce the risk of losses in poor years. Better predictions of weather within three to six months, would possibly lead to careful decisions that can decrease adverse impacts while taking advantage of expected favourable conditions (Bert *et al.*, 2006). Planting and crop selection are functions of the weather and of the normal cycles of the seasons. Timing of cultural operations, such as cultivation, application of pesticides and fertilizers, irrigation and harvesting, are strongly affected by the weather of the past few days and in anticipation of the weather for the next few days. In countries with monsoonal climates, planting dates of crops depend on the arrival of the monsoonal rains (Stefanski, 2007).

The positive effect of weather forecasts in agriculture is maximized if weather forecasters are aware of the farmer's requirements and farmers know how to make the most use of the forecasts. It is not possible to determine anomalous attributes unless one knows what the normal picture is, both with reference to crops and weather. Thus, the first step in familiarizing the weather forecasters with the weather warning requirements of farmers is the preparation of crop guides to forecasters i.e. weather correlated phenological phases (i) giving the times of occurrence and duration of developmental phases from sowing to harvest of major crops in the regions of their forecast interest and (ii) specifying the types of weather phenomenon for which weather warnings and forecasts are to be issued in the different crop phases. Such guides can be used by the forecasters to prepare periodical and regional calendars of agricultural weather warnings. In the crop guide to forecasters normal values of important weather elements in the crop season, for the national short-time period adopted for agro meteorological work, should also be given and such guides made available to the farming community so that any farmer will know immediately the normal features of weather for a given crop and season in his/her place (Das *et al.*, 2007).

In Kenya, seasonal weather forecasts are based on empirical statistical models developed from sea surface temperatures (SSTs) and sea surface gradients. It also considers tropospheric and stratospheric winds. The predictions of the seasonal rainfall are also derived from statistical analysis of past analogue years (Kenya Meteorological department, 2009a). Meteorological services in many countries in Africa now issue seasonal climate forecasts on an operational basis. However, despite the availability of these services practical applications and utilization of these forecasts for decision-making in various areas of agriculture and health has been limited (Amissah-Arthur, 2003). People in developing countries have the potential to benefit most from climate forecasts as a result of their high vulnerability. Farmers can use this information to help manage their risk and improve their livelihoods in response to climatic uncertainties. Despite numerous scientific, technological and humanitarian efforts food insecurity remains critical, especially in Sub-Saharan Africa where food production is based mainly on subsistence rain fed systems that are inherently risky (Vogel and O'Brian, 2006).

The arid and semi-arid lands (ASAL) that cover approximately 80 per cent of Kenya, experience water shortages and drought due to unreliable and poorly distributed rains. Smallholder farmers in these regions have evolved strategies to cope with variable conditions, but the weather has become even more unpredictable in recent times putting lives and livelihoods to greater risk. Climate change is making matters worse (Republic of Kenya, 2004). It is projected to lead to significant declines in rainfall and river flows in many parts of the arid and semi-arid regions of Kenya. This additional stress further threatens the water and lands upon which smallholder farmers rely for their livelihoods, health and well-being. Kenya must, therefore, identify and implement policies, processes and technologies to sustainably develop an agricultural sector resilient to current weather variability and long-term climate change (Wandiga, 2008)

Traditional ways of forecasting are still a major source of information on weather and climate patterns for farmers in Kenya. However, increased variability associated with climate change has reduced farmers' confidence in traditional knowledge. Scientific forecasts on the other hand, are formulated on a much larger scale and presented in a way that is unfamiliar to farmers. This makes it difficult to get farmers to use climate outlooks generated by the Drought Monitoring Center (DMC) and the Kenya Meteorological Department (Strachan, 2008). The widening incompatibility of scientific forecasts as viewed against the needs of the farmers coupled with the erosion of the integrity of traditional knowledge provided the rationality of this study to evaluate the status of agro meteorological products in terms of their accessibility and utility among smallholder irrigation farmers in Kenya.

1.2. Statement of the Problem

Frequency and severity of extreme weather events such as droughts and floods has compromised smallholder farmers' agricultural productivity. Despite efforts by national climate institutes to issue weather forecast and early warning signals, food insecurity persists and cases of crop failure are particularly common in arid and semi-arid areas. Most farmers in Kenya rely to a significant extent on the local indigenous knowledge for predicting weather. However, increased variability in weather and seasonal patterns seems to reduce farmers' confidence in traditional knowledge. At the same time the advancement in technology has made the scientific weather forecasting more accurate and farmers need to compliment their local technical knowledge with the advanced climatic prediction methods. In Kenya agro meteorological innovation products are rarely used operationally and if so, only by commercial farmers or directly by government and research institutions.

The limited use of agro meteorological innovation products raises concern as to whether agricultural production problems are a result of farmers' perceptions, accuracy, communication channels or inappropriate packaging of these products. Nevertheless farmers in Kenya have the potential to benefit significantly from climate and weather forecasts. The greatest benefit may go to those farmers who have the means and resources to take the most advantage of the technology. These productivity enhancing technologies include irrigation facilities, improved seeds and labour. It is against this background that this study evaluated farmers' access and utilization of agro meteorological information for decision making among smallholder irrigation farmers in Kenya. The study targeted small scale irrigation farmers in Lari Wendani irrigation scheme in Nakuru North District and Perkerra irrigation scheme in Baringo district.

1.3. Broad Objective

To identify and quantify the factors that influences the accessibility, acceptability and adoption of agro meteorological innovations.

1.4 Specific Objectives

The specific objectives of the study were to:

1. Identify the sources, dissemination channels and factors that influence the access and utilization of agro meteorological information by smallholder irrigation farmers in Lari-Wendani and Perkerra Irrigation schemes.
2. To determine the packaging suitability of agro meteorological information for smallholder farmers.
3. To assess the accessibility of relevant agro meteorological information to smallholder irrigation farmers in Lari-Wendani and Perkerra.
4. To assess the utilization of agro meteorological information by smallholder irrigation farmers in Lari-Wendani and Perkerra.

1.5. Research Hypotheses

1. Farmers' access to agro meteorological information is not affected by the dissemination channels available
2. Packaging of information does not affect the access and use of agro meteorological information.
3. There is no relationship between farmers' access to agro meteorological information and the use of such information.
4. Farmers' use of agro meteorological information is not affected by socio-economic, psychological and demographic factors.

1.6. Significance of the Study

The expected outcomes of this study are:

1. To come up with recommendations for policy makers on the effective ways of packaging and disseminating agro meteorological information for utilization by smallholder irrigation farmers.
2. A Master of Science thesis in Agricultural Information and Communication Management.
3. Publications in peer reviewed journals and conferences

1.7. Assumptions of the Study

During the study the following assumption were made.

i. The respondents gave honest responses to questions during the data collection
ii. Farmers have knowledge of the importance of agro meteorology
iii. Agro meteorological information has no value unless it changes management decisions.

1.8. Definition of Terms

Meteorology: is a study of the atmospheric conditions and especially the weather (Sci-Tech Encyclopedia, 2005).

Agro meteorology: is a branch of meteorology that examines the effects and impacts of weather and climate on crops, rangeland, livestock and various agricultural operations (Sci-Tech Encyclopedia, 2005).

Synoptic meteorology: is a study and analysis of large weather systems that exists for more than one day (Redmond and Ahrens, 2009)

Weather: is the day-to-day variation in the atmosphere. This includes precipitation, temperature, humidity, cloud cover among other variables (Romisio *et al*., 2007).

Climate: is the collating of weather statistics to obtain estimates of the daily, monthly and annual means, medians and variability of weather data. Climate is therefore a long term average of weather (Romisio *et al*., 2007)

Climate variability: is the deviation of climate statistics over a given climate statistic in a given period of time (such as specific month, season or year) from the long term climate statistics relating to the corresponding calendar period. (In this sense climate variability is measured by those deviations which are usually termed anomalies) (National Snow and Ice Data Centre, 2009).

Climate change: is any long term change in the statistics of weather over periods of time that range from decades to millions of years. In this study climate change is defined to denote a significant change (having significant economic, environmental or social effects) in the mean value of the meteorological elements in the course of a certain period of time where the means are taken in the order of a period over a decade (National Snow and Ice Data Centre, 2009).

CHAPTER TWO

LITERATURE REVIEW

2.1. General Overview of Agriculture in Kenya

Agriculture remains the most important economic activity in Kenya. Less than 20% of the land is suitable for cultivation, of which only 12% is classified as high potential (adequate rainfall) agricultural land and about 8% is medium potential land. The rest of the land is arid or semi arid. About 80% of the work force is engaged in agriculture or food processing. Farming in Kenya is typically carried out by small producers who usually cultivate no more than two hectares (about five acres) using limited technology (Encyclopedia of the Nations, 2009). In general the smallholder sub-sector contributes about 75% of the country's total value of agricultural output, 55% of the marketed agricultural output and just over 85% of total employment within agricultural sector. For this reason, it has a major role in the economy and consequently on the design of poverty eradication programmes (United Nations Development Program (UNDP, 2004).

Large-scale growers dominate commercial horticulture, while the majority of horticultural growers (about 80%) are small-scale farmers. However, virtually all rural households located in arable areas grow fruits and vegetables for home consumption and sale. A wide range of horticultural crops is grown which include bananas, mangoes, tomatoes, brinjals, french beans, summer flowers, apples, plums, peaches, carrots, kales, cabbages, snowpeas, greenhouse flowers and local vegetables. These crops are grown under both rain-fed and irrigated conditions but production is inadequate due to seasonal variability of rainfall. (Kimenia and Oyare 2006).

The area under horticultural crops increased from 226,989 ha in 1998 to 403,749 ha in 2005 which is mainly attributed to the expansion of vegetable cultivation from 91,297 ha to 245,660 ha (269%) during the same period. Between 2004 and 2005, the area under vegetable crops increased by 4.2%, but the overall production decreased by 15.4%, mainly as a result of a drought. Of the estimated production of 2.5 million tonnes of vegetables in 2005, Irish potatoes accounted for about 39%, cabbages 21%, tomatoes 14%, kale 13%, and onions 3%. The yields and quality of horticultural crops especially by smallholder farmers are below the expected potential but there is substantial potential for improvement through expansion of irrigated horticulture and intensification of production which will contribute to generation of improved farm incomes and better living standards. Smallholder irrigation schemes comprise about 45.6% of the estimated 102,930 ha under irrigation in Kenya (Republic of Kenya, 2007).

Agriculture is inherently sensitive to climate variability and is among the sectors most vulnerable to weather and climate risk. Risks can be minimized by making adjustments with the coming weather through timely and accurate weather forecast (Mannava *et al*., 2007). Accurate forecasts of weather 3–6 months ahead of time can potentially allow farmers and others in agriculture to make decisions in order to reduce unwanted impacts or take advantage of expected favourable climate (Hansen, 2002). Weather forecasts for agriculture can be grouped into short range, covering a period of 12-72hrs, medium range covering a period of 3-10 days and long range forecasts covering a period of a month to a season (Ramamasy, 2007).

2.2. Current State of Forecasts in Kenya

Agro meteorological services were started in Kenya in 1974 with the objectives of assisting researchers in selecting appropriate plants and animal breeds so as to attain a sustainable food production system in the country. Up to the end of 1980s the Kenya Meteorological Department maintained a dense network of observing stations numbering over 2,500 most of which were rainfall stations. However since 1990 this network has gradually declined considerably and currently the observing stations stands at below 1000 (KMD, 2009b). This has resulted in dwindling amounts and gaps in data sets and decline in the aerial coverage. The department maintains a network of 32 Synoptic stations and out of these 13 stations report agro meteorological information, crop phenology and soil moisture in addition to other meteorological information. The rest of the stations supply climatological information. Advancement in technology and the use of Information and Communication Technology (ICT) has resulted in modernization of weather observing instruments and equipments such as automatic weather stations (AWS). The Kenya meteorological Department has been in the process of installing AWS to replace the manual instruments and more than 24 AWS have been installed (Kinuthia, 2006).

Crop data is obtained from the 13 agro meteorological stations on, variety of crops being grown, stage of development, crop performance, plant density and soil moisture. Expected yields are normally observed at the end of each 10 days and along with the meteorological data are communicated to the agro meteorological section to facilitate crop-weather impact assessment (Kinuthia, 2006). In order to obtain a general overview of crop performance in the country, especially on the main staple food maize, beans and wheat all the 32 stations report on the stage of crop growth, crop performance and expected yield through visual inspection and oral interviews from farmers (Kenya Meteorological Department (KMD), 2009b).

2.3. Applications of Agro meteorology to Agriculture

The application of meteorology to agriculture is essential, since every facet of agricultural activity depends on the weather. Planting and crop selection are functions of the climate and of the normal change of the seasons. Timing of cultural operations, such as cultivation, application of pesticides and fertilizers, irrigation and harvesting, is strongly affected by the weather of the past few days and in anticipation of the weather for the next few days (Mannava *et al*., 2007). In countries with monsoonal climates, planting dates of crops depend on the arrival of the monsoonal rains. Operations such as hay-making and pesticide application will be suspended if rain is imminent. Cultivation and other cultural practices will be delayed if the soils are too wet. The likelihood of a frost will trigger frost-protection measures. Knowledge of imminent heavy rains or freezing rains will enable farmers to shelter livestock and to protect other farm resources. Irrigation scheduling is based on available soil moisture and crop-water-use rate, both of which are functions of the weather (Gommes *et al*, 2007).

The traditional use of weather in farm management is useful, but it is not the only use of weather information in farm management. In addition to these well-known direct effects of weather on agricultural production, farm management includes the indirect effects of weather (Das *et al*., 2007, Mannava *et al*., 2007) Temperature determines the rate of growth and development of insects, temperature and humidity combinations influence the rate of fungal infection, thus applications of agro meteorological information is important in pest and diseases management. Evapotranspiration rates determine water use rates and irrigation schedules, and radiation and moisture availability are important in the rate of nutrient uptake by crops (Das *et al*., 2007).

Mobile technologies are being implemented in a pilot index insurance project supported by Syngenta foundation for Sustainable Agriculture in Kenya. Weather based index insurance offers a method to insure farms as small as one acre by replacing costly farm visits with measurements from automatic weather stations as the indicator of drought conditions (Syngenta East Africa, 2010).

Other agricultural decision makers derive benefits from agro meteorological applications such as government policy makers in ensuring adequate food supplies, affordable food prices for their consumers, sufficient farm income for their farmers, and reducing the impact of agricultural practices on the environment. Decision makers in international agricultural organizations also apply meteorology to ensure food security and to react to potential famine situations (Patt and Gwata, 2002). At any level, these objectives can only be achieved through active co-operation between National Meteorological and Hydrological Services (NMHSs), agricultural extension services, farmers and their associations, agricultural research institutes, universities, and industry (Stefanski, 2007).

2.4. Farmer Climatic Requirements

In a study of seasonal climatic forecasting applications for farmers in West Africa and India, it has been noted that while farmers were generally interested in receiving seasonal forecasts that provided the expected quantities over the season, they were much more interested in receiving forecasts that were more relevant to their actual decisions (Sivakumar, 2006). It was found that farmers require information about onset and cessation of rains, rainfall amount, spatial distribution, timing and frequency of wet and dry spells and agronomic recommendations in order to make decisions on agricultural management. The most useful forecast information according to the farmers is the early warnings of a poor season, the commencement of the planting season and whether the rains would be adequate (Stone and Meinke, 2006).

The Kenya Meteorological Department through the Agro meteorological Division provides various periodic information, products and services to its clients who include: Private individuals, small scale farmers and pastoralists, large scale commercial farmers and ranchers, government ministries and departments, research institutions, universities and NGO. (Kinuthia, 2006)

2.5. Dissemination of Agro meteorological Information

Recent advances in technology for communicating data and information electronically have opened up new avenues of opportunity to communicate agro meteorological information in a timely and effective manner, but there are varied capabilities between the developed and developing world (Sivakumar, 2006). In Kenya it is easy to pass agro meteorological information to the government departments, research institutions, universities and other stakeholders including large scale farmers especially those in horticulture/floriculture, ranching and agriculture. These stakeholders have knowledge in ICT and also have access to modern communication equipments (Ngugi, 2002). Providing agro meteorological information and services to the small scale farmers in the rural areas in a timely framework has been very difficult due to communication barriers. This is because of the assumption that agro meteorological information and services successfully reach farmers through agricultural extension services while this has not been the case (Kinuthia, 2006).

The Kenya Meteorological Department provides the following information and services;
The start and end of the rainy seasons and the rainfall performance during the seasons, probable planting dates, monthly and decadal (10 day) agro meteorological bulletin, which gives the following information: forecast on weather and crop performance, advisory services on adverse effects of weather on crops, breeding conditions for pests, water status for livestock and pasture conditions and advisory on farm operation (Kenya Meteorological Department (KMD), 2009a).

2.6. Conceptual Framework

There is need for an agro meteorological system to disseminate weather information at national level. This national agro meteorological service should comprise of scientists/experts who are capable of analyzing data from different sources including satellite, process and package this information into usable formats. One of the requirements for good packaging is adequacy of appropriate knowledge. Knowledge in this case includes knowledge of other people's language usage (e.g. scientific terms), knowledge of the subject matter (meteorology) and general knowledge. If the farmers or users have no knowledge of the subject matter, then packaging of information has to be in such a way that it is not difficult for them to understand.

The communication channel for agro meteorological information should ensure that the correct medium or communication channel is being used for the packaged message. The meteorological services should ensure that the farmers are able to interpret the climatic forecasts. Shared meaning between the scientists and farmers should be understood by those who disseminate information for effective communication.

To enhance agricultural productivity among smallholder farmers, access to and effective utilization of agro meteorological information by farmers play crucial roles. The abilities to use climate forecasts could be constrained by factors such as age, gender, literacy levels, and availability of extension services and packaging of such information for application by farmers.

The accuracy and importance of agro meteorological information is not valuable if the affected farmers do not have options for their decisions. The available options will include adequate draft power, sources of income, crop cultivars, irrigation, fertilizers etc. Identifying these options is essential in understanding how farmers may use and or benefit from climate forecasts.

To enhance productivity, one of the options would be to increase farmers' access to and effective utilization of agro meteorological information through identifying and working on the problem that affects the extent of access and utilization of agricultural information. This can be done through analyzing the socio-economic, demographic and psychological factors that might significantly influence information access and utilization.

The conceptual framework of this study is based on the assumption that the access and utilization of agro meteorological information is influenced by a number of demographic, socio-economical, and psychological factors of the farmers.

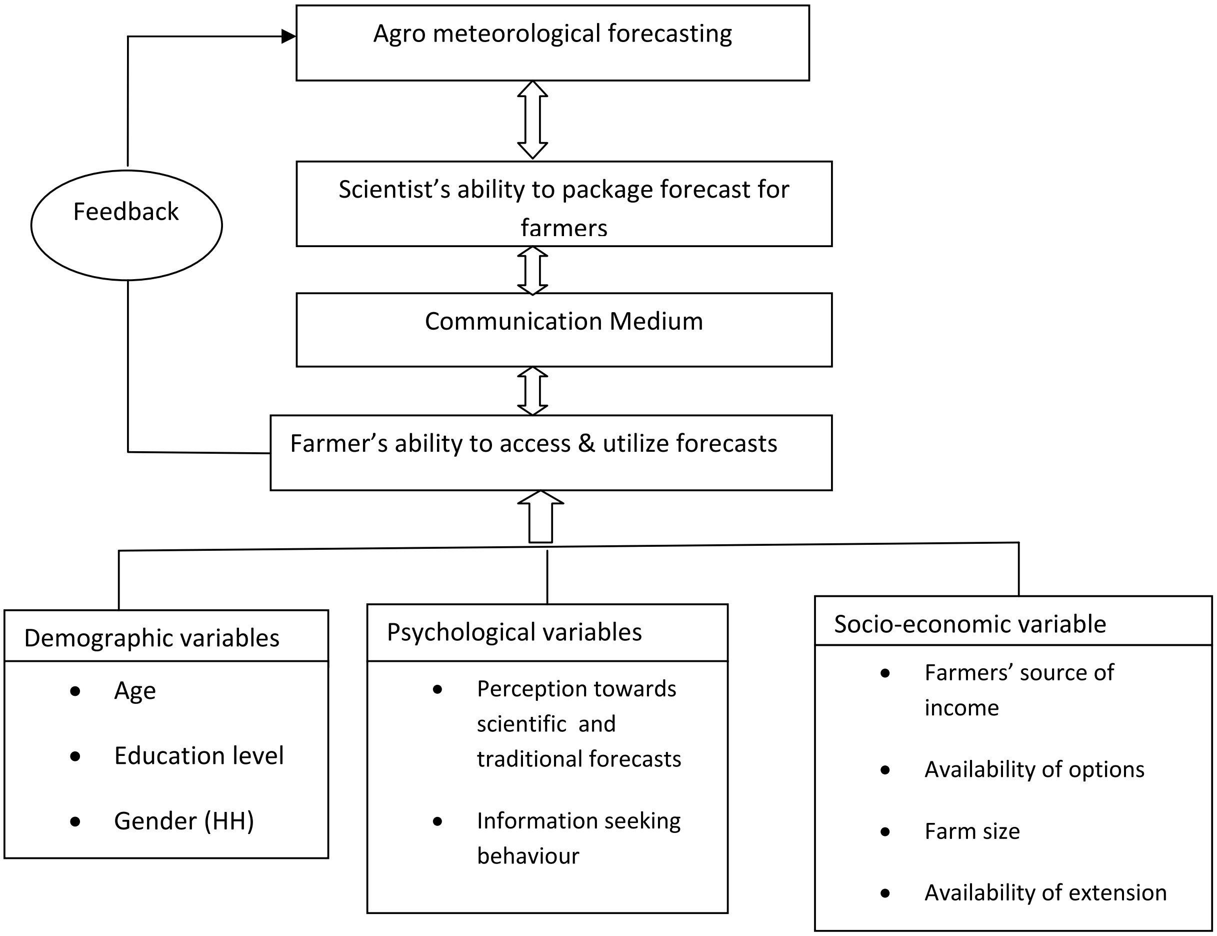

Figure 1: Conceptual framework

The figure presents variables hypothesized to influence the access to and utilization of agro meteorological information by farmers in the study areas.

CHAPTER THREE

METHODOLOGY

3.1. Study Area

The study was conducted in two irrigation schemes namely Lari Wendani irrigation scheme, Nakuru North District and Perkerra irrigation scheme, Baringo district (Figure 2). The target irrigation schemes, lie within agro-ecological zones of medium to low agricultural potential where climatic conditions are unfavourable for rain-fed agriculture.

3.1.1. Perkerra Irrigation Scheme

Perkerra irrigation scheme (0^{o} 28'N, 36^{o} 1'E) is situated 100 km north of Nakuru in Marigat Division, Baringo District. The mean annual rainfall varies from 120 mm in a dry year to 586 mm in a wet year with an average of 322 mm. It derived its name from the Perkerra River, which is the source of irrigation water and the only permanent river in the district. The scheme is therefore in Arid and Semi Arid Lands (ASAL) (Kipkorir, 2002). The scheme has a potential area for irrigation of 2 340 ha, 810 ha were developed for irrigation but due to irrigation water shortages only 607 ha are cropped annually. The scheme assumed a horticultural production from the onset and was a major source of bulbed onions, dried chillies, watermelon, pawpaw for papaya wine making and cotton in the past. However, due to the marketing problems seed maize crop was introduced in 1996 as a diversification measure. The seed maize crop is planted under a growing contract with Kenya Seed Company Ltd. The scheme has 672 farm households each with 1.2 to 1.6 ha (3-4 acres) of farm land irrigation scheme. The scheme faces challenges of inadequate irrigation water and river bank protection (National Irrigation Board (NIB), 2007).

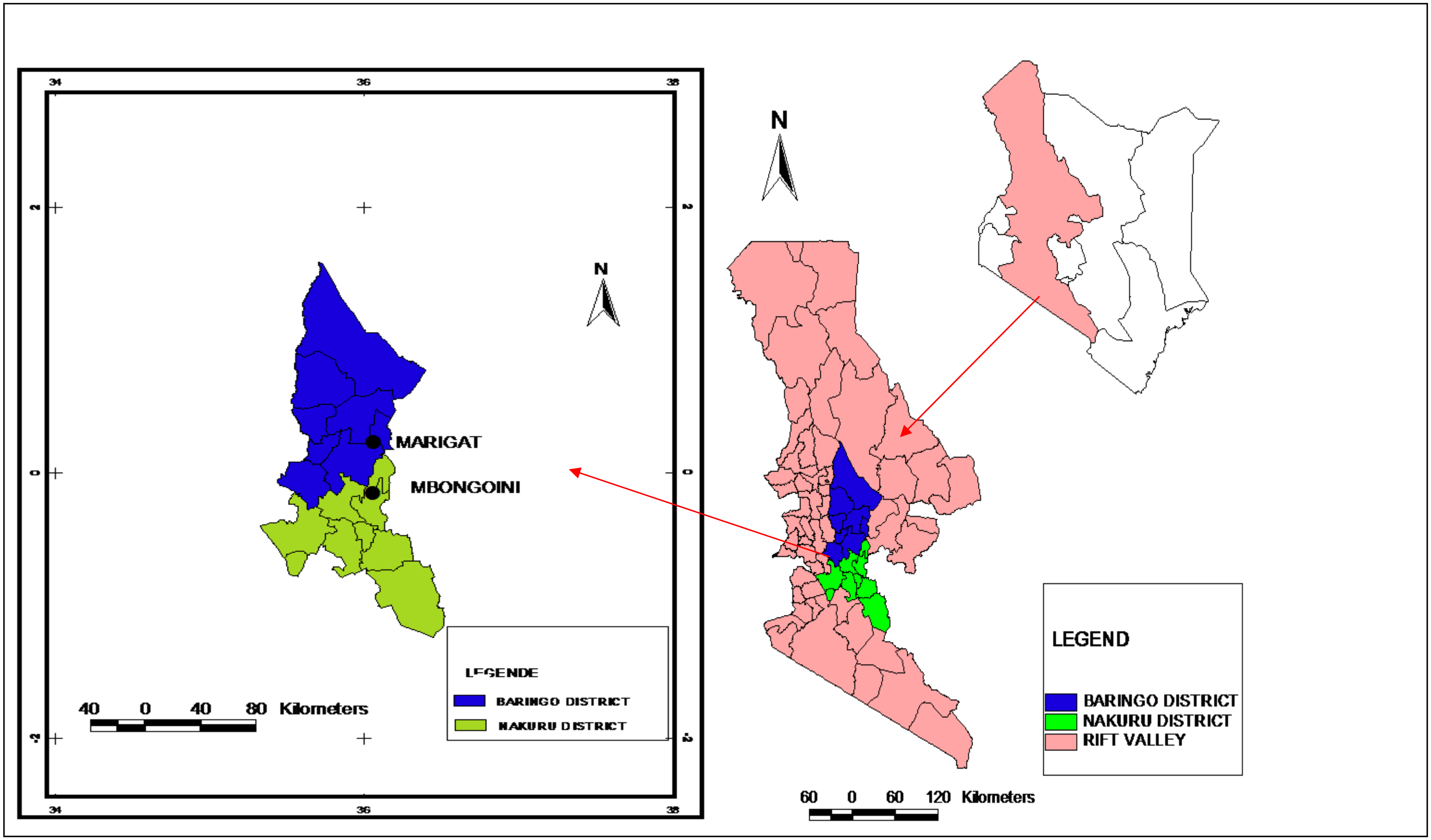

Figure 2: Map showing the two study sites Perkerra irrigation scheme in Marigat division and Lari Wendani irrigation scheme in Mbongoini division

3.1.2. Lari Wendani Irrigation Scheme

Lari Wendani scheme (0^o 7' N, 36^o 16' E) is located in Waseges location of the Mbogoini Division Nakuru District in the Rift Valley Province of Kenya. Waseges is in lower highlands agro-ecological zone 3. This is a transitional zone with mean annual precipitation of 750 mm. Temperature ranges from 18^o C to 39^o C with a mean of 25^o C (Lake Bogoria National Reserve (LBNR), 2007). The total number of households in Waseges is 4 179 with an average farm size of less than 2 ha (5acres) with about 550 farmers in irrigation. The project was implemented in 1984 and it became fully operational in 1986. Water for irrigation is abstracted from Igwamiti River, a tributary of Waseges River. The scheme which serves 100 farmers has 4 sub-schemes of equal membership. The scheme has 3 intake weirs each serving a sub scheme except for weir I which serves sub schemes I and II. The method of water conveyance is by gravity pipelines. During the dry season (November to January) each farmer irrigates ¼ acre land under a horticultural crop (Tomato, onion, cabbage and Kale) and during the wet season (April to October) supplementary irrigation is practiced with each farmer irrigating up to 1 acre of food crops. In 1999 the scheme started implementing water pans to harvest flood water for use during the dry season. This gave the farmers the following advantages:-

1. The farmer will have full control over the water stored in his/her water pan
2. The pans will be filled with water using the same schedules that the farmers use for watering crops.
3. The water pans can be used for fish farming.

Currently 94 water pans are complete. The main challenge of this scheme is the water conflicts due to depletion of water during the dry season leading to serious water conflicts in the river basin.

3.2. Sampling Design

3.2.1. Sampling Frame

A current list of the households in the two schemes was obtained from the irrigation management, NIB for Perkerra irrigation scheme and Nyamamithi agricultural extension office for Lari Wendani. Each of the names on the list was assigned a number.

3.2.2. Sample Size

Sample size for the farmers was determined using the formula below (Mugenda and Mugenda 2003)

$$n = \frac{Z^2 pq}{d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where:

n = the desired sample size if the target population is greater than 10,000

Z= the standard normal deviate at the required confidence interval

P= the proportion in the target population estimated to have the desired characteristics being measured

q= 1-p

d = the level of statistical significance

In this case no pilot study has been done to establish the proportion of the population with the desired characteristics that is households that access and use agro meteorological information. In such a case Mugenda and Mugenda (2003) recommended that 50% should be used. Thus the target population who has access and use agro meteorological information is taken to be 0.5 and the statistical level of significance of 0.05 giving a z-value of 1.96.

Sample size for population greater than 10 000 is as follows

$$n = \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} = 384$$

In this case, the total sample size in both study sites is less than 10 000 therefore the formula below was used

$$n_f = \frac{n}{1 + {}^{n}/_{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where: n_f= the desired sample size (when the population is less than 10,000)

n= the desired sample size (when the population is more than 10,000)

Total Sample size $n_f = \frac{384}{1+384/772}$ = 256

Final sample size Perkerra = 672/772 * 256= 222

Final sample size Lari Wendani =100/772 * 256= 33

Total sample size= 255

3.2.3. Method of Sampling

A systematic random sampling procedure was employed. This approach was chosen because it ensures an equal probability of inclusion of each unit in the population than simple random sampling (Nassiuma and Mwangi, 2004). The procedure involves drawing a sample of size n from a population consisting of N units in such a way that starting with a unit corresponding to a number r chosen at random from the numbers 1,2….,k every k^{th} unit is selected.

The number k is taken as the nearest integer N/n and is called the random interval. The number r picked at random is called the random start.

For **Perkerra irrigation scheme** k= 672/222 =3

For **Lari Wendani irrigation scheme** k= 100/33 =3

To get a random start number between 1 and 3 was randomly picked from a container. In this study the number 2 was picked and from the list obtained every 3^{rd} number was selected from the list until a total of 222 households were obtained from the list for Perkerra and 33 for Lari.

In the event that the selected household is not available on the day of the interview the next household on the list was used.

3.2.4. Sampling Unit

The units of measurement were farmers, agro meteorological and extension staff. A structured questionnaire was developed and elicited responses from interviewees provided the data required in this study (Appendix 1).

3.3. Data Type, Sources and Methods of Data Collection

Structured interviews were used to collect primary data. Both qualitative and quantitative, and primary and secondary data were collected to address the research objectives of the study. Data collected included; demographic, socio-economic, and perceptions, as well as access and utilization of agro meteorological information services provided to these farmers. The data was gathered through formal survey interviews and through discussions and observations.

3.3.1. Primary Data Sources

The primary data sources used included smallholder farmers, as well as extension officers and research scientist (KARI) and irrigation managers on various aspects of access and utilization of climatic data. Pretesting was conducted on fifteen farmers in Lari Wendani who were attending an agri-business workshop. Necessary adjustments were made to the questionnaire before the actual survey was conducted. Primary quantitative data was collected from the respondents using pre-tested, structured interviews. The variables analyzed from primary data that was collected from the smallholder farmers included:

1. **Age** – the age of the respondents/farmers has an impact on the experience that they have in agriculture. The ability to make use of new innovations and integrate climatic data and personal judgment regarding weather is a function of age.

2. **Gender of respondent**- gender has an effect on access to information from different sources. It influences the information seeking behaviour and ability to make decisions.

3. **Education level-** educational level has an influence on the interpretation and understanding of climatic data and applications of this information in decision making.

4. **Major occupation (on farm/off-farm) -** occupation of the farmer influences concentration of the farmer on farming activities his/her ability to learn new ideas in agriculture and off farming income that influences other farming options.

5. **Land size-** the size of the farm gives the farmer options as to whether he/she can expand the area under cultivation and it also influences farmer diversification of crops.

6. **Types of crops grown**– High value crops and sensitivity of these crops to weather influences the farmer’s information seeking behaviour.

7. **Access to electronic media -** usefulness in disseminating weather information. The time of the day and language used in disseminating information has an effect on farmer's access to this information.

8. **Use of print media** – usefulness in disseminating weather information. Frequency of the print media and detail on actions to take in the event of abnormal weather conditions is critical.

9. **Access to internet-** is very important in getting detailed information about weather/climatic conditions and it is also important as a follow up for radio/TV forecasts.

10. **Accuracy of information on:-**

    I. Onset and cessation date of the main rains
    II. Quality forecast of the rainy season (rainfall amount)
    III. Temporal and spatial distribution of the main rains
    IV. Timing and frequency of active and dry periods (wet and dry spells)
    V. Agronomic recommendations in terms of which crop varieties to grow
    VI. Packaging of this information (easy to understand)
    VII. Utilization of agro-metrological information in decision making

3.3.2. Secondary Data Sources

Secondary data on sources of agro meteorological information and population were collected from reports, bulletins and documents from provincial, district and local extension, CBOs and national meteorological services. Information such as sources of agro meteorological information, spatial distribution of forecasts and population was collected as secondary data. Dissemination channels such as radio stations, internet and bulletins were also established from the above secondary sources of information.

3.4 Data Analysis

Raw data was coded and input into the computer for analysis. The statistical package for social sciences (SPSS) version 16 was employed for data analysis. Qualitative data or non numerical data were used in describing various aspects in drawing conclusions and recommendation. The Likert scale was used to indicate the degree of agreement or disagreement with a given series of statements. Each statement was assigned a numerical score. A Likert scale enables one to rank attitudes but does not measure the difference between attitudes. It is easy for the research to administer and also easy for the respondent to understand.

Table 1: Descriptions of the variables.

Variable Name	Description	Variable Type	Value
Dependent variables			
ACCMETINFO	Access to agro meteorological information	Ordinal scaled	0= not at all, 1= rarely 3= when I look for it 4= highly accessible
USEMETINFO	Utilisation of agro meteorological information	Ordinal scaled	0= not at all, 1= rarely 3= when there is need 4= always in making decisions
Independent variables			
LANG	Language	Ordinal scaled	Yes= 1 No= 0
COMPLEX	Complexity of forecasts	Ordinal scaled	1= easy to understand 2= difficult to understand 3= does not understand at all.
SPDIST	Spatial distribution	Ordinal scaled	1= covers a wide area 2= sometimes specific 3= specific to our area
ACCRTV	Access to radio/TV	Ordinal scaled	2= Yes 1= sometimes 0= No
ACCINT	Access to internet	Ordinal scaled	2= Yes 1= sometimes 0= No
ACCPRINT	Access to print media	Ordinal scaled	2= Yes 1= sometimes

			0= No
USMOBILE	Use of mobile phone to get weather forecasts	Ordinal scaled	2= Yes 1= sometimes 0= No
BARAZATT	Baraza attendance	Ordinal scaled	2= Yes 1= sometimes 0= No
EXTAV	Availability of extension	Ordinal scaled	2= readily available 1= sometimes 0= No
AGE	Age	Continuous	Years
EDULEVEL	Education level	Ordinal scaled	0= no formal education 1= read and write 2= primary school level 3= Secondary 4= Technical college 5= Secondary
GENHH	Gender (HH)	Dummy	1= male 0= female
PERCTRFR	Perception of traditional forecasts	Ordinal	0 = not reliable 1= sometimes 2= always reliable
PERCSCIFR	Perception of scientific forecasts	Ordinal	0 = not reliable 1= sometimes 2= always reliable
INNOV	Innovativeness	Ordinal scaled	1= immediately I learn about the new technology 2= after I have seen it working 3= when everyone is using it
ATTFREQ	Frequency of attending agro-social groups	Ordinal scaled	0= not a member 1= sometimes 2= once a week 3= once a month 4= seasonally 5= rarely
FAMSIZE	Farm size	Continuous	Ha
CROPS	Crops grown	Discrete	Names of crops
INCOME	On farm income	Continuous	Ksh
INCOMEMJ	Major source of income	Dummy	1= Off farm 2= on farm

3.4.1. Descriptive Statistics

Quantitative data were analyzed using descriptive statistics, which included the mean, standard deviation, percentages, frequency tables and pie charts.

3.4.2. Inferential Statistics

a) Chi-square test of independence was used to analyze and determine whether to reject or accept the hypotheses at 5% level of significance for ordinal scale data. Chi-square test of independence can be used to find out whether two or more attributes are independent or not. Attributes are independent if the distribution of one criterion in no way depends on the distribution of the other criterion. If they are not independent there is an association between the criteria. The null hypothesis that there is no association between the attributes under study is used i.e. that the two attributes are independent is taken (Gupta, 2009). A significant chi-square test result ($p<0.05$) indicates that two variables are not independent. A result that is not significant ($p>0.05$) indicates that there is no significant dependence of one variable on another. It should be noted that chi-square does not measure the degree or form of relationship; it only measures whether two variables are significantly related without any reference to any assumption concerning the form of relationship (Cronk, 2008).
b) The correlation coefficient was used to describe the strength of the relationship between the independent and dependent variables for interval or continuous scale data. The Pearson correlation coefficient indicates the significance, strength, and direction of the relationship between variables.
c) Multiple linear regressions were used for the fourth hypothesis to determine if the independent variables together predict the dependent variable.

The multiple regression model was of the form

$Y=\beta_0 + \beta_1X_1 + \beta_2X_2+\ldots\ldots\ldots\ldots\ldots\ \beta_nX_n+\varepsilon$ .... (3)

Y= is the dependent variable (access and utilization of agro meteorological information)

β_0= is a constant or y intercept

$\beta_{1.......n}$= are the regression coefficients or change induced in Y by each X

$X_{1......n}$= are the independent variables (access to extension services, access to radio and access to agro meteorological information)

ε = is the error term.

Table 2: **Summary of data analysis.**

Hypothesis	Dependent variable	Independent Variable	Statistics
Packaging of information does not affect access and use of agro meteorological information	Access and use of agro meteorological information	Language of dissemination Complexity of forecasts Time of dissemination. Spatial distribution of forecasts.	Descriptive statistics. e.g. percentages, mean, standard deviation. Chi-square Correlation analysis Multiple regression
Farmers access to meteorological information is not affected by dissemination channel	Access and use of agro- meteorological information	Access to radio/TV Access to internet Access to print media Availability of extension	Descriptive statistics. e.g. percentages, mean, standard deviation. Chi-square Correlation analysis Multiple regression
There is no significant relationship between farmers use of agro meteorological information and demographic factors	Access and use of agro meteorological information	Age Education level Gender of household head	Descriptive statistics. e.g. percentages, mean, standard deviation. Chi-square Correlation analysis Multiple regression
There is no significant relationship between farmers use of agro meteorological information and psychological factors	Access and use of agro meteorological information	Perception of traditional forecasts Perception of scientific forecasts Information seeking behaviour Innovativeness	Descriptive statistics. e.g. percentages, mean, standard deviation. Chi-square Correlation analysis Multiple regression
There is no significant relationship between farmers use of agro meteorological information and socio-economic factors	Access and use of agro meteorological information	Farm size Crops grown On farm income Major source of income	Descriptive statistics. e.g. percentages, mean, standard deviation. Chi-square Correlation analysis Multiple regression
There is no significant relationship between farmers access to agro meteorological information and the use of that information	Use of agro meteorological information	Demographic Psychological Socio-economic	Descriptive statistics. e.g. percentages, mean, standard deviation. Multiple regression

CHAPTER FOUR

RESULTS

4.1. Demographic Characteristics.

The characteristics presented in this study were responses from household members who participated in agricultural production in Lari Wendani irrigation scheme and Perkerra irrigation scheme.

4.1.1. Gender

Majority of respondents were male, constituting 77% of respondents. Albeit this does not imply that females do not participate in agriculture. Findings from this study demonstrate that adult family members including spouses participated in agriculture and also contributed their ideas in terms of making farm decisions and sharing of knowledge (Table 3). A chi-square test of independence indicated a significant correlation χ^2 (2) =7.01, $p< 0.05$ between gender and utilization of agro meteorological information. Female respondents (56.9%) were more likely to make use of agro meteorological information than their male counterparts.

Table 3: Gender of respondents.

	Perkerra	Lari –Wendani	Total
Attributes	%	%	%
Female	23.4	18.2	22.7
Male	76.6	81.8	77.3
Total	100.0	100.0	100.0

4.1.2 Age of Respondents

The ages of the respondents ranged from 20 to 86 years with the mean age being 49 and a standard deviation of 14.31. The majority of the respondents were between the age range of 40-59 years. Figure 3 shows the age distribution of the respondents.

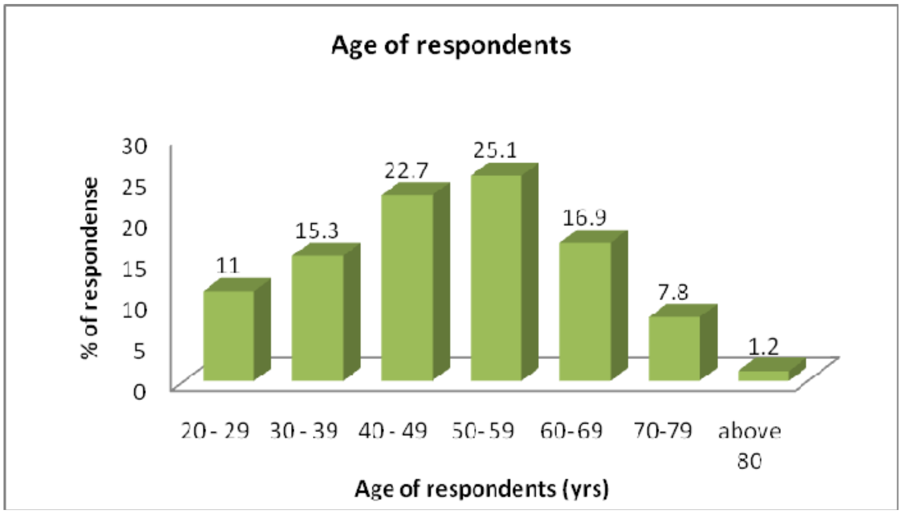

Figure 3: **Age of respondents who were interviewed in both Perkerra and Lari Wendani irrigation scheme.**

4.1.3 Level of Education

The majority of the farmers had attained primary level of education (31%). A few (1%) had a university qualification and 7% had some form of literacy but had not completed primary level of education (Figure 4). A chi-square test of independence indicated a significant correlation χ^2 (10) =26,57, p<0.05 between the level of education and the use of agro meteorological information. More than 50% of the respondents who have attained at least primary level of education made use of agro meteorological forecasts in decision making (Appendix 4).

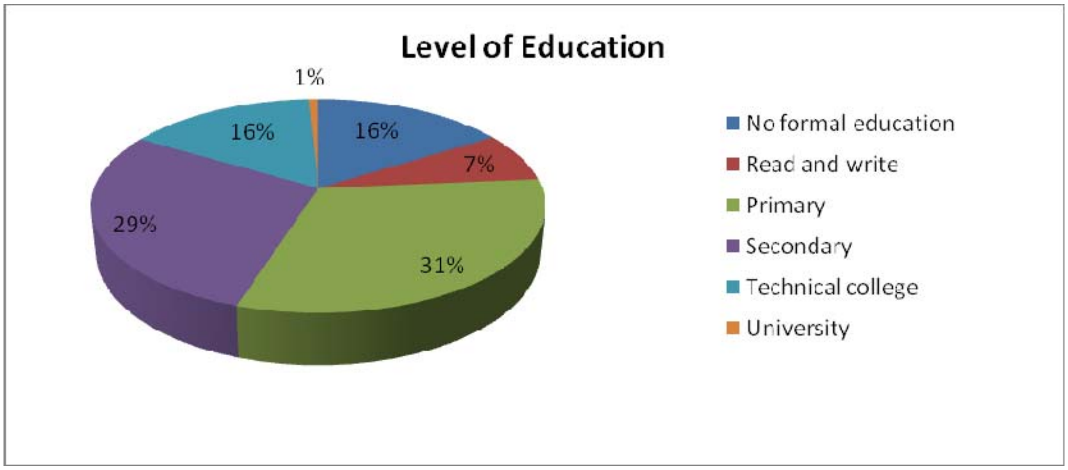

Figure 4 : Level of education of respondents.

4.1.4. Languages Spoken

The most common language spoken in both Perkerra and Lari is Kiswahili (98.4%). In Perkerra most people speak Kalenjin which is the dominant tribe in the area and less than 20% of the respondents speak Njemps. In Lari Wendani Kikuyu was the dominant ethnic language, less than 10% speak Kalenjin. Figure 5 shows the language spoken in the two irrigation schemes.

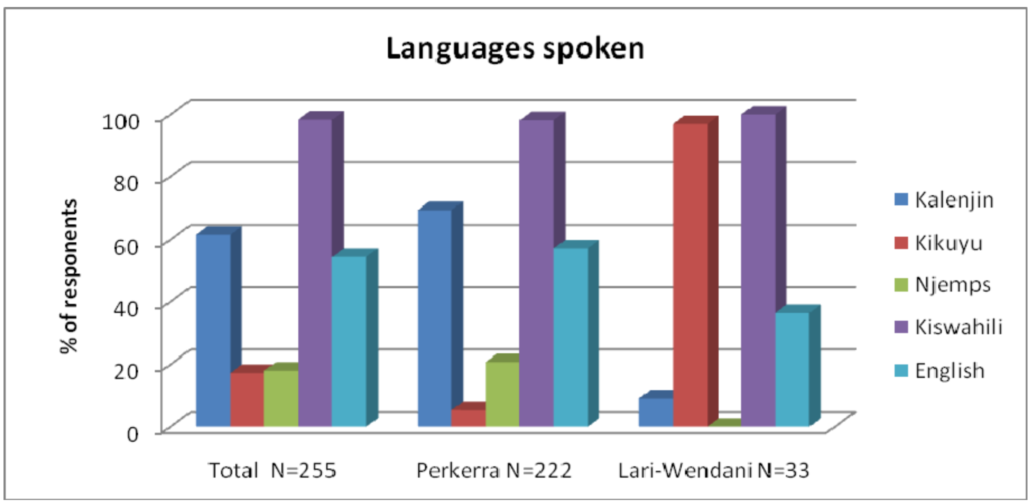

Figure 5: Languages spoken by respondents in both Perkerra and Lari Wendani irrigation schemes.

4.2. Socio-economic Characteristics

4.2.1 Primary Economic Activities

Over 80% of the respondents indicated farming as their primary economic activity in both irrigation schemes (Figure 6). Almost all the farmers (97%) indicated that agriculture was their major source of income. Most of the farmers were involved in crop production; some farmers practiced both livestock and crop production

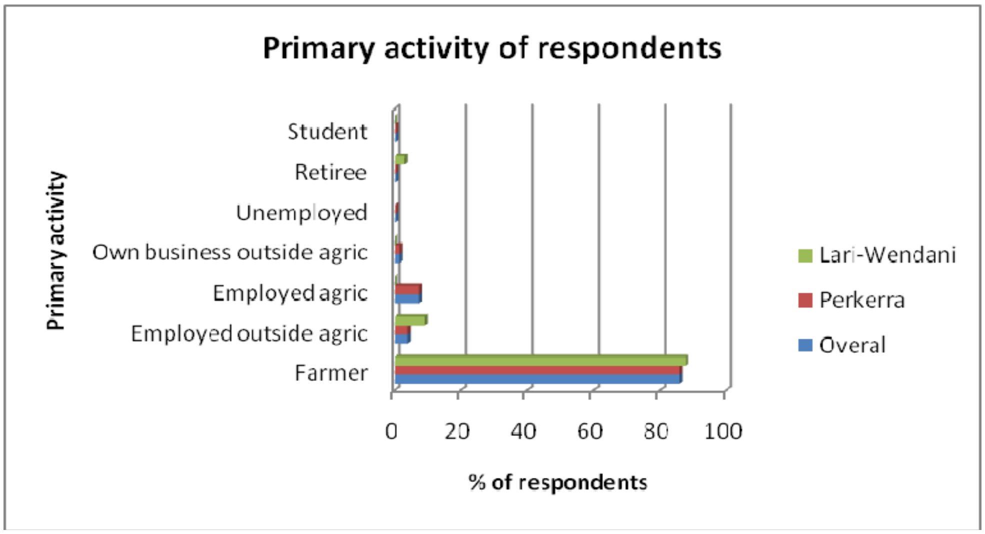

Figure 6: Primary economic activities of respondents in Perkerra and Lari Wendani irrigation schemes.

4.2.2. Farm Size

There was a similarity in the farm sizes in both irrigation schemes with a minimum land size of 0.5 hectares and a maximum of 7 hectares. The mean farm size was 2 hectares. The distribution of farm size was as follows Lari Wendani mean= 2.06 ± 1.32 and Perkerra mean = 1.94 ± 1.17.

4.2.3. Farm Based Annual Income

The minimum incomes for the respondents were 20 000/= and 40,000/=, and the maximum 255,000/= and 950,000/= in Lari and Perkerra respectively. The mean farm based incomes in the two schemes were as follows Lari Wendani, mean = 103,515.00 ± 65, 674.91 and Perkerra mean =233,905.00 ± 129,486.40

4.2.4 Types of Crops Grown in Perkerra and Lari Irrigation schemes

In Perkerra irrigation scheme seed maize and water melon are the most common crops grown. Most of the farmers in Lari Wendani grow commercial maize, beans and tomatoes. Table 4 shows the distribution of crops grown in the two irrigation schemes.

Table 4: Types of crops grown in Perkerra and Lari irrigation schemes

	Perkerra n=222		Lari Wendani n=33	
Crop	%	Rank	%	Rank
Seed maize	77.9	1	0	10
Tomatoes	36.5	4	84.8	3
Maize commercial	33.3	5	93.9	1
Water melon	62.6	2	0	10
Beans	40.5	3	90.9	2
Onions	29.3	7	63.3	4
Vegetables	32.9	6	33.3	5
Pawpaw	16.7	8	15.2	7
Sorghum/millet	9.9	9	33.3	5
Fruits	7.7	10	15.2	7
Pumpkin	2.3	11	6.1	9

4.2.5 Annual Income per Crop Enterprise

Despite seed maize being grown by many farmers tomato was the highest income earner with an average annual income of KSh 71 217.00. Pawpaw, watermelon and seed maize were among the highest paying enterprises. Table 5 shows the average annual income distribution per crop enterprise per year.

Table 5: Annual income per crop enterprise.

Crop	N	Mean	Std. Deviation	Rank
Tomatoes	170	71,217.00	37,953.33	1
Pawpaw	74	64,554.00	34,067.67	2
Water melon	139	62,568.00	22,823.21	3
Seed Maize	173	58,237.00	33,390.16	4
Onions	86	52,744.00	30,536.84	5
Fruits	22	52,727.00	25,575.62	6
Pumpkin	7	41,428.00	22,860.86	7
Maize commercial	144	37,645.00	25,657.90	8
Vegetables	84	30,595.00	24,023.14	9
Sorghum/millet	25	26,960.00	15,925.56	10
Beans	120	23,591.00	14,306.08	11

4.2.6 Group Membership and Frequency of Attending Meetings

The most common group is Marigat Farmers' Cooperative Society with a membership of 38% of the respondents. There were also quite a number (28.2%) of the respondents who were not members of any particular group (Table 6).

Table 6: Group membership

Group name	Frequency	%
Marigat Farmers Co-operative Society	99	38.9
Non members	72	28.2
Baringo Teachers Sacco	26	10.2
Ndambul Water Project	18	7.1
Zero Grazing Group	13	5.1
Lari Irrigation Group	12	4.7
Kenya Women Finance Group	3	1.2
Bee Keepers Association	2	0.8
Farmers Saving Association	2	0.8
Kadets	2	0.8
ROSEO	2	0.8
Rutugaa Self-help Group	2	0.8
Namanyana Youth Group	1	0.4
Umoja Group	1	0.4
Total	255	100

The majority (48%) of the farmers attended meetings in their respective groups seasonally (Figure 7), especially at the beginning of the planting season when they received loans.

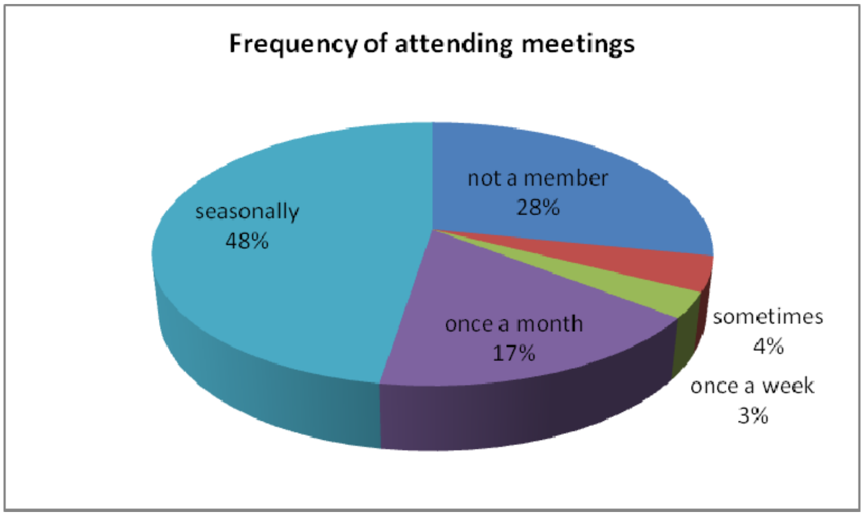

Figure 7: **Frequency of attending agro-social group meetings**.

4.3. Sources of Agro meteorological Information.

Five sources of agro meteorological information were indentified with 58.8% of the respondents getting their information from the National Meteorological Centre in Nairobi through radio and television. Other sources included Kenya Agricultural Research Institute (25.1%) mostly in Perkerra, extension officers (10.6%), internet (5.5%) and the Drought Monitoring Centre (DMC) (0.8%).

4.4. Access to Agro meteorological Information.

Figure 8 shows the dissemination channels used by farmers to access weather forecasts. Many farmers (> 85%) accessed weather forecasts through radio. There was no access of weather forecasts through other dissemination channels (>60%) such as extension services, internet, mobile phones, barazas and bulletins. Chi-square test of independence indicates a significant relationship between farmers' access to agro meteorological information and the following dissemination channels radio, television, mobile phone, extension services, friends/neighbours and barazas ($p < 0.05$).

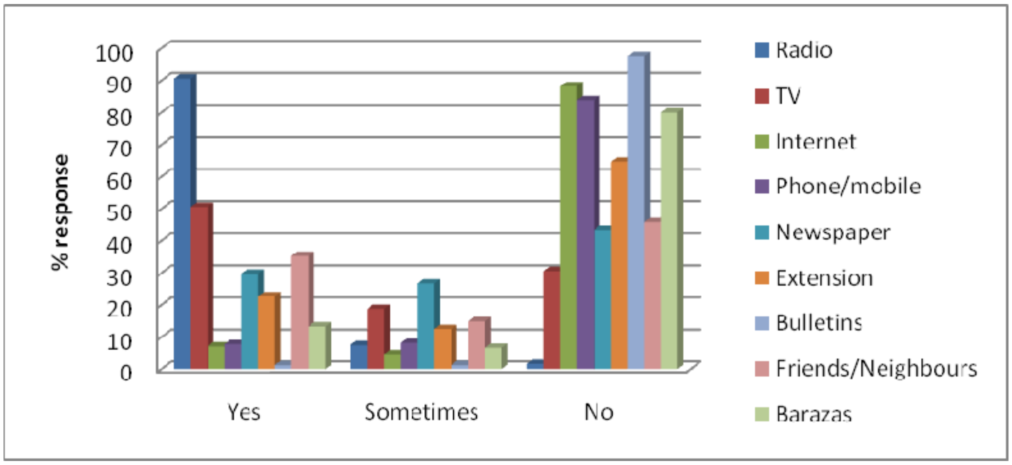

Figure 8: **Dissemination channels of agro meteorological information by smallholder irrigation farmers.**

4.4.1 Frequency of Access to Dissemination Channels

Results indicated that 98.1% of the farmers had at least access to radio (Figure 10). Up to 90.4% of these farmers were able to listen to the radio daily. Other significant dissemination channels were internet for weekly forecasts, barazas for monthly forecasts and for seasonal forecasts, bulletins and extension were the most appropriate.

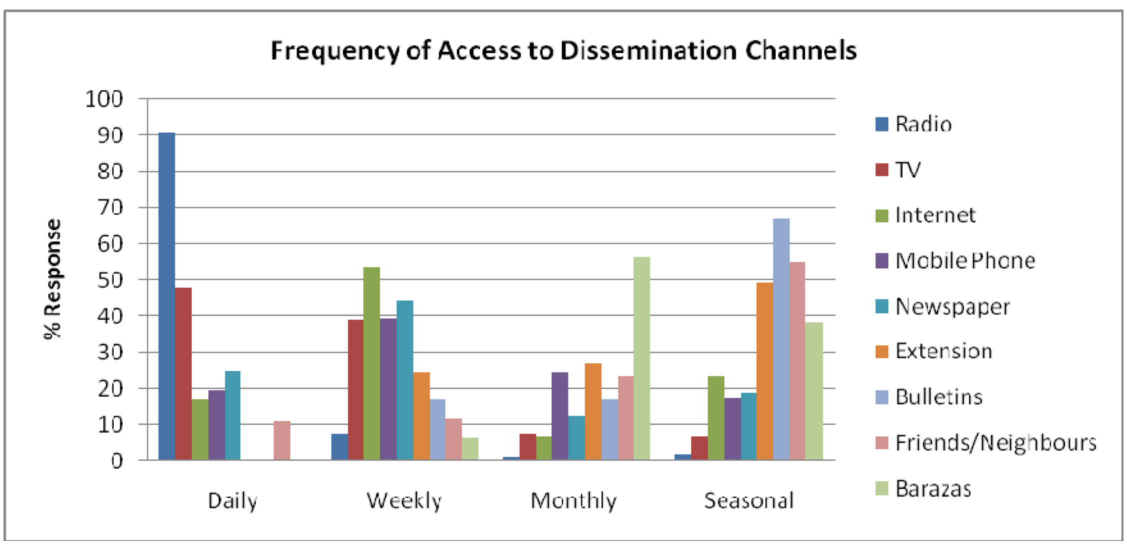

Figure 9: **Frequency of access of agro meteorological information from various dissemination channels by smallholder irrigation farmers.**

4.4.2. Perceptions on Accuracy of Dissemination Channel

Most of the respondents (above 60%) perceived the information they received from the available dissemination channels to be moderately accurate. Respondents who obtained information from friends, family and neighbours (51.5%) considered the information to be inaccurate (Figure 11).

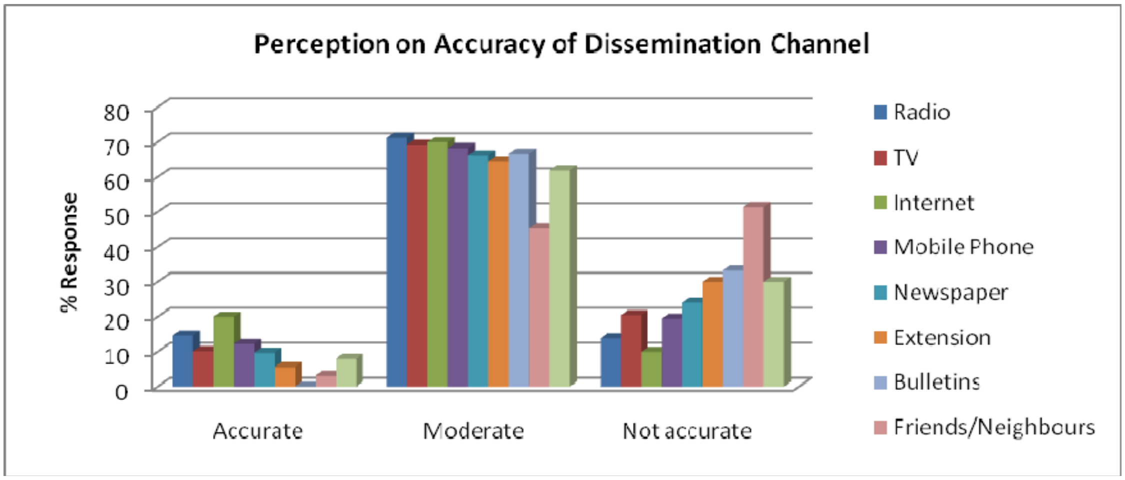

Figure 10: Perception on accuracy of agro meteorological information from various dissemination channels.

4.5. Packaging of Agro meteorological Information.

Above 60% of the respondents indicated that all the disseminating channels presented their weather reports in the language that the farmers understood. Those who made use of bulletins (33.3%) felt that the language used was difficult and 7.6% indicated that they found it difficult to understand the terminology used in the newspapers.

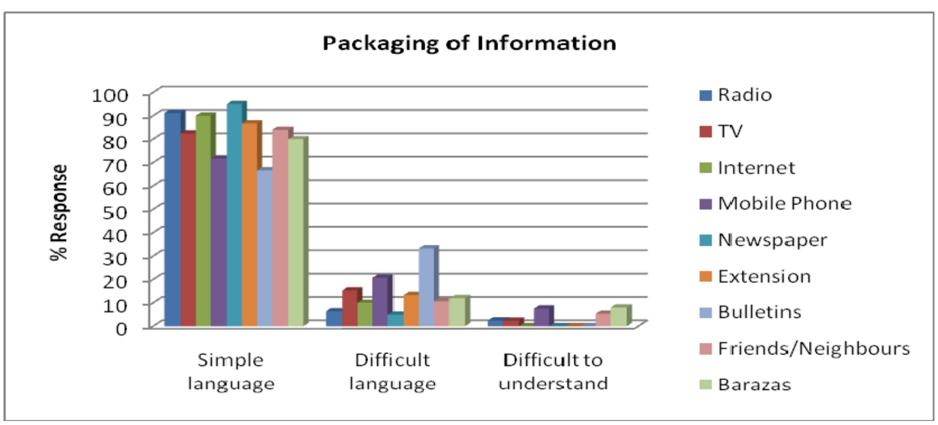

Figure 11: Packaging of agro meteorological information through various dissemination channels.

4.6 Factors Affecting the Access to Agro meteorological Information

Most farmers indicated inadequate extension (72.5%), no access to internet (70.6%), newspapers not delivered on time (61.2%) and no access to TV (58.8%) as the major factors that affect their access to agro meteorological information (Figure 12).

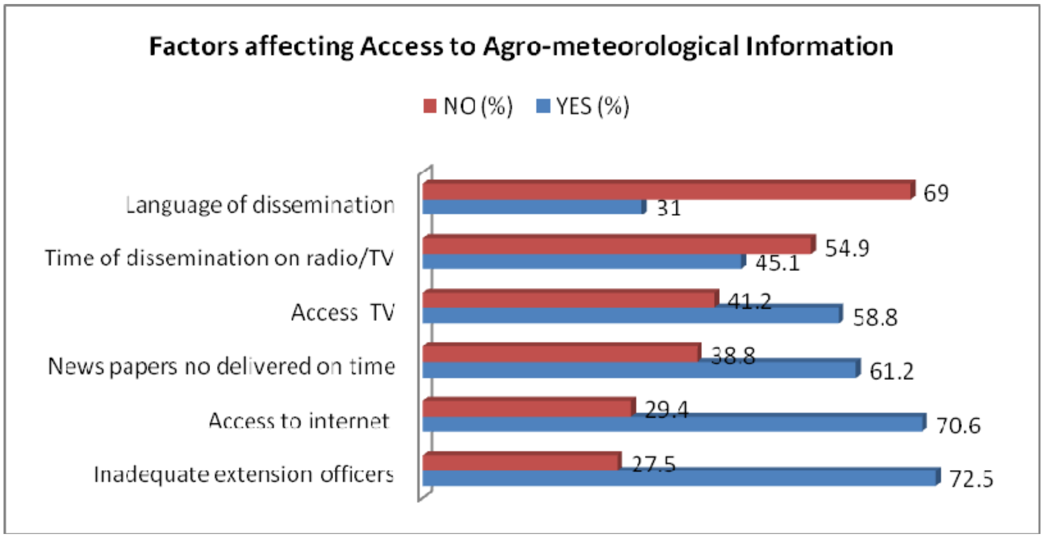

Figure 12: Factors affecting the access to agro meteorological information

4.7. Utilization of Agro meteorological Information by Smallholder Farmers in Decision Making.

Few farmers (46.7%) made use of agro meteorological forecasts to decide on which crops to grow. In terms of planting decisions the majority (49.8%) followed normal season in their planting calendar of activities 24.7% who waited for the normal rains, 23.5% of the farmers made use of scientific forecasts in planting decisions. This low percentage made the majority of farmers more vulnerable to unfavourable climatic conditions. Table 7 shows a summary of the factors affecting planting decisions.

Table 7: Factors influencing planting decisions.

Decision	Frequency	%
After receiving sci. forecasts	60	23.5
Follow normal planting season	127	49.8
Wait for the rains	63	24.7
Use local forecasting methods	5	2.0

4.8. Scientific and Local Methods

There were similarities between the perception of traditional and scientific forecasts with the majority of respondents (56%) perceiving both methods to be sometimes reliable, always reliable (23%) as inaccurate (20%) (Figure 14).

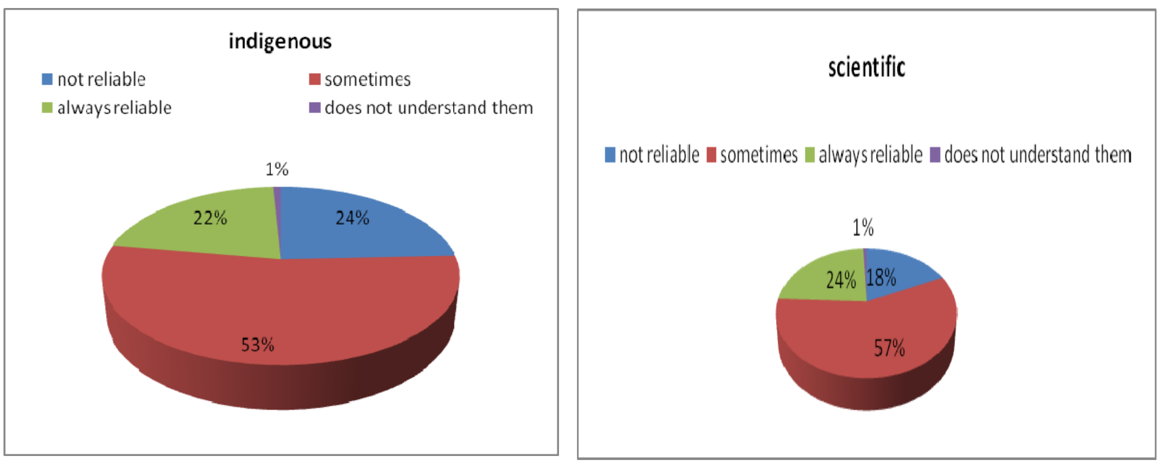

Figure 13: Perception on local and scientific forecasts reliability

Farmers incorporate a variety of local climate forecasting methods in both the two irrigation schemes. The most common forecasting methods mentioned by the farmers include the observation of the moon and the stars. They indicated that if the male and female stars appear at the same time it signifies that rains are coming. Studying of the intestines of goat, sheep and cattle can enable the farmers to tell the coming of the rain season. Croaking of frogs and the flowering of certain plants can also signify the coming of rains. Wind direction, movement of birds and bees and the quality and quantity of honey helps farmers also to tell the changes in the weather. Some farmers can also make atmospheric observations such as the appearance of certain clouds, wind direction, temperatures and lightening coming from certain direction in order to tell the coming weather conditions. A few respondents 1.2% indicated that they do not employ local forecasting methods because of their religion. Most of the local forecasting methods indicate seasonal patterns such as the beginning of the season, coming of the rains and end of the rain season. Appendix 3 shows the local weather forecasting methods.

4.9. Scientific Forecasts

Above 70% of the farmers indicated crop/weather recommendations and irrigation schedules as highly accessible information. Seasonal forecasts in general were highly accessed by 47.7% (crop and weather recommendations) and 43% (irrigation schedules). The respondents indicated that the onset date of the main rains and rainfall amount were highly accessible.

4.9.1 Important Seasonal Forecasts

Farmers indicated that the information on irrigation schedules and crop/weather recommendation was highly accessible. However less than 50% of the respondents had access to seasonal forecasts, onset date of the main rains, and timing/frequency of wet and dry spells (Table 8).

Table 8: **Access to important seasonal forecasts.**

	Access to agro meteorological information			
Important seasonal information	**Highly accessible**	**When I look for it.**	**Sometimes**	**Not at all**
Seasonal forecasts	47.8	7.5	43.5	1.2
Onset dates of the main rains	43.9	9.0	41.2	5.9
Amount of rainfall	43.1	7.5	36.5	12.9
Cessation dates of main rains	30.2	8.2	43.9	17.6
Timing & frequency of wet and dry spells.	38.0	4.3	34.9	22.7
Crop/weather recommendations	72.5	5.9	13.7	7.8
Irrigation schedules	78.0	1.6	19.2	1.2

4.9.2 Perceptions regarding Spatial Coverage of Agro meteorological Forecasts.

When asked about how they perceived the spatial coverage of meteorological forecasts the majority (76.1%) of farmers indicated that the in information they got covered a wide area (Figure 15). Some farmers gave examples of Rift Valley Province or Nakuru district in which information covered a wide area making it difficult for them to relate the reports to their particular areas.

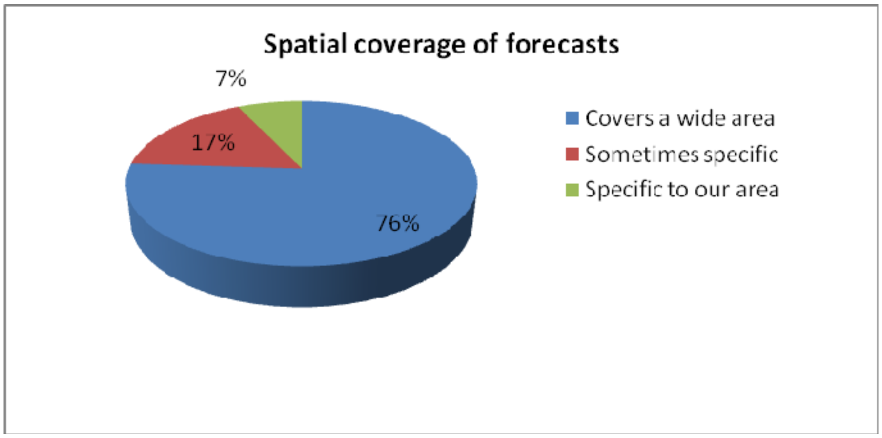

Figure 14: Respondents' perception on spatial coverage of forecasts.

4.9.3 Use of Agro meteorological Information

On the use of important forecasts, farmers always made decisions when they obtained information on irrigation schedules and crop/weather recommendations (above 70%). On receiving seasonal forecasts 54% incorporated the information in making decisions (Table 9).

Table 9: Use of agro meteorological information for decision making.

	Use of information in decision making		
Important forecasts	Make decisions always	Sometimes make decisions	Not at all
Seasonal forecasts	54.1	44.3	1.6
Onset dates of rains	56,1	36.5	7.5
Rainfall amount	57.3	29.0	13.7
Cessation dates of the main rains	42.0	38.4	19.6
Timing & frequency of wet and dry spells	42.4	35.7	22.0
Crop/weather recommendations	75.7	16.9	7.5
Irrigation schedules	76.9	22.4	0.8

4.10. Application of Seasonal Agro meteorological Forecasts

The farm decisions made by farmers in terms of preparations for the coming season were influenced by the forecasts they received. These decisions depended on whether they were anticipating excess rainfall, normal rainfall or they expected the rainfall to be below normal.

Most of the actions taken involved change in crop varieties, land size, soil and drainage management practices as explained in sections 4.11.1 to 4.11.2.

4.10.1. Above Average Rainfall

The decisions made by farmers in anticipation of above average rains, mostly involved the change of the crops or crop varieties to be grown. The majority of farmers (34.1%) indicated that they would switch to crops which tolerate a lot of rainfall or grow long season varieties which gave higher yields. Similarly 23.9% of farmers indicated that they would grow maize with seed maize being more popular in Perkerra irrigation scheme. Establishment of fruit trees such as pawpaw and bananas was also common. Soil management and drainage activities were practiced in anticipation of excess rain; including early land preparation and breaking of ridges/terraces to reduce water logging. About 20% of the farmers indicated they would change the size of land under cultivation with, 11% increasing the acreage, (5.9%) would rent more land and 4.3% indicating that they reduce the area under cultivation in order to reduce the risks associated with floods (Table 10). Some farmers indicated that they would practice inter and double cropping so as to maximize yields. 4.3% mentioned buying of more inputs such as fertilizers whilst 1.6% would focus more on livestock production.

Table 10: **Farm management decisions informed by above average rainfall seasonal forecasts**

Forecast	Decision	Percentage
Above average rainfall	Grow flood tolerant crops	34.1
	Plant maize	23.9
	Increase cropped area	11.0
	Drainage practice	9.4
	Rent more land	5.9
	Practice double cropping	5.5
	Reduce area	4.3
	Prepare more inputs (fertilizer)	4.3
	Livestock	1.6
	Total	**100.0**

4.10.2. Normal Rainfall

No major decisions are made in anticipation of a normal season with the majority of farmers diversifying their crops and staggering planting dates. However, 16.5% indicated they would grow more tomatoes under the irrigable area to supplement the rainfall (Table 11).

Table 11: **Farm management decisions informed by normal rainfall seasonal forecasts**

Forecast	Decision	Percentage
Normal rainfall	Diversify crops	55.3
	Grow more tomatoes	16.5
	Follow normal cropping programme	15.3
	Use irrigation	12.9
	Total	**100.0**

4.10.3. Below Average Rainfall

The highest number of farmers indicated decisions related to crop varieties i.e. they would grow short season varieties or drought tolerant crops. Conservative decisions made by some farmers include reducing the cultivated area, leasing out their land and confining themselves only to irrigated land. Very few farmers indicated soil and water conservation strategies and 3.1% mentioned they would focus more on bee keeping (Table 12).

Table 12: Farm management decisions informed by below average rainfall seasonal forecasts.

Forecast	Decision	Percentage
Below average rainfall	Grow drought tolerant crops	36.9
	Use irrigation	18.4
	Reduce cropped area	16.9
	Grow short season varieties	12.2
	Lease out land	8.6
	Water conservation practice	3.9
	Practice bee keeping	3.1
	Total	**100.0**

4.11. Factors Influencing Farmers' Adoption of Agro meteorological Information.

Several socio-economic factors were found to influence farmers' adoption of agro meteorological information (Figure 13). The major factors were related to the communication of agro meteorological information itself. The majority of farmers (87.1%) blamed the inaccuracy of forecasts.

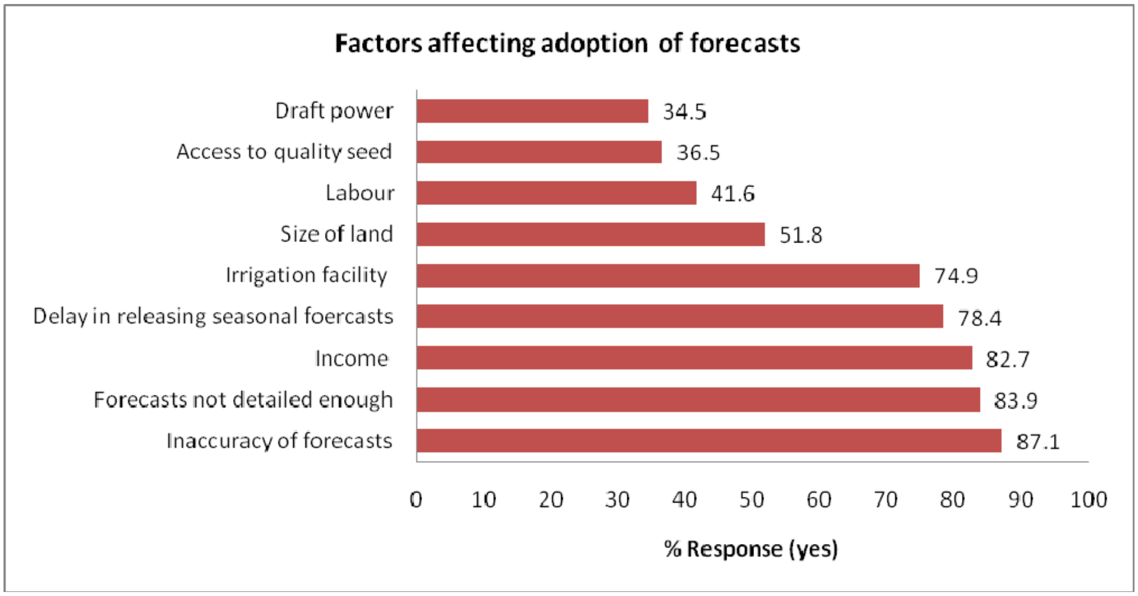

Figure 15: Factors affecting farmers' use of agro meteorological forecasts

4.12. Relationship between Farm Size, Average Income and Age with the use of Agro Meteorological Information.

The Pearson coefficient correlation was used to explore the correlations between farm size, average income and age with the use of seasonal agro meteorological information forecasts. According to the correlation analysis there was a negative significant relationship between the average income and the use of seasonal agro meteorological information (Table 13).

Table 13: Pearson correlation between farm size, average age and the use of seasonal agro meteorological forecasts.

	Use of seasonal forecasts	
Variable	**R**	**P**
Farm size	-0.120	0.056
Average income	-0.133*	0.034
Age	-0.040	0.520

*Correlation is significant at 0.05 level (2-tailed).

4.13. Influence of Socio-economic Variables on the Utilization of Agro meteorological Information by Smallholder Irrigation Farmers.

The multiple correlation coefficient R= 0.54 indicated a moderate and positive correlation between agro meteorological information use and the independent variables.

The value of the coefficient of determination R^2=0.291 implies that 29.1% of the variation in the use of agro meteorological information is explained by the independent variables in the model .For the model the value F is 12.57, which is also highly significant $p<0.05$. We can interpret that the final model significantly improves our ability to predict the outcome variable.

Table 14: **Multiple linear regression model showing the influence of independent variables on the use of agro meteorological information**

Variables	Coefficients		T	Sig.
	B	std. error		
(Constant)	0.416	0.231	1.797	0.07
EDULEVEL	0.051	0.027	1.889	0.06
AGE	0.001	0.002	0.465	0.64
ACCMETINFO	0.233	0.031	7.444	0.00*
ACCRADIO	0.163	0.083	1.966	0.05*
ACCTV	0.00	0.037	-0.006	0.99
ACCINTNET	0.049	0.056	0.880	0.38
ACCEXT	0.095	0.036	2.666	0.01*
INNOV	0.054	0.045	1.197	0.23

*p<0.05

The variables derived as an output of the model are described below.

$$Y=\beta_0 + \beta_1X_1 + \beta_2X_2+ \beta_3X_3+\ldots\ldots\ldots\ldots\ \beta_nX_n+\varepsilon \ldots\ldots\ldots\ldots\ldots (3)$$

Y= is utilization of agro meteorological information (INFOUSE)

X_1= is a access to agro meteorological information (ACCMETINFO)

X_2= is a access to radio (ACCRADIO)

X_3= is a access to agricultural extension officers (ACCEXT)

ε = is the error term.

INFOUSE= 0.42+ 0.233 ACCMETINFO + 0.163 ACCRADIO + 0.095 ACCEXT + ε

ACCMETINFO, $t (245) = 7.44$ $p< 0.01$

ACCRADIO, $t (245) = 1.97$ $p< 0.05$

ACCEXT, $t (245) = 2.67$ $P< 0.05$

4.14. Innovativeness

The response pattern of adoption of new technologies suggested that 28% of the respondents would adopt agro meteorological information as soon as they have learned about the technologies (Table 15). The chi-square test of independence indicates a significant interaction X^2 (4) =9.66, $p< 0.05$ between farmers innovativeness and the use of agro meteorological information.

Table 15: **Farmers' adoption of new technologies**.

Response	Frequency	%
Immediately I have leant about the technology	72	28.2
After I have seen it working	136	53.3
When everyone is using it	47	18.4
Total	255	100.0

CHAPTER FIVE

DISCUSSION

5.1. Demographic Characteristics of Farmers

The majority of the respondents were male as evidenced by a proportion of 77%. While women's participation in agricultural activities is very important, according to the Egerton University Participatory Rural Appraisal Programme (1999) traditionally men are the most influential in Kenyan rural families and are as such regarded as household heads; women only head their households when their husbands are absent. All the respondents who were married indicated that their spouses also contributed in decision making and knowledge sharing at the farm. There was a significant relationship between gender and utilization of agro meteorological information. Female respondents (57%) are more likely to make use of agro meteorological information than their male counterparts 53%. A study done by Okitoi *et al.* (2007) on gender and poultry production reported that women were more involved in the day to day activities whist men would contribute in the activities that involved cash such as buying of inputs and selling of the chicken. A similar argument can also be used in this study that women are the ones responsible for the day to day operations on the farms and are therefore more conscious of weather variations than their male counterparts who will be mainly concerned with cash related duties and seasonal decisions.

The mean age of the respondents was 49 years. A study by Obati (2007) in the South Western Mau Forest indicated a mean age of 49. The majority of the respondents were between 40-59 years old. According to Southgate and Hulme (2000), age group system historically played an important role in the ownership and management of land among Kenyans, where customarily, elders remain leaders with youth having little independent authority until they get married. However this could also be attributed to the fact that most youth are pursuing higher education and looking for formal employment in urban areas.

A few farmers (7.5%) had no formal education but were able to read and write with 16.1% having no formal education at all. This result indicates an overall literacy rate of 83.1% if only considering minimum literacy skills as being able to read and write, this figure is higher than the adult literacy rate in Kenya of 61.5% (CBS, 2007). Lin (1991) mentioned that higher levels of literacy are associated with access to information and adoption of improved technologies. A significant relationship was observed between levels of literacy and levels of education. Generally about 50% of respondents who have attained at least primary level of education tend to make use of agro meteorological information in decision making. In a similar study carried out in Lesotho to evaluate the up-take of agricultural information it was observed that farmers who had some form of formal education find relevance in the information that they get than those who did not go to school (Mokotjo and Katusopa, 2010). Similarly in this study farmers who did not have formal education do not find agro meteorological information contributing to increased production in their agricultural activities.

The most common language spoken in both irrigation schemes was Kiswahili (98.4%) with the majority of farmers in Lari speaking Kikuyu and Kalenjin in Perkerra. In both irrigation schemes 55% were able to communicate in English. Rural development educational programmes are conducted in the two official languages Kiswahili and English (KNBS, 2006) therefore it is important that communities are taught these languages. It is instructive for developmental agencies to consider local ethnic languages in disseminating information in order to reach a wider population. As indicated in Figure 12, language of dissemination did not affect farmers' access to agro meteorological information. This could be attributed to the fact that most of the farmers speak at least two languages (Kiswahili and their ethnic language). The other reason could be that since most farmers access their information through radio and they are more likely to tune in to a channel that broadcast in a language they understand.

5.2. Socio-economic Characteristics

As a source of livelihoods over 80% of the farmers indicated farming as their primary activity. Agriculture was similarly the major source of income. The sole reliance on agriculture indicates the vulnerability to weather variability by these small scale irrigation farmers. The farm sizes ranged from 0.5 hectares to 7 hectares and the mean farm size is 2 hectares. In general each farmer is expected to have an average of 2 hectares but some managed to till more land through hiring out from other farmers and others their land was reducing through giving out to their sons and renting it out.

Generally the income levels of farmers in Perkerra earned more from agriculture than those in Lari-Wendani despite similarities in farm sizes. The mean income in Perkerra was 230 000/= and in Lari 100 000/=. This could be attributed to the high presence of agricultural institutions in Marigat which include the Ministry of Agriculture, KARI, KEFRI and the National Irrigation Board (NIB). NIB plays an important role in the irrigation water management and in facilitating the seed maize contract with Kenya Seed Company. The ministry of agriculture provides extension services whilst KARI and KEFRI are involved in research they also provide advisory services through their demonstration plots. KARI is also engaged in disaster management programmes and farmers have indicated that they also get climate related advice from them. In Lari the shortage of extension staff and lack of adequate infrastructure contributed to the low income levels from agricultural activities. Perkerra has a very large market for its products in Marigat and it is connected by a good road to Nakuru town which makes it easier for farmers to purchase inputs and market their products. Lari Wendani is accessible by a gravel road which is sometimes inaccessible during rainy days which makes it difficult for farmers to send their products to the market.

A negative significant correlation was observed between the use of agro meteorological information and income. Farmers who get less are the ones who are more conscious of weather variability than the ones who earn more. The reasons could be that these farmers get less income because of the size of their plots and therefore have very little options in the event of bad weather. Farmers who get more income can afford to have other option in the event of bad weather such as buying drought tolerant varieties and even renting more land from other farmers. Ziervogel *et al*. (2006) argued that farmers' response to climate change and variability also depends on the socioeconomic position of the household poor farmers are likely to take measures to ensure survival.

Twelve crops were characteristically grown in the two irrigation schemes. Seed maize was the most common crop grown in Perkerra irrigation scheme mainly through the contracts with the Kenya Seed Company. Other common crops included water melon and pawpaw. Tomatoes are also common in both irrigation schemes and it is the major crop grown in Lari-Wendani, beans and onions are also common in Lari wendani irrigation scheme. Although seed maize is grown by many farmers tomato is the highest income earner with an average annual income of 71 000 KSh. Pawpaw, watermelon and seed maize are also among the highest paying enterprises. The reason why seed maize is grown by farmers in Perkerra is mainly because of the contract between NIB and Kenya Seed Company and the provision of inputs to farmers. Tomatoes tend to pay more because of the high market demand during the dry seasons.

Most of the farmers attended group meeting seasonally (48%) followed by 38% who indicated they attend meetings only once a month in the twelve groups identified in these irrigation schemes. The most popular groups identified were mainly involved in facilitating inputs and loans for the farmers. Group membership and frequency of attending meetings has significance in enhancing farmers' exchange of ideas and it has a potential use in terms of disseminating agro meteorological information. Findings indicated that none of these groups were involved in providing agro meteorological information to farmers. These groups can be used as discussion support systems, where farmers and meteorological officers can discuss about weather information needs in order to increase the acceptance and utilization of agro meteorological needs.

5.3. Sources of Agro meteorological Information.

Farmers in these areas get their weather forecasts from the Kenya Meteorological Department, KARI, Drought Monitoring Centre, internet and local forecasters. No farmer in these two areas seemed to be aware of the radio and internet communication system (RANET) which is one organization that plays an important role in disseminating climate, weather, health and other developmental information to rural communities. A follow up with the Kenya Agricultural Research Institute staff in Marigat to find out what kind of information they were disseminating to farmers showed that most of the enquiries they got were on rainfall amount because they have a weather station. This means that KARI-Marigat provides historical climatic data. This information is also critical in irrigation scheduling. KARI staff provides very little forecast information though they can also advice farmers on future seasonal patterns through their disaster and early warning activities where they make use of their historical climatic patterns and the reports from the Kenya Meteorological Department. The Kenya Meteorological department provides seasonal forecasts in both English and Kiswahili on their website which farmers and other agro-based organizations can download for free and distribute to farmers.

5.4. Dissemination of Agro meteorological Information.

This study revealed that besides accessing agro meteorological information through radio and television, the accessibility through other channels is very low. More than 60% of respondents indicated that they could not access agro meteorological information through bulletins, mobile, internet, extension and barazas. This result was even lower among the pastoralists in Kenya and Ethiopia suggesting that radio is by far the most common medium through which pastoralists receive scientific weather forecasts (Luseno *et al*., 2003). No other external source (television, printed media, and extension agents) reaches more than 3% of the pastoralist population (Luseno *et al*., 2003). Findings by Curry (2001) among institutions that make use of meteorological forecasts in Kenya, Tanzania and Ethiopia indicated that more than 70% received their information electronically either by e-mail or through the web. However this could be attributed to the fact that most farmers have limited access to internet and cannot afford to subscribe specific information from the climatic information providers.

Radio plays a very important role in disseminating daily weather forecasts but the type of reports are very short and covers a wider area. Ani and Baba (2007) mentioned that radio transcends across all the literacy barriers required in accessing written information. Radio in essence does not require higher educational qualifications to be effective. For those with access to internet 53.3% have access to internet weekly. On a monthly basis barazas had the highest percentage and extension services and interpersonal contacts were the major dissemination channels for seasonal forecasts. These results demonstrated how all the dissemination channels are important and how they complement each other in terms of the frequency and type of content that can be used to pass agro meteorological information to farmers. Institutions involved in disseminating agro meteorological information can also take advantage of the several farmer groups to disseminate information on monthly and seasonal basis. Farmers in Perkerra for example can take advantage of the Semi-arid Lands Information Network (ALIN) which operates a telecenter within their area, where farmers can have access to the Kenya Meteorological Department website for free. According to the staff at ALIN, if farmers have any specific information that they want they can make requests through their focal groups and the information can be availed to them in print through the centres notice board. During the time of this study farmers were only making use of this center to access market information.

Very few farmers (< 20%) considered the information they get from the various dissemination channels to be accurate. Recha *et al.* (2008) found out that 37% of the farmers in Machakos and Makueni districts had confidence in scientific forecasts and they attributed the lack of confidence to inaccuracy. Majority of the farmers consider scientific forecasts to be moderately accurate which limits their capacity to trust these innovations. The reason for these responses could be the fact that the information is not really location specific and because of the probabilistic nature of the generation of agro meteorological information. Patt and Gwata (2002) argued that farmers may become suspicious of scientific forecast if they tend to contradict it with their local traditional indicators.

Farmers indicated that the language of dissemination through the various media was not a problem; however concerns were raised in print media such as bulletins indicating that the language used was difficult and 8% raising concern on the use of terminology which they do not understand. This is also further supported by the factors affecting access to agro meteorological information, where 72% of the farmers indicated that inadequate extension services was a factor affecting their access to agro meteorological information. Several agricultural development specialists concur that extension contact gives farmers information that promotes their adaptability to changes in agricultural development (Qamar, 2002; Ochieng, 2004; Kamau, 2006). Farmers would prefer to get information from experts rather than reading through newspapers and bulletins on their own. Stone and Meinke (2006) argued that for uptake of more complex climate and weather information farmers need to contribute to the development of appropriate response strategies.

Other factors affecting farmers' access to agro meteorological information were lack of internet facilities, newspapers not delivered on time and lack of access to television. The internet can play a major role in agro meteorological information either through direct or indirect access. In developing countries telecentres can be used as focal points for many types of information. Theses telecentres can be sources of agro meteorological information that can be further disseminated through other channels such as extension services, local radio stations and newsletters in local languages (Weiss *et al.,* 1999).

5.5. Use of Agro meteorological Information

Less than 50 % of the farmers make use of agro meteorological forecast deciding on which crops to grow. The majority (50%) of the farmers indicated that they would prefer to follow the usual season or irrigation programme in order to make planting decisions, 25% of the farmers wait for the rains and 23% made use of scientific forecasts. This result is similar to the finding by Recha *et al.* (2008) who indicated that more than 50% of the farmers in Machakos and Makueni took a risk to plant by following the usual season. The low percentage of farmers who made use of scientific forecasts to decide on their planting dates makes the majority of farmers more vulnerable to unfavourable climatic conditions. Farmers fail to take advantage of a good season and they risk losing their crop if the rains do not come during the expected beginning of the rain season.

Farmers incorporated a variety of local climate forecasting methods in the two irrigation schemes. The common local forecasting methods used by farmers are observation of stars and studying of goats' intestines croaking of frogs and the flowering of certain plants as indicators of the onset of the rains, wind direction, movement of birds and bees and the quality and quantity of honey helps farmers also to tell the changes in the weather. Some farmers can also make use of atmospheric observations such as the appearance of certain clouds, wind direction, temperatures and lightning coming from a certain direction in order to predict the coming weather conditions. Most of these observations conform to the observations by Ngugi (2002). These local methods indicate seasonal patterns such as the beginning of a season and coming of the rains. It is difficult to predict the amount of the rains and the exact dates. There were similar perceptions in the reliability of local and scientific forecasts. Less than 25% of the farmers perceived both forecasting methods to be always reliable. This calls for the need to catalogue the local forecasting methods as a way of adopting the language of traditional forecasters and harmonizing it with the scientific forecasting methods (Mwinamo, 2001).

Above 70% of the farmers indicated crop weather recommendations and irrigation schedules as information that is highly accessible. This information was mainly shared through the irrigation committees for water management. Seasonal forecasts information is not highly accessible with 47% of respondents indicating that the information was highly accessible.

Few farmers (43%) had high access to onset date of rains and rainfall amount information. More than 50% of the respondents made decisions in the event that they received seasonal forecasts, onset date of the main rains and information on the expected amount of rainfall. The measures taken by farmers were influenced by the anticipated coming season. The decisions were based on whether the farmers were expecting above average, normal or below average rain. In anticipation of above average rainfall decision mostly involved change of crops or crop varieties. The majority of respondents (58%) indicated that they would switch to crops which tolerate a lot of rainfall or long season varieties. Similarly the farmers indicated that they would grow maize with seed maize being more popular in Perkerra irrigation scheme. Establishment of fruit trees such as pawpaw and banana was also common. Soil management and drainage practices were also some of the actions taken in anticipation of excess rain. Some farmers indicated that they would either increase or reduce the size of their land. No major decisions were made in anticipation of a normal season but this gives farmers a chance to diversify their crops and try out new varieties. When farmers are anticipating below average rainfall they would grow drought tolerant crops, reduce land size and concentrate more on irrigated crops. These decisions also conform to observations made by Ngugi (2002).

Significant relationships were observed between some independent variables and the use of agro meteorological information using the chi-square and Pearson correlation models at 0.05 level of significance. Gender, level of education, location, innovativeness, and average income were observed to have significant relationships with the use of agro meteorological information.

More farmers in Lari (81%) made decisions always when they received agro meteorological information than in Perkerra (50%). The reason could be due to the nature of irrigation management within the two schemes. Farmers in Lari-had their own independents plots and had the option to irrigate from their ponds which made their irrigation scheduling a responsibility of the individual farmer. In Perkerra farmers irrigated on the basis of a fixed cycle and had very little flexibility in terms of determining when to irrigate their plots based on weather forecasts. On the basis of the level of income between these two irrigation schemes, farmers in Lari sought for agro meteorological information more as a means of survival.

Most farmers (83.9%) felt that the forecast information obtained from the meteorological services was not detailed enough for them to make meaningful decisions. Another communication related factor was the delay in releasing seasonal forecasts: 74.8% indicated that the seasonal forecasts information such as the onset of the rains and rainfall amount was not disseminated on time for farmers to be able to make enough preparations in terms of securing loans and inputs. Quite a number of farmers (82.7%) mentioned income as a constraint that affected their adoption of meteorological information. Recha *et al*. (2008) also reported that 85% of the farmers cited income as a major constraint to the application of seasonal weather forecasts. Farmers experienced income shortages especially if they were coming from a bad season and they indicated that they had limited loan facilities. Farmers were unlikely to respond to seasonal forecast especially if they had to purchase inputs. The other critical factors mentioned by farmers were irrigation facilities (74.9%) and size of land (51.8%). Farmers pointed out that water shortage had an impact on the land size put under irrigation in the dry season and the limited farm sizes as affecting their adoption of agro meteorological information as they were left with limited options in the event of a bad or good season respectively. The other less critical factors were labour shortages (41.6%), failure to access quality seed (36.5%) and draft power shortages (34.5%). Literature points out to a number of similar factors that influence adoption of agro meteorological innovations. These factors include accessibility and usefulness of the information (Roncoli *et al*., 2002), and the socioeconomic position of the household (Ziervogel *et al*., 2006) among others.

5.6. Influence of Socio-economic Variables on the Utilization of Agro meteorological Information

The results of the multiple linear regression models showed three variables that significantly influenced the utilization of agro meteorological information as follows**.**

1. Access to meteorological information. The results indicated that as the access to agro meteorological information increased by one unit the need for use of agro meteorological information increased by 0.233 units. This means that the accessibility of information will lead to use of that information all things being constant. This finding does not support the fourth hypothesis that there is no relationship between access and use of agro meteorological information. The t-value of 7.44 and $p < 0.01$ implies that access to meteorological information has a greater contribution to the predictors.

2. Access to extension services. As access to extension services increases by one unit as the use of agro meteorological information increases by 0.095. From this result it can be surmised that if the number of extension officers with knowledge of agro meteorology is increased chances are higher that farmers would access that information and use it in decision making. The t-value of 2.67 and $p < 0.01$ makes access to extension services the second significant contributor in the model.

3. Access to radio. The result indicated that as the access to radio increased by one unit the use of agro meteorological information increased by 0.163. This means that all things being constant access to meteorological information from the radio will lead to the utilization of such information in decision making. The t-value of 1.97 $p < 0.05$ implies that access to radio has the least impact on the predictor model.

5.7. Innovativeness

The majority of farmers (53.3%) indicated that they would adopt the technology after they have seen it working. Most of these farmers indicated that they relied mostly on demonstration plots for them to adopt new technology. The late adopters/ laggards constituted 18.4%, most of these late adopters were from Perkerra who mentioned that in the previous year (2009) they had used a maize variety which had very good maize stalks but did not produce seeds. These farmers also indicated they would only use new varieties after they had been tried at the demonstration plots and satisfied with their performance.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1. Conclusions

On the basis of this study the following conclusions were made:-

1. Kenya Meteorological Department was found to be the major source of agro meteorological information for smallholder farmers in Kenya. A mix of media is important for disseminating agro meteorological information at different periods and content.
2. The language used in disseminating information was not a problem as evidenced by more than 65% of the respondents. Lack of internet facilities, inadequate extension services, lack of access to television and newspapers not delivered on time were cited as some of the critical factors affecting the accessibility of agro meteorological information.
3. Farmers had very little (57%) confidence in scientific forecasts. They considered them as sometimes accurate. The utilization of seasonal agro meteorological information was very low (54%). Traditional forecasting methods were still being applied in making farm decisions.
4. There was a significant relationship between farmers' use of agro meteorological information and gender, level of education and location. Females were more likely to make use of agro meteorological information than males. Farmers who had attained at least primary level of education found agro meteorological information applicable to their farm activities.
5. Delays in releasing forecasts, forecasts not detailed enough and income were the major factors affecting farmers' adoption of agro meteorological information. There was a negative significant relationship between the average income and the use of seasonal agro meteorological information.

6.2. Recommendations

1. Short term frequent radio forecasts and television casts are appropriate communication instruments for daily agro meteorological innovations. For weekly agro meteorological information updates internet and newspapers are appropriate channels. For disseminating monthly and seasonal weather forecasts barazas, bulletins and newsletters are the most appropriate. CBOs involved in disseminating information to rural communities should also engage in the dissemination of agro meteorological products in their activities. Accessibility to internet and the use of mobile phones should be increased in disseminating agro meteorological information.
2. Extension agents' participation in the dissemination of agro meteorological information should be increased. These agents should have some training background in agro meteorology and they should be deployed in areas where they are able to communicate in the local ethnic languages within their areas of jurisdiction.
3. There is need to catalogue the local forecasting methods as a way of adopting the language of traditional forecasters and harmonizing it with the scientific forecasting methods. The scientific forecast reports should be supported by local observations understood by the farmers
4. There is need for collaboration between the Kenya Meteorological Services. Extension services and farmers in the development of appropriate strategies to synchronize climate/weather uncertainties with the farming calendar.
5. Efforts should be made to disseminate location specific weather forecasts through government institutions such as KARI, NIB and local agro-based groups. Use of agro meteorological information should also be encouraged among women since they are the ones involved in the day to day operations in the field

6.3 Further Research

- There is need for further research to assess the relationship between scientific and local weather forecasts and come up with possible ways of integrating the two.
- Further research is also needed to evaluate the impacts of climate variability and climate change on agricultural productivity.

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A PPENDICES

APPENDIX 1: Questionnaire

Title: Access and utilization of agro meteorological information among small-holder farmers in kenya.

Dear respondent
I am an MSc student at Egerton University and currently carrying out a field research in Nakuru North district (Lari Wendani) and Baringo District (Perkerra). The focus of the research is on the access and utilization of agro meteorological information among smallholder farmers in irrigation schemes.
Kindly respond to the questions as accurately as possible to make this research a success

Yours sincerely

Willard Zendera

Identification Number (code) ------------------
Location---
Date of interview---------------------------------

HOUSEHOLD COMPOSITION CHARACTERISTICS

1.1 Name of the respondent ___________________________
1. 2. Age of respondent _______________
1.3 What is your position in the household?

[1]	Husband	[ ]
[2]	wife	[ ]
[3]	Child	[ ]

1.4 What is the gender of household head?

[1]	Male	[ ]
[2]	female	[ ]

1.5 What is the age of the household head?......................................
1.6 Marital status

[1]	Married	[ ]
[2]	Single	[ ]
[3]	Divorced	[ ]
[4]	Widowed	[ ]
[5]		[ ]

1.7 languages spoken………………………………………………

1.8 Educational level of household head.

[0]	No formal education	[ ]
[1]	Can read and write	[ ]
[2]	Primary school	[ ]
[3]	Secondary school	[ ]
[4]	Technical college	[ ]
[5]	University	[ ]

1.9 Primary occupation

[1]	Farmer	[ ]
[2]	Employed (outside agriculture)	[ ]
[3]	Employed (agriculture)	[ ]
[4]	Own business (outside agriculture)	[ ]
[5]	Unemployed	[ ]
[6]	Retiree	[ ]
[7]	Student	[ ]

1.10 Major source of income **(1)** off farm **(2)** on farm

1.11 **Household members**

Family member	**Age**	**Gender**	**Level of education**	**Advice to family in agriculture (1=yes) (2=no)**	**Primary occupation**

2.0 AGRO METEOLOGICAL INFORMATION REQUIREMENTS

2.1 Average farm size

2.2 Types of crops grown

	Crop Name	**Time of year**	**Average income/crop/year**
[1]			
[2]			
[3]			
[4]			
[5]			
[6]			
[7]			

2.3 Are you a member of any social or agricultural group?

[1]	**YES**	**[ ]**
[2]	**NO**	**[ ]**

If yes name the group(s)

2.4 If so how often do you attend meetings?

[0]	Not a member	**[ ]**
[1]	Sometimes	**[ ]**
[2]	One a week	**[ ]**
[3]	More than once a week	**[ ]**

2.4 Forecast information needed by farmers

Forecast information useful for farmers	**Information access**	**Information use**
1. Agro meteorological information	**[0] not at all** **[1] sometimes** **[2]when I look for it** **[3]highly accessible**	**[0] not at all** **[1] sometimes** **[3]make decisions always**
2. Onset date of the main rains		
3. Quality forecast of the rainy season (rainfall amount)		
4. Cessation date of the main rains		
5. Timing and frequency of active and dry periods (wet and dry spells)		
6. Agronomic recommendations in terms of which crop varieties to grow and so on		
7. Frost protection		
8. Fire protection		
9. Harvesting schedules		
10. Irrigation schedules		
11. Fertilizer application schedules		
12. Temporal and spatial distribution of the main rains.	**1. Covers a wide area** **2. Sometimes specific** **3. Specific to our area**	

2.4.1 State the various farm decisions that might be influenced by the following forecasts.

Above average rainfall	Normal rainfall	Below average rainfall

2.5 Perception of scientific weather forecasts

[0]	Not reliable	[ ]
[1]	Sometimes	[ ]
[2]	Always reliable	[ ]
[3]	Does not understand them	[ ]

2.6 Which traditional methods do you use for weather forecasts?

[1]	
[2]	
[3]	
[4]	
[5]	
[6]	
[7]	

2.7 Perception of traditional weather forecasts

[0]	Not reliable	[ ]
[1]	Sometimes	[ ]
[2]	Always reliable	[ ]
[3]	Does not understand them	[ ]

3.0 Sources of Agro meteorological information and access to the following dissemination channels.

3.1 Source of information

1	Meteorological department	[ ]
2	Drought monitoring center	[ ]
3	RANET	[ ]
4	Internet	[ ]
5	RCMRD	[ ]
6	Extension	[ ]
7	KARI	[ ]
8	Other sources	[ ]

3.2 Dissemination channel

Media	Access	Frequency	Accuracy	Packaging of information
Radio	**[0] no** **[1] sometimes** **[2] yes**	**[1] daily** **[2] weekly** **[3] monthly** **[4] seasonal**	**[1] very accurate** **[2] moderate** **[3] not accurate**	**[1] Simple language** **[2] difficult language** **[3] difficult to understand**
TV				
Internet				
Phone/mobile				
Newspaper				
Extension services				
Bulletins				
Friends / family members				
Chiefs barazas				

4.0 Factors affecting access to agro meteorological information

4.1 Do the following affect your access to agro meteorological information?

Factor	[1] Yes	[2] No
Language of dissemination		
Time of dissemination (Time during the day)		
No radio/TV		
No access to internet		
Inadequate extension		
Print media arrive late		

4.2 What time is the weather report on radio/TV are you able to listen at that time?

[1]	**Yes**	**[ ]**
[2]	**No**	**[ ]**

5.0 Use of forecasts in decision making

5.1 Do you wait for forecasts to decide on which crop to grow?

[1]	**Yes**	**[ ]**
[2]	**No**	**[ ]**

5.2 When do you make decisions to plant?

[1]	**After receiving forecasts**	
[2]	**Follow usual season**	
[3]	**Wait for rains**	
[4]	**Use traditional forecasts**	
[5]	**Follow neighbours**	

6.0 Factors affecting adoption of agro meteorological information

6.1 Do the following factors affect your adoption of agro meteorological information?

Factor	**[2] Yes**	**[1] No**
Size of land		
Irrigation facility		
Labour		
Draft power		
Access to appropriate seed		
Income		
Inaccuracy of forecast		
Forecast not detailed enough for decision making		
Forecast not disseminated on time		

6.2 When do you adopt new technologies? *Please tick*

[1]	Immediately I learn about the technology	[ ]
[2]	After I have seen it working	[ ]
[3]	When everyone is using it	[ ]

APPENDIX 2. Relationship between Use of Agro meteorological Information and Location.

		Use of agro meteorological information		
Location		not at all	Sometimes	Make decisions always
	%Lari	0.0%	18.2%	81.8%
	%Perkerra	1.8%	48.2%	50.0%
	%Total	1.6%	44.3%	54.1%

APPENDIX 3: Local Weather Forecasting Methods

	local/Traditional forecasting methods	**Frequency**	**%**
1	Stars and moon observation	124	48.6
2	Studying intestines of animals	116	45.5
3	Croaking of frogs	83	32.5
4	Flowering of plants	70	27.5
5	Wind direction	47	18.4
6	Appearance of certain clouds	42	16.5
7	Bird movement	38	14.9
8	Shoes	38	14.9
9	Atmospheric temperature	36	14.1
10	Animal behavior	35	13.7
11	Information from the rain makers	28	11.0
12	Flies	13	5.1
13	Sound made by ostrich	7	2.7
14	Bees movement & honey production	7	2.7
15	Butterflies	7	2.7
16	Lightening	4	1.6
17	Termites	4	1.6
18	Rats	3	1.2
19	Non believers	3	1.2
20	Sound made by insects	2	0.8

APPENDIX 4. Relationship between Use of Agro meteorological Information and Gender

	Use of agro meteorological information			
Education level		not at all	sometimes	Make decisions always
No formal education	% within education	7.3%	51.2%	41.5%
Read & write		0.0%	73.7%	26.3%
Primary		0.0%	36.2%	63.8%
Secondary		0.0%	49.3%	50.7%
College		2.5%	32.5%	65.0%
University		0.0%	0.0%	100.0%
Total		1.6%	44.3%	54.1%