UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

SCIENTIFIC WEATHER FORECAST INFORMATION COMMUNICATION: PERSPECTIVES OF RURAL FOOD CROP FARMERS IN THE LAWRA DISTRICT.

BY

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DECLARATION

Student

I, Yelevielbayire, Angzene Jonathan hereby declare that this dissertation/thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere:

Candidate's Signature:……………...…………Date:……………………..…….........

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Supervisors'

I hereby declare that the preparation and presentation of the dissertation/thesis was supervised in accordance with the guidelines on supervision of dissertation/thesis laid down by the University for Development Studies.

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This thesis is dedicated to my son Kim Nwenumbu Yelevielbayire and My Mother, madam Christiana Songnibong Yelevielbayire and particularly in loving memory of my late father, Mr. Yelevielbayire John for his sacrifice in sending me to school.

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LIST OF ACRONYMS

ACCRA	African Climate Change Resilience Alliance
AEA	Agricultural Extension Agent
ALP	Adaptation Learning Programme
CCAFS	Climate Change Agriculture and Food Security Project
DDA	District Department of Agriculture
DOI	Diffusion of Innovations
ECL	Esoko Company Limited
ENSO	El Nino Southern Oscillation
FGD	Focus Group Discussions
GDP	Gross Domestic Products
GMA	Ghana Meteorological Agency
GSS	Ghana Statistical Service
GSZ	Guinea Savannah Zone
ICT	Information Communication Technology
IDI	In-depth Interviews
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
JHS	Junior High school
KARI	Kenya Agricultural Research Institute
KCCWG	Kenya Climate Change Working Group
KII	Key Informant Interview
KMD	Kenyan Meteorological Department

LDCB	Lawra District Composite Budget
LDMTDP	Lawra District Medium Term Development Plan
NADMO	National Disaster Management Organization
NGO	Non-Governmental Organization
RANET	Radio and Internet
RKC	Rural Knowledge Centre
SARCOF	Southern African Climate Outlook Forum
SARI	Savannah Agricultural Research Institute
SMS	Short Message Service
SRID	Statistics, Research and Information Directorate
SSA	Sub-Saharan Africa
SST	Sea Surface Temperature
SWFI	Scientific Weather Forecast Information
TPB	Theory of Planned Behaviour
VKC	Village Knowledge Centre

ABSTRACT

The study explored perspectives of rural food crop farmers in the Lawra District on SWFI communication and uptake. The study was conducted in 4 purposively selected communities. A qualitative approach was adopted and employed exploratory case study design in collecting the data using a convenience sample. Study employed Semi-structured questions and data collection techniques used were in-depth interviews, Focus Group Discussion, participant observations and audio-visual materials. Data gathered from the field were mainly from primary sources and analysed using qualitative approaches. The study identified weather updates on expected rainfall, temperature conditions, nature of wind and amount of rainfall as weather information delivered to the rural farmers. The SWFI is generic in nature and lack agronomic advisory information. The dominant delivery channel of SWFI is the mobile phone. The delivery format is mainly short message service alerts. Respondents preferred rainfall onset and cessation dates followed with intermittent weather updates, agronomic advisories, crop specific information on staple crops. Voice message in the local language is preferred as packaging format. Preferred delivery channels are farmer-meteorologist interactive platforms, WIAs, mobile phones with voice messages in Dagaare, broadcasting SWFI using radio, complement with rain gauge readings. These were found to have an influence in the uptake of SWFI. The study observed that SWFI is used during pre-season, season and post-season periods. Weather information downscaled to specific communities. Following this, farmers reported

increase in crop yields. The study recommends wide range of delivery strategies, packaging should be participatory, advisories in the forecast is paramount.

CHAPTER 1

INTRODUCTION

1.1 Background to the Research

Globally, rain-fed agriculture is the dominant source of food crop production and constitutes the livelihood foundation of the majority of rural population (Shakespear & Nhamo, 2014) especially in developing countries where most are susceptible to weather related disasters and impacts on food crop production. The food crop subsector is frequently hit by changes in climate and especially subsistence farming (Winsemius *et al*. 2014).Variability in terms of temperature and rainfall implies some concerns for African food situation because of underdeveloped irrigation schemes, low adoption of conservation agriculture and other pressing agricultural development constraints (Waha *et al*., 2013). The impact is devastating in sub-Saharan Africa (SSA) in particular where agricultural productivity is typically rain-fed. Weather is often devastating to agriculture because of its associated periodic uncertainties (Bert *et al.*, 2006) and where farmers are unable to make appropriate adjustments to these manifestations.

In the Ghanaian situation, the Guinea Savannah zone is experiencing increasing temperature and whereas rainfall levels and pattern have been generally becoming erratic and unpredictable (Ndamani & Wantanabe, 2013). As a result, northern Ghana is already experiencing more extreme weather conditions such as dry spells, droughts and floods. Drought and floods are recurrent explaining why Lawra District has higher levels famine and poverty. This situation is currently affecting sustainable food crop production and human livelihoods (Lawra District

Composite Budget [LDCB], 2013) and had led to food shortages in recent times. Negative effect of variable weather patterns have been pointed to for many years (Adams *et al.*, 1990) and meteorologists are working to make available the requisite information to help the food crop sub-sector in adapting to these effects (Walthall *et al.*, 2012). This is important for the agricultural sector because according to the Statistics, Research and Information Directorate [SRID] (2013), of the District Department of Agriculture (DDA), the food crop sub-sector accounts for 61.3% of the Agricultural Gross Domestic Product (GDP) in the country. The concern is that if the food crop sub-sector is to continuously adapt to a changing weather, it will need the requisite weather information that provides farmers with decision support to guide farm management activities (Wilke & Morton, 2015).The requisite weather information services offer great potential to inform farmer decision-making in the face of increasing uncertainty and improved management of weather related food crop production risks (Tall & Hansen, 2013). These uncertainties can be lessened via adjustments with the coming weather through timely and accurate scientific weather forecast information (SWFI) services to rural farmers using context specific approaches in producing and disseminating the weather information (Mannava *et al.*, 2007). The positive effect of SWFI in food crop production is attained if meteorologists are aware of how farmers are feeling and embracing SWFI, and farmers can therefore make the most use of the forecasts in terms of application in food crop production (Willard, 2011).

However, there seems to be some concerns linked with communicating the science of weather variability (Weber &Stern, 2011) and this is particularly evident in the food crop production sector (Rejesus *et al.*, 2013). Previous research indicates that farmer perspectives on adjusting to weather variability are influenced by trust in sources of information, values, beliefs, personal experiences, opinions and perceived risks (Arbuckle *et al*., 2013) rather than only scientific facts. The uncertainty nature with future weather conditions means that scientific or technical information alone is inadequate to achieve place-based solutions (Wilke & Morton, 2015). There is a need for scientists to actively engage farmers in two-way dialogue about scientific interventions in order to increase trust in science, climate change knowledge sharing and learning that can lead to better adaptation (Wynne, 2006). Obtaining feedback from the farmers by actively engaging farmers and soliciting for their perspectives, meteorologists will be able to formulate scientific information in ways compatible with farmers' values, beliefs, opinions and experiences (Wilke & Morton, 2015). Bartels *et al*, (2012) call for hybrid forms of knowledge produced through two-way engagement between the scientists and farmers so that farmers are not treated as passive recipients of SWFI. This engagement can strengthen farmer trust, shape thinking and opinion on the process, help farmers understand and contend regularly with regards to adapting to weather variability by using SWFI in the Lawra District. It is therefore, vital that these vulnerable rural farmers are helped by first knowing their perspectives about scientific weather forecast information

(SWFI) service delivery, its influence on food crop production and building upon these perspectives in terms of policy initiatives.

1.2 Problem Statement

One of the most daunting challenges of the food crop sub-sector development in northern Ghana and Lawra District of the Upper West Region in particular, is how to secure sustainable food crop production for vulnerable and marginalized rural populations under the current weather variability regime. The Guinea Savannah Zone (GSZ) of Ghana is experiencing rising temperature and changing rainfall trends within the past two or three decades in the form of shift in onset and cessation dates, intensity, frequency, erratic rains which are unevenly distributed in time and space and have resulted in dry spells, droughts and floods causing food crop failure and reduced productivity and yields (Adiku, 2013). In effect, farmers in the Upper West Region of Ghana are increasingly confronted with major shifts in rainfall distribution patterns, not only from year to year, but also within the season (Adiku *et al*, 2017).

These issues constituted the key challenges in the Lawra District (LDCB, 2013). As a result of these uncertainties farmers in the District seem to be using "lottery" in their farming activities. That is, farmers guessing timing of rainfall and cessation dates to undertake adequate farming activities coupled with the mono-modal nature of the rainfall pattern (Ndamani & Wantanabe, 2013). It implies that farmers in the Lawra District have the opportunity to farm rain-fed crops once in a year as against their southern colleagues who farm twice in the same year. Food production is relatively low due to these unfavourable weather conditions thus affecting food security in the Lawra District (LDCB, 2013). For instance, over the years productivity has declined in the District as a result of weather variability with many farms recording yields of major staple crops such as maize and millet/sorghum below 1000kg/ha despite the use of integrated soil fertility management strategies, while there is a potential of attaining more than 4000kg/ha under well managed variable weather conditions (Ndamani & Wantanabe, 2013). During a reconnaissance visit to the District and interaction with the rural farmers, it was revealed that food shortage becomes severe in the months of June, July and August of every year linked to weather variability which used not to be the case in the past two to three decades. The combination of increasing temperatures and changing rainfall distribution implies that farmers face new realities that their indigenous farming knowledge alone may be incapable of coping with (Adiku *et al*, 2017).

In the midst of these issues in the study area, it appears that farmers are challenged in terms of weather predictions as they used to do with ease and adjust on their own due to the disappearance of many of the traditional weather forecast indicators because of global climate change. While at the same time, there has been improvement in the scientific weather forecasting approaches in recent times. It therefore, appears that the provision of scientific weather information is one such domain when produced with farmers has the potential for maximum uptake by farmers. In an effort to help rural farmers in the Lawra District adjust to weather variability and improve yields, profit and non-profit (Ghana Meteorological Agency [GMA] as well as Climate Change Agriculture and Food Security Project [CCAFS]) making organizations have all supported farmers in the study area with SWFI at least for the past four to five years. However, the approach has largely been passive and does not fully involve the farmers. As a result of this "take it or leave it" approach in SWFI service delivery seems to have caused many farmers to be skeptical about the anticipatory adaptation technology intervention and its uptake in food crop production in the study area. As Bisht & Ahluwalia (2014) study revealed, in Ghana one of the key obstacles to meeting the challenge of climate change adaptation is a failure to meaningfully engage existing local institutions that allow for dialogue between scientists, development partners, policy makers and community members. These gaps in climate change knowledge sharing seem to have resulted in the anticipatory adaptation information not making maximum impact in food crop production due to an inadequate influence of voices from the ground in that regard. Hence, it is unclear or little information exists on how rural farmers are involved with weather information for sustaining food crop production under the current weather variability in the study area. As Abayomi (2015) indicated farmers' engagement with and utilization of SWFI is an area of research on which little is known. Hence, this study explores perspectives of rural farmers on SWFI uptake in food crop production in the Lawra District.

1.3 Research Questions

Research questions are questions that a researcher would like to answer through a study (Kumar, 1999). They are essential because they help in addressing the research problem. In this research, the following are the main and specific questions the study seeks to answer:

1.3.1 Main Research Question

What are the perspectives of rural farmers on scientific weather forecast information services uptake in food crop production in the Lawra District?

1.3.2 Specific Research Questions

1. How is the existing situation on scientific weather forecast information services delivery in the study area?
2. What are the ways of delivering scientific weather forecast information services to rural farmers?
3. How do rural farmers in the study area make use of scientific weather forecast information in food crop production?
4. How effective is scientific weather forecast information in food crop production?

1.4 Research Objectives

1.4.1 Main Research Objective

To explore perspectives of rural farmers on scientific weather forecast information uptake in food crop production.

1.4.2 Specific Objectives

1. Find out farmers' knowledge on scientific weather forecast information services delivery process in the study area.
2. Investigate ways scientific weather forecast information services are delivered to rural farmers.
3. Assess the use of scientific weather forecast information in food crop production in the study area.
4. Examine the effectiveness of scientific weather forecast information on food crop production in the study area.

1.5 Significance of the Research

The research is designed to explore the perspectives of rural farmers on weather forecast information uptake and how it has influenced farmers' decisions on food crop production in the Lawra District. In exploring the perspectives of rural farmers, the results will make some contribution to policy and sustainable agricultural development practice and knowledge. In terms of agricultural policy formulation and intervention as well as sustainable rural food crop production, it will inform policy makers and development practitioners on the need to mainstream perspectives of rural farmers (grass root) in scientific weather forecast information communication processes in order to enhance adoption and adaptation to weather variability in the study area. Building on the perspectives of rural farmers identified by the research will help in the development of tailored weather variability adaptation policies and hence, adoption for the development of sustainable rural agriculture in the Lawra District. Other target groups in the study District that will benefit from the findings include disaster management authorities such as National Disaster Management Organization (NADMO), Ghana Meteorological Agency (GMA), drought relief agencies (in the case of early warning systems), institutions responsible for food security, as well as other weather and climate sensitive sector. Organizations working in that regard in the Lawra District will build on the issues identified in this research to facilitate their work on weather and climate science communication.

The research will contribute to knowledge in that it brings to bear perspectives that exist among vulnerable rural smallholder farmers that can help shape the on-going debate of scientific weather forecast information communication and uptake. Meanwhile, this study recognizes similar studies in Ghana such as the works of Jawoko *et al* (2012) who studied "smallholder farmers access to weather forecast information and how improved access could positively impact food crop production in the Ejisu-Juaben District in Ghana", Mabe *et al* (2014), explored "farmers' willingness to pay for weather forecast information in the Savulugu-Nanton Municipality in Ghana". However, these studies seem not to have focused explicitly on qualitative study.

Therefore, this study provides a new look as it is principally based on participatory approach and sought to fill in the methodological gap by explicitly been limited to the interpretivist tradition or approach in knowledge production.

In terms of geographical scope, the study is limited to the vulnerable rural smallholder farmers in the Lawra District which differs from other similar studies in Ghana and that focused on generic farmers and somewhat cover regional, national and international scope and may not have captured rich perspectives from the community levels. In terms of content scope, many of these studies focused on climate and seasonal forecast and a very little information on weather forecast, this study findings add up to the little literature existing on weather information uptake in the Upper West Region.

1.6 Scope of the Research

The research covered four (4) purposively selected rural communities in the Lawra District and it is limited to the rural farmers. The research focused on the perspectives of rural farmers on scientific weather forecast information services delivery and uptake in food crop production in the Lawra District. The study spanned from September, 2015 to July, 2016.

1.7 Organization of the Research

This thesis is presented in five (5) chapters. Chapter one provided a general introduction to the research. The chapter discussed the extent of the problem and addressed the significance of the research in the study area. Chapter two explores literature on weather forecast information communication and uptake in food crop production in Africa, particularly sub-Sahara African countries including Ghana. It encompassed definition of terms related to the study, empirical studies on the issue being investigated. The chapter concluded with summary of key lessons obtained from the review. Chapter three covered a description of the study area and the study methodology. It explains the research philosophical underpinnings, research design, data sources, techniques and data collection tools as well as data analysis. Chapter four presents the results and analysis of the findings of the research. It included the presentation and analysis of perspectives of rural farmers on weather forecast information communication and uptake in the Lawra District as well as discussion of the findings. Finally, in chapter five a summary of the findings of the research, conclusion, recommendations and a direction for future research are presented.

1.8 Limitation of the Research

The researcher encountered myriad of challenges in the course of the study. Difficulty in getting farmers to participate in the FGD sessions. This is because the time of data collection coincided with household construction activities. The research had to strategize and meet respondents either early in the morning or evening based on agreed schedules with the respondents. Respondents such as women were not willing to participate because of cultural issues in that they need to seek the consent of their husbands in order to grant an interview; however, it took the researcher's facilitation skills to get the women to participate and contribute to the FGD discussion sessions. Again, respondents were made to understand that the research work was purely academic and that their concerns would be communicated to the appropriate government authorities and thus in cooperate in policy decisions. Other constraints encountered were dialectical differences made the interviews challenging. Following this, the researcher recruited natives who could translate to intervene. Financial constraint was also a major limitation since the study required the use of some financial resources to be able to secure the necessary information. For instance the use of the internet, travelling expenses, payment of research assistants' allowances and accommodation for the team, secretarial works and community protocols. These and many other constraints limited the study in one way or the other. In spite of these limitations above, the study was carried out successfully after employing mitigation strategies and there is no doubt about the credibility of the study results. Thus the quality of data collected was not compromised.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explores literature on weather forecast information uptake and its influence on food crop production in African countries particularly in sub-Saharan countries including Ghana. The chapter begins with definition of terms used in the study. The theory of planned behaviour and diffusion of innovations theory were adopted as an analytical tool in understanding attitudes/behaviours changes of farmers and how innovations can be diffused and adopted readily by the famers and how this influence uptake of SWFI. The study concludes with summary of key lessons obtained from the review.

2.2 Definition of Terms

Weather is the day-to-day variation in the atmosphere and includes rainfall, sunshine, temperature; humidity, cloud cover and wind speed among other variables (Mawunya & Adiku, 2013) and usually weather parameters are considered over short periods of time say a few seconds to a few hours over a small location (Romisio *et al*., 2007). Forecast on other hand refers to short-term assessment of weather conditions up to one week (Rautela & Karki, 2015). Weather forecast therefore involves the dynamical modelling or a statistical approach where data are inputted into a computer software for analysis and determination of the expected weather conditions and these data could be observed or modelled sea surface temperatures (SST), satellite information, historical data (past 4, 7 or 10 days) or a combination of these (Goddard *et al*., 2001). Weather forecast information is the processed outcome of raw observations or data either using SST modelling or statistical approach. Forecast information includes products such as predictions of weather elements (temperature, rainfall, cloud cover and wind speed) on daily, weekly, monthly and seasonal basis.

2.3 Theoretical Frameworks

Kombo & Tromp (2006) see a theoretical framework as a collection of interrelated ideas based on theories. It is a reasoned set of prepositions which are derived from and supported by data or evidence. A theoretical framework accounts for or explains phenomena. Hence the theory of Reasoned Action (TRA), theory of Planed Behaviour (TPB) and Diffusion of Innovations theory (DOI), have been employed and used as analytical tools in understanding how innovations/technologies can better get to farmers in a form that can be appreciated and thus influence behaviours that will contribute to adoption and mainstreaming of such innovations in their farming activities.

2.3.1 The Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) was first introduced by Ajzen and Fishbein in 1967, in an attempt to understand and explain the relationship between beliefs, attitudes, intentions and behaviour (Fishbein & Ajzen 1975). The TRA is based on the premise that an individual's intention to carry out a given behaviour is the most proximal antecedent of that behaviour. Individuals' intentions are informed by their attitudes toward carrying out the behaviour and the subjective norms relating to behavioural performance (Ajzen & Fishbein 1980; Fishbein & Ajzen 1975). The TRA indicates that the two determinants of intention are the individual's attitudes toward the behaviour and the subjective norms (Ajzen & Fishbein 1980). Together, these forces determine intent. Ajzen and Fishbein (1980) found that individuals would intend to carry out the behaviour when they evaluate it positively and when they believe the 'most important people' think they should carry out it.

Attitude refers to the individual's overall evaluation of their behaviour, which might be positive or negative (Fishbein & Ajzen 1975). Attitudes are established from a combination of beliefs about behaviours and outcome evaluations. Attitudes have different scales of measurement and may be assessed using bipolar adjectives like harmful or beneficial, favourite or least favourite, good or bad. In this study, the assessment of SWFI by farmers in terms of the bipolar objectives in food crop production will largely determine attitude towards the innovation. Subjective norm refers to an individual's perception of others' beliefs. Subjective norms depend on normative beliefs; the significance of people's desire and willingness to raise support from others influences their motivation to comply (Fishbein & Ajzen 1975). Normative beliefs interact with multiple factors to encourage compliance, indicating which people the individual needs to emulate to determine subjective norms. Thus, the more favourably an individual evaluates behaviour and the stronger the perception of support from others, the stronger the intention will be to do the behaviour, and the more likely a person is to actually engage in that behaviour.

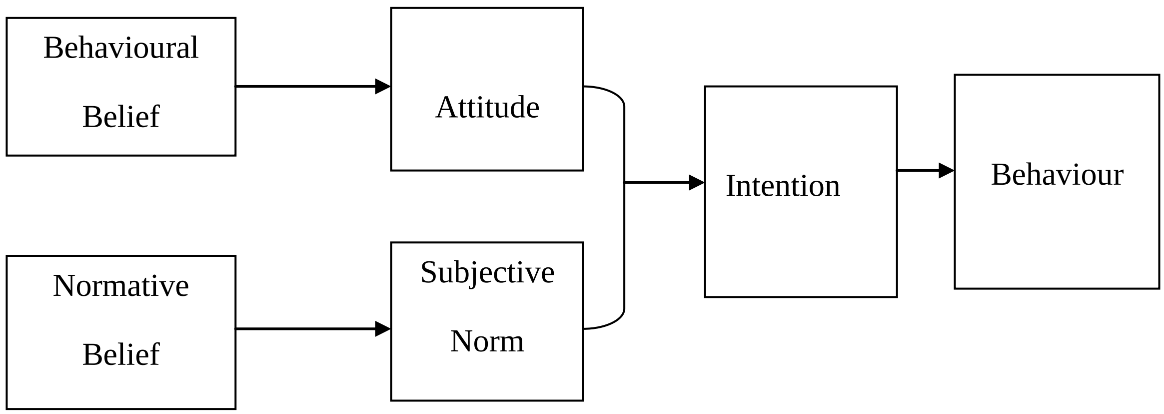

Figure 2.1: The Theory of Reasoned Action (TRA)

Source: Fishbein & Ajzen (1975)

2.3.2 Theory of Planned Behaviour (TPB)

The theory of planned behaviour (TPB) was proposed by Icek Ajzen in 1985 through his influential article "From Intentions to Actions: A Theory of Planned Behaviour". The TPB is an extension of Fishbein and Ajzen's theory of reasoned action as indicated in Figure 2.3.1. The TPB is a theory of attitude-behaviour relationships that links attitudes, subjective norms, perceived behavioural control, behavioural intentions and behaviour in a fixed causal order. The TPB states that attitude toward behaviour, subjective norms and perceived behavioural control together shape an individual's behavioural intentions and eventual behaviours (Ajzen, 1991). The difference between the TPB and TRA is an addition of another component to the TRA which is perceived behavioural control. Ajzen noted that behaviour specific attitudes are more predictive of intent, and thus of pro environmental behaviour, than are generic environmental attitudes. The TPB assumes that behavioural intention is the most psychological determinant of behaviour. It theorizes that intention is, in turn, causally determined by three factors. Firstly, individuals must have a positive attitude about the climate relevant behaviour (as determined by their values and beliefs). Secondly, individuals must believe that social norms support the behaviour implying that the behaviour is normal and congruent with the expectations of important reference individuals or groups. Finally, individuals must believe that they have sufficient control over the action. The TPB postulates that the more that these three factors are aligned in the pro environmental direction, the more likely the person will intend to engage and will actually engage in pro environmental behaviour. Behaviour therefore, is deemed to be a direct function of intention and indirect function of perceived behavioural control.

Predicting attitude and behaviour of farmers in the use of short term weather forecast service is a huge challenge in behavioural science and scholars have attested to that. The TPB by Ajzen (1991) best explains farmers' attitude and behaviour in relation to weather information uptake. This present study focused on positive behavioural change via soliciting for the perspectives of vulnerable rural farmers in the study area. The TPB serves as a guide in conducting the study, since the study approach is inductive and therefore seeks to learn from the grass root. The TPB gives direction to the study and helps the researcher to formulate, ask the requisite questions in the data collection phase and guide in the analysis process, since weather forecast information uptake in food crop production by the target population is an attitudinal and behavioural change issue.

2.3.3 Diffusion of Innovation Theory (DOI)

DOI theory was developed by E.M. Rogers in 1962 that seeks to explain how, why, and at what rate new ideas and technology spread through cultures. Rogers (1995) defines diffusion as “the process by which an innovation is communicated through certain channels overtime among the members of a social system.” In other words, the study of the diffusion of innovation is about how, why, and at what rate a new idea or technology spreads among the members of a social system. The perceived attributes of innovations can help in understanding the rate of diffusion. Rogers describes these factors in five categories of innovations attributes as follows: relative advantage, compatibility, complexity, trialability, and observability (Rogers 1995; Walker 1999).

Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes (Rogers, 1995). Relative advantage indicates the benefits and costs resulting from adoption of an innovation and is one of the best predictors of an innovation’s rate of adoption. Compatibility is the compatibility of an innovation with existing values, beliefs, and the needs of potential adopter. Compatibility is the key factor for all innovations, even those with a high relative advantage. If the idea seems morally irreconcilable, then the innovation will not be adopted. To be implemented, an innovation must be considered socially acceptable. Complexity refers to the adopters’ perception on the degree of difficulty to understand and use an innovation. The perceived complexity of an innovation is generally related to its rate of adoption in a negative direction. Some innovations are easily understood by most members of a social system and will be adopted quickly, whereas others may be more complicated and will be adopted more slowly. Trialability is the degree to which an innovation may be experimented with on a limited basis. Thus, the perceived trialability of an innovation is usually positively related to its rate of adoption. The trialability is more important for earlier adopters than later ones, because earlier adopters have no precedent to follow when they adopt, while later adopters are surrounded by peers who have already adopted the innovation and, these peers act as a kind of vicarious trial for later adopters. Observability is an innovation that offers observable results. The easier individuals can see the results of an innovation, the more likely they are to adopt it. The perceived observability is related to the rate of adoption in a positive direction. Therefore, argued that innovations that are perceived by individuals as having greater relative advantage, compatibility, trialability, observability, and less complexity will be adopted more rapidly. However, in this context, because of the differences in personal experiences, environments, and technology needs, faculty members will certainly perceive the attributes of online databases technology differently. Among the three theories the study reviewed above, the latter has been used and its five components compared with the findings and ascertained claims made by the theory. This is because among the theories reviewed the DOI theory is more appropriate for the study.

2.4 Conceptual Framework

A conceptual framework represents the researcher's synthesis of literature on how to explain a phenomenon. It maps out the actions required in the course of the study given his previous knowledge of other researchers' point of view and his observations on the subject of research. In other words, the conceptual framework is the researcher's understands of how the particular variables in his study connect with each other. Thus, it identifies the variables required in the research investigation. It is the researcher's "map" in pursuing the investigation. According to (McGaghie *et al*. 2001) the conceptual framework "sets the stage" for the presentation of the particular research question that drives the investigation being reported based on the problem statement.

The conceptual framework as contained in Figure 2.2 above guided and provided a general picture for the study. For effective SWFI service delivery, meteorologist and farmers must work together for appreciation of each other's views in the process. This will lead to appropriate generation and packaging of the SWFI (content) and the choice of farmer friendly delivery channels and formats. There is also the need to consider some fundamental factors which are intrinsic (inherent) and contextual (specific to the study area) because these factors together shape the process and largely influence adoption which will lead to effective and sustainable SWFI service delivery. This will further lead to resilience building against weather variability in food crop production and hence food security.

Below is the conceptual framework of the study:

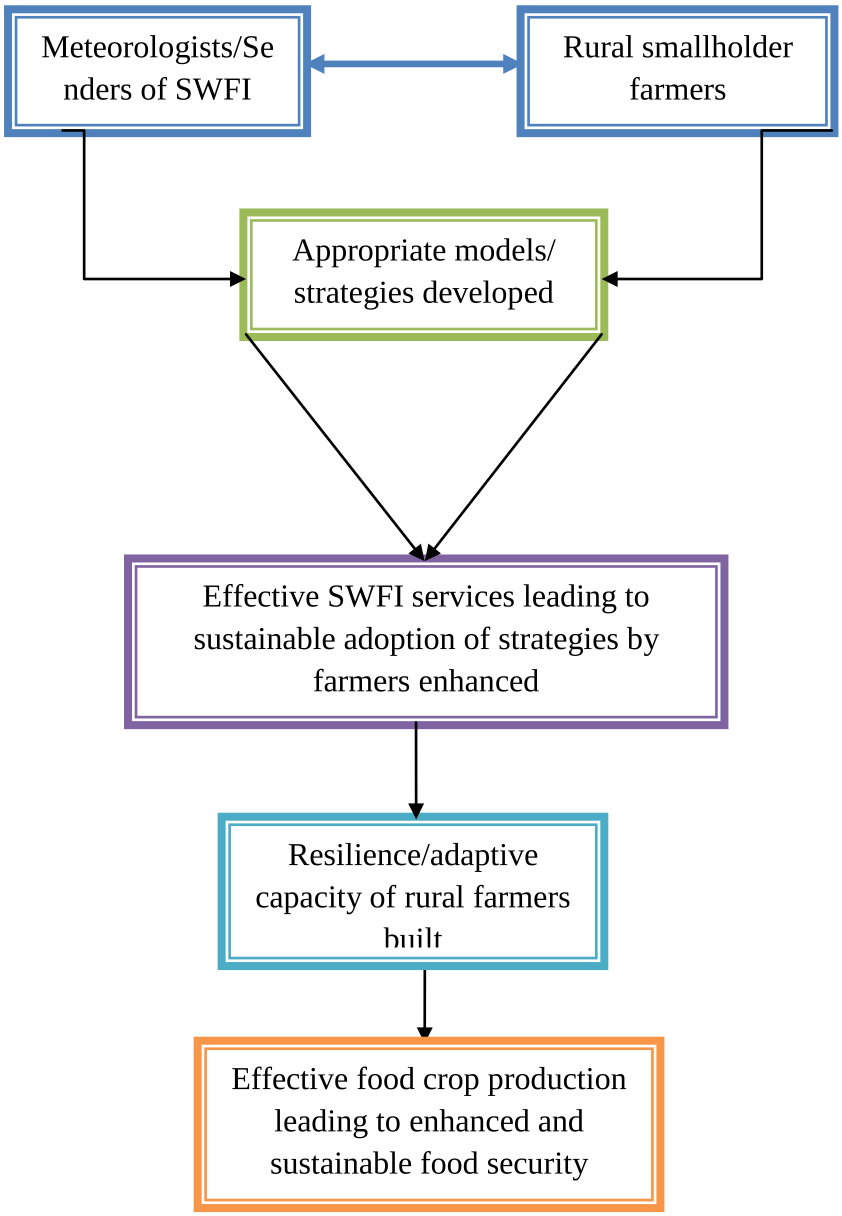

Figure 2.2: Conceptual framework of the study

Source: Author's construct (2016)

2.5 The Ghana Meteorological Agency

GMA was created in 1957 to provide national meteorological services and became an Agency in 2004 under act 628 (Kadi, *et al*, 2011). The mission of is to provide efficient weather and climate services by collecting, processing, archiving and disseminating meteorological information to end users such as farmers in the country. Specific activities of the GMA include; Provision of weather information to farmers, research institutions, private and public agencies where charges for services provided are levied dependent upon the nature of the information being sought and whether it is required for profit making, giving early warning forecasts of changing weather conditions (imminent storm, wind gust and hurricanes), provision of agro-meteorological information, provision of advisory services to the general public on environmental issues. Weather products include; weather reports, rainfall forecast (daily, monthly and seasonal including number of rainy days, rainfall intensities, return periods and patterns), agro meteorological bulletin, eco-climate, expert weather advice on bird sanctuaries, evapotranspiration and data on evaporation, humidity, Sunshine duration, wind speed/direction, temperature, cloud cover and height, SST, radiation, thunderstorms/lightning, windstorms (Squalls), soil/earth temperatures and visibilities (Kadi, *et al*, 2011).

2.6 Weather Variability

Weather in Africa is changing at unprecedented rates (IPCC, 2014) and international studies (Boko *et al.*, 2007) confirmed that Africa is the most susceptible region to weather variability. This susceptibility is been connected to the region's low adaptive capacity and its over-reliance on rain-fed food crop production (Boko *et al.*, 2007). Rain-fed agriculture constitutes the mainstay of most African countries' economies, employing about 60% of the population (Sarris & Morrison, 2010)). In terms of future trends, Christensen *et al* (2007) projected an average increase of between 3^0C and 4^0C for Africa by 2080–2099 based on the 1980–1999 period, under medium-high IPCC emission scenarios. In Africa, sub-Saharan Africa (SSA) is considered to be the most susceptible to the adverse impacts of weather variability. According to the IPCC (2007), sub-Saharan Africa is likely to experience an increase in both minimum (1.8^0C) and maximum (4.7^0C) temperatures. Christensen *et al* (2007) posits that Minimum and Maximum rainfall levels are likely to change by -9% and 13% respectively. Sub-Sahara Africa (SSA) has experienced both seasonal and annual rainfall variability (Hulme *et al.*, 2001). Several studies investigating rainfall variability have noted a decline in annual rainfall in SSA, especially West Africa, and particularly in the Sahel and Guinea Savanna Zones (Hulme *et al.*, 2001). Rainfall is getting more errant and intense, affecting the quality and availability of water for crop production (Mcgranahan *et al.*, 2007). Ghana has experienced considerable variations in temperature and rainfall patterns over the past four decades. Several studies have projected that temperature will increase and rainfall will decrease in all of the country's agro-ecological zones (Owusu &Waylen, 2009).

2.6.1 Weather Variability and Crop Production Nexus

Many studies have indicated that food production in Africa, especially SSA, will be seriously affected by weather variability (Schlenker &Lobell, 2010; Thornton *et al.*, 2011). The most susceptible group to the effects of weather variability is the smallholder farmers who live in dry land communal areas and have the least ability to adapt to weather variability (Galvin *et al*., 2001). These poor and vulnerable communities living in rural areas directly depend on substance from rain-fed agriculture. They are also the most susceptible to ecosystem changes that leave them exposed to natural and human disasters such as drought, famine and floods. Boko *et al* (2007) project about 50% reductions in crop yield by 2020 with an estimated 90% fall in crop net revenue by 2100 due to weather variability in many African countries.

Much of SSA will experience a significant reduction in the length of growing period; when soil moisture and temperature are most conducive for crop growth (Thornton *et al.*, 2011). Lobell *et al* (2009) found that there are increasing temperatures and declining levels and distribution of rainfall which had reduced yields of maize, rice, wheat and other food crops in semi-arid regions. Changes in weather conditions that control plant growth such as temperature, soil moisture and atmospheric carbon dioxide could alter crop production. Weather and climate variability can also influence the incidence of pests and diseases that could reduce agricultural productivity (Gan, 2004). Crop yields are directly affected either positively or negatively by weather variability especially in rain-fed agricultural systems. Porter & Semenov (2005) noticed that high temperatures during flowering could be very costly for crops such as maize and soy bean. This is because physiological processes such as germination, flowering and photosynthesis have an optimum temperature range within which they function effectively (Gliessman, 2007). Extreme weather events due to weather variability makes the application of farm inputs such as fertilizers difficult and this can reduce their efficiency (Porter & Semenov, 2005) in cases of drought and waterlogged areas. Weather variability may also increase the risk of soil erosion and salinization (Nearing *et al.*, 2004). This may reduce soil fertility, especially in arid and semi-arid regions, where there are serious challenges posed by land degradation and desertification. This may reduce crop yields eventually. Further, drought as a result of increased temperature and reduced rainfall could pose serious challenges to many poor small-scale farmers.

In Ghana, a study by Djagbletey *et al* (2012) in their assessment of coping and adaptation strategies to climate change in Offinso North and South of Ashanti region revealed that farmers' perception on climate change included increased temperatures, unpredictable rainfall in the form of reduced and erratic pattern, incidence of floods, severe drought, increased fire outbreak, changed planting season, increased extinction of species. These observations are in conformity to results of other scholars such as Gyampoh *et al* (2007) and Nelson & Agbey (2005). The effects of these on the livelihood of the farmers are reduced crop yields, incidence of insect pests and diseases, increased incidence of wildfires and shortage in water resources. According to the authors, their observation revealed that certain practices such as illegal logging, farming along river banks, excessive use of weedicides and unsustainable farming practices were exacerbating weather and climate variability in the two districts. Kunstmann & Jung (2005) observed that the total duration of the rainy season has shortened, while dry season and rainy season temperatures increased around 1°C and 2°C respectively. There have been shifts in when Ghana's seasons start. Rainy season begins in April or May, research shows that rain has decreased during those months but increased at the end of the rainy season between June and August. There has been an overall decrease in rainfall linked to weather variability. Variability in rainfall and temperature made agriculture very sensitive to climate change, this also makes it challenging for farmers to predict for their crops (Assan *et al.*, 2009). Based on the Participatory Research study in Ghana, participants noted specific changes they have noticed in weather and crop production. The changes they noticed vary from extreme weather to more dry spells. 92% of study participants agreed that weather has been less predictable (Rademacher-Schulz &Mahama, 2012). In the Lawra District of Ghana, Ndama &Wantanabe (2013) observed that rainfall variability in the month of June is high. Their work concluded that the rainfall distribution in the month of June is very erratic and could pose dangers of dry spell sand could affect crop development at the early stages if farmers attempt to delay crop planting. The seasonal rainfall ranges from 436mm to 1,583mm per year. A separate view of the average monthly rainfall totals over the 33 year period in the Lawra District reveals that rainfall is generally highest in the month of August. Most of the seasonal rainfall occurs between July and September. This situation has the potential of causing water logging of fields (Ndama & Wantanabe, 2013).

2.7 Science Communication

The science of weather is the state of scientific knowledge available on the subjects of weather variability gained from satellite observations or statistical modelling of weather parameters and assessing the interaction of earth's terrestrial surface and atmosphere (Wilke & Morton, 2015). In the meteorological sciences, uncertainties are particularly important to illustrate discrepancies and statistical error potential of forecasting. Experiential factors affect trust in weather information sources (Arbuckle *et al*., 2013) and social value systems (Kahan & Braman, 2006) seem to have great influence in how people perceive and respond to scientific initiatives (Wilke& Morton, 2015). According to Wynne (2006), the public involvement in science and technology model is a useful framework for more effectively communicating scientific information to rural smallholder farmers. Leshner (2003) affirm that education on weather variability issues has not positively influenced the public's (including farmers) skepticism about the science of weather due in part to socio-cultural factors. Bartels *et al* (2012) claim that the complexity of the uncertainty associated with future weather conditions suggests that scientific or technical information alone may be inadequate to realize place-based solutions. Scholars have argued that there is therefore, the urgent need to actively engage the public particularly farmers in a two-way dialogue about scientific initiatives such as uncertainty communication in order to increase trust in science, knowledge sharing and learning that can lead to effective adaptation (Bartels *et al* 2012).

However, most scientists have little training in communication (Wilke & Morton, 2015) and their message is skewed towards accuracy and objectivity and they (scientists) are most likely to believe that the science speaks for itself and needs little interpretation (Nielsen, 2001). In most cases this approach seems not to have worked well and Dietz (2013) affirms that good decisions must not only be factually competent but also be value competent. The values brought to scientific facts affect whether the information is relevant or of any value or useful to the farmer. Relevant communication patterns acknowledge the necessity of some level of translation of the science "facts" in order for farmers to relate to the information and perceive those facts as applicable to their own situations (Wilke & Morton, 2015). Framing information as important is necessary to acknowledge individual value judgments and convey information in a way in which the farmers recognize real-world connections to scientific knowledge (Kahneman, 2003). Nisbet & Scheufele (2009) argue that science communication efforts need to be based on a methodical empirical understanding of farmers' existing values, knowledge and attitudes, their interpersonal and social contexts, their preferred media sources and communication channels. According to Dietz (2013), acknowledging values and opinion of farmers can help meteorologists easily convey the importance of their information and what should be done. Nisbet (2009) supports that tailoring of weather information to farmers and using examples that initiate values can make scientific initiatives more significant to the farmer and ensure effective uptake of weather information. Identifying the importance of scientific facts and hoping the information is useful are not enough to ensure it will actually be used (Dilling & Lemos, 2011). Bartels *et al* (2012) call for bidirectional and 'hybrid' forms of knowledge coproduced through two-way interaction between the meteorologists and farmers so that farmers are not treated as passive recipients of weather information as is the case of the rural smallholder farmers. According to Coleman (1990), this engagement can strengthen trust and shape thinking and opinion with regard to concern about weather variability and management (Malka *et al*, 2009). Jones *et al* (2000) suggests that engagement and trust building are required to help farmers understand and regularly use weather information in adjusting to the uncertain nature of weather variability. Jones and colleagues recommend that meteorologists need to work with famers to develop a common language for communicating weather information and further suggest that effective communication and uptake of weather information is best accomplished through collaboration between providers of weather information and farmers.

To further enhance communication and uptake of weather information Dahlstrom (2014) suggests that narrative formats of communication somewhat offer increased engagement, comprehension and uptake of weather information. Arbuckle *et al* (2014) found that in some African countries farmers use narratives to interpret and give meaning and recommended that listening to farmers' word choices and the language of these narratives can provide guidance to gaining their attention and effective communication and uptake of weather information. Dahlstrom (2014) in a study identified trust in the source delivering the information as essential for successful science communication and concluded that the inclusion of farmers as active participants will consolidate trust and ensure effective uptake of weather information. Assessment of various agricultural stakeholder groups, including scientists, indicates that to effectively connect weather information to agricultural decision support, efforts should focus on management of risks associated with climate (Prokopy *et al.*, 2015) and this will depend on how the right information is made available to farmers.

2.7.1 Communicating SWFI to Farmers

Communication plays central role in ensuring community empowerment especially in weather sensitive areas. Studies showed that information and communication technologies are effective mediums for sharing knowledge and information and thus facilitating socio-economic development in vulnerable rural areas particularly of developing countries (Lwoga, 2010). Participation of vulnerable farmers ensures interactive communication which leads to freedom of expression of opinions, building a sense of ownership and strengthening local level planning and implementation of climate change adaptation programs. By dialogue and consensus building it enables people to expand their capabilities to negotiate with, influence, control and hold accountable institutions that affect their lives (Lwoga, 2010).

Since, development cannot be induced by communication controlled by external forces alone, it is important to use participatory approaches in communication as development is a participatory process of social change. Participatory communication is an approach grounded on exchange of ideas and information, perceptions and opinions among the various stakeholders thereby creating awareness, providing community based solutions, strengthening community voices and facilitating empowerment of vulnerable and marginalized communities (Bisht & Ahluwalia, 2014). According to Bisht & Ahluwalia in their study in Ghana West Africa, found that, one of the key barriers to meeting the challenge of climate change adaptation is a failure to meaningfully engage existing local institutions that allow for dialogue and exchange between scientists, local government officials, policy makers and community members. The study as part of its conclusion revealed that these huge gaps in climate change knowledge sharing have resulted in adaptation information failing to reach the most vulnerable communities and an inadequate influence of voices from the grass root in policy development (Bisht & Ahluwalia, 2014).

2.7.2 Factors influencing the Uptake of SWFI

The uptake of SWFI by farmers in SSA is influenced by fundamental or intrinsic factors as the communication approaches used (channels, forms and formats) and contextual factors. Such contextual factors include: community's cultural practices and traditions including religious and non-religious beliefs; community's indigenous knowledge; community's social structures and networks; locality i.e. rural versus urban settings; community livelihood practices, opinions and experiences as well as gender. The kind of communication channels used to disseminate weather information influences its usability (Bisht & Ahluwalia, 2014).The different channels include: radio, internet, newspapers, television, on-farm field demonstrations, community gatherings or forums (mosques and churches), face-to-face interactions and most recently mobile phones and social media (Mamun *et al*., 2013). Other channels are indigenous knowledge informers, through local administration and through extension support services. According to Moser (2010) the intrinsic characteristics of these information channels, forms and formats affect their usability. The review found that when weather information is communicated to local communities in official national but not local languages, it is difficult for communities to understand and relate to the communicated information (Roncoli *et al*., 2008; Khan *et al*., 2012; Mamun*et al*., 2013; Muchunku *et al*, 2014).The timing of weather information announcement can also be critical for its usability (Cash *et al*., 2006; Lemos *et al*., 2002).

2.8 Generation and Delivery of SWFI Services

Daily forecasts are weather forecasts that are issued out to the agricultural communities daily. They normally contain detailed likelihood of forecasts (possibility of showers and temperature) for the following day(s) for specific locations. They also include detailed daily weather statistics (usually for yesterday) including temperature and rainfall (Kadi *et al*, 2011). Forecast may exceed a day and may include: 4-day forecast which contains information on how the weather performed during the last 4 days and how it is expected to be in the next 4 days. On the other hand, 7-day forecast contains information on how the weather performed during the last 7 days and how it is expected to be in the next 7 days. The 4-day and 7-dayforecasts are used for short term agricultural planning such as planting, drying grains, applying fertilizer and insecticides. Monthly forecast contains review of the current month and the expected conditions during the coming month. The summarized contents of the forecast are; rainfall performance for the month under consideration, prevailing synoptic situation during the month, impacts experienced during month on various socio-economic sectors, forecast for the coming month and the expected impacts on socio-economic sectors during the coming month (Kadi *et al*, 2011) especially food crop sub-sector. Experience in a variety of contexts (Ziervogel, 2001) showed that farmers can optimize forecast information when it is interpreted at a local scale, includes information about timing (e.g rainy season onset, risk of dry spells), expresses accuracy in transparent and simple probabilistic terms; and can be interpreted in terms of agricultural impacts and management implications (Hansen *et al*, 2007).

A study in Kenya revealed that dissemination of weather information occurs at the community level in a participatory manner involving farmers, extension workers, local community leaders (Chiefs), Kenyan Meteorological Department (KMD) and other development partners (Mwesigwa & Omukuti, 2013)**.** Mwesigwa & Omukuti study found that the contents of the weather products are accompanied with advisories which include; planting time**,** good farm management practices, choice of inorganic fertilizers and use of farm manure, suitable crop types and varieties to be planted, weeding regimes, the available seed suppliers, prevention and control measures for crop pests and diseases. The study concluded that SWFI services are effective and appreciated by the farming community due to the participatory manner of the process. In another study, on "Access to Climate Change Information and Support Services by the Vulnerable Groups in Semi-Arid Kenya for Adaptive Capacity Development", Cherotich *et al* (2012) found that the majority of Kenyan's vulnerable women preferred to obtain weather forecasts through radio, while those who were elderly (60years and above) preferred to use indigenous knowledge. In terms of the medium of dissemination, Oyekale (2015) results showed that the majority of the farmers accessed forecasts via radio transmissions and followed by friends. The results noted that involvement of extension officers in weather forecast dissemination was highest for pests/diseases in Ethiopia, Kenya, Tanzania and Uganda compared with onset of rainfall. Other farmers monitored the weather on their own using indigenous knowledge. A study by Tall *et al* (2014) on "Reaching the Last Mile: Best Practices in Leveraging ICTs to Communicate Climate Information at Scale to Farmers" revealed that network of Village Knowledge Centres (VKC) and Rural Knowledge Centres (RKC) provided an appropriate platform and contributed to rural farmers' timely access and use of meteorological information in rural India. According to the study, the VKC and RKC were built using participatory frameworks that first ascertained village needs and established multi-village hubs and then it offered shared access point to innovative information communication tools (ICT) where farmers could go to retrieve information, discuss issues with trained agriculture extension agents or trained village intermediaries, and access the knowledge of experts about farming topics with weather information been the core of farmers' discussions. According to Tall *et al* (2014) study it was observed that farmer-to-farmer demonstration model was highly successful in transferring weather information by first through expert-farmer training and then providing support for farmer-to-farmer peer trainings. The authors noted that through these Knowledge Hub Consortiums, they create a centralized base for knowledge and enable open distance learning through two-way interactions between meteorologists and rural farmers. Trained local intermediaries not only communicate between experts and farmers but also gain the skills to directly help address community identified needs that relate to weather variability in rural India. Another study by Thomas *et al* (2011) revealed that farmers in rural India makes use of Green SIM which offers voice messages of relevant information on topics ranging from weather reports to information about pests to the status of crop markets. Farmers can receive the voice messages free of cost.

2.8.1 The Use of Radio in Delivering SWFI

Radio constitutes one of the most easy to get communication channels to reach out to mostly grass root communities. Irrespective of their social or educational status (Gauthier, 2005) it is easily understandable and in simple formats as well as lower investment costs (Balan *et al.*, 2012). Weather forecasts disseminated through radios and in which the information is communicated in official national languages are at times not easily understood by local communities due to the use of technical terms (Luseno *et al*., 2003; BBC World Service Trust, 2010a; Mpandeli & Maponya, 2013). Bisht & Ahluwalia (2014) study in Kenya found that weather information disseminated via radios and in which the information is translated in local dialects and packaged using local metaphors and delivered through entertaining approaches such as catchy songs, dramas or games, enable better understanding, learning and also help listeners to easily relate with and use the information. Through the use of local languages, weather information is commonly understood by the majority of beneficiaries, with radios appearing to be the most common communication channel among local communities in Africa (BBC World Service Trust, 2010a; Churi *et al*, 2012; Kalungu *et al*., 2013). In India, research findings indicates that radio and television is the most widespread and easily accessible media through which 60 to 70% farmers could access information on weather forecast (Kalungu *et al*., 2013) .Ogallo (2007) found that radio and television talkshows now exist in Kenya that takes telephone calls to answer questions and obtain feedback directly from farmers. Weather information communicated through music, drama and plays has been found to be more easily understood by local farmers in Africa and to enable individuals to relate with information much faster (ALIN, 2013; BBC World Service Trust, 2010a, Ospina, 2012; Saravanan, 2011).

In terms of ownership, radios can be put into three categories: private radio stations are advertisement sponsored stations meant for maximizing their numbers of listeners for higher financial returns. Their main aim is to provide entertainment to listeners thus maximizing their financial returns. Public radios are mostly government funded and have a massive coverage. Public radios are obligated to inform and educate mass audiences. Hence, a lot of emphasis is given on social journalism such as awareness programs. Community radios on the other hand are mostly centered on the idea of participatory journalism citizens informing their fellow communities about local issues affecting them on a day to day basis. Community radios are characterized by three basic aspects including local ownership and control, participation of people and non-profit approach. Broadcast is within a radius of 10 to 15 kilometres making the community radio very localized in its approach (Fratzke, 2008). According to Patil (2010), community radios have been very effective in creating grassroots level participation and exchange of ideas among rural communities. Community radio is designed for the community and operated by the community to address their concerns. Thus it facilitates incorporation of people's participation in the development process. Its ownership and participatory methodology (Patil, 2010; Perkins, 2012; Balan *et al*., 2012) initiates community dialogue necessary for representing needs of the marginalized communities. Radio reporters belong to the local communities, speak in the local dialects and are well aware of the social issues of their areas. Besides being community members, community radio reporters also play multiple roles as information providers (Sharma, 2011), investigators, information intermediaries, local campaigners and mass communicators. Community radio overcomes the barriers (affordability, illiteracy, accessibility, simplicity, local relevance) which often limit the use of other mass media tools including newspapers, television and internet for information and knowledge dissemination in rural areas. The community radio broadcasts regional entertainment and engages the communities in information dissemination and local debates making it an important means of development communication (Bisht & Ahluwalia, 2014).

A study of the impact of community radio in rural India found that community radio has been an effective tool in promoting women's participation (Balan & Norman, 2012) in disaster management and agricultural development(Bisht & Ahluwalia, 2014).Community radio has also been used as a tool to communicate research and advocate on climate change adaptation and promote climate justice under the Climate Airwaves initiative, a pilot project tested in Ghana(Harvey, 2011).It was found that technical concepts like greenhouse effect, adaptation and vulnerability among others which have no local language equivalent in Ghana were explained through different analogies developed by the community members themselves then communicated to the community using community radios. Research findings by Buckley (2009) suggests that countries like El Salvador, Peru, Indonesia, India and USA have been salvaged from natural catastrophes linked to the important role that community radios played in informing and rebuilding communities. Kirui, (2012) study on "Characterizing access to climate information and services by the vulnerable groups in semi-arid Kenya" revealed that radio was preferred by majority of women (88.5%) while indigenous knowledge was preferred by majority of the elderly (83%). The study showed that the elderly consistently rated radio lower than women for features related to information reliability, detail and language used. The study in conclusion suggests that different channels are necessary to reach out to women and the elderly. Kadi *et al* (2011) in their study on the State of Climate Information Services for Agriculture and Food Security in Kenya observed that RANET network is used in communicating weather and climate information to farming communities. RANET (Radio and Internet) is a rural communications pilot project in Kenya that seeks to transmit vital weather information to rural communities using Radio and Internet (Kadi *et al.*, 2011). RANET uses multimedia such as internet, multimedia digital receivers, rural community FM transmitters, wind up radios and climate information centres to disseminate vital weather and climate information to vulnerable rural communities, to enable them alleviate the effects of extreme weather and climate events (Kadi *et al.*, 2011; Ayub, 2013).

According to JotoAfrika Series on "Adapting to Climate Change in Africa", Ayub (2013) issue revealed that the RANET radio stations in Kenya are managed by local steering committees and facilitated by a team from the Kenya Meteorological Department (KMD). Four stations have been setup and in full operation in Suswa, Kangema, Budalangi and Kwale, two are in development in Isiolo and Baringo, all in Kenya. Information centres have also been established country-wide and are housed by partner institutions like the Kenya Agricultural Research Institute (KARI) (Ayub, 2013). In terms of content dissemination RANET FM stations in the study area broadcasts weather information every hour, disseminating daily forecasts, seasonal updates and explanations weather and climate related terms using simple languages for educational purposes. Early warning information in particular receives the highest priority. Programs are collated using local government officers working in key sectors such as agriculture, health, water, culture and education. Information relevant to local people and national government policies are broadcasted. All broadcasts are done in local languages where stations have been established. According to Ayub (2013) issue results, over 350 wind up radios have been distributed to vulnerable rural communities prone to extreme weather and climate events. These include farmers, pastoralists, fishing communities, subsistence agricultural communities among others communities. These radios according to Ayub (2013) results are given to poor households in the study communities with consideration of gender balance and listening groups of youths. The study concluded that local people perceived RANET as very exciting and educational because weather and climate information are disseminated in their local languages and that locals make calls to these stations and contribute which goes to ensure involvement of and full ownership by the local people because broadcasting is done by their own children. However, the study revealed sustainability of RANET weather forecast services as the main challenge and recommended that other radio stations to replicate this instrumental practice to enable communities make informed decisions.

A key limitation of communication with farmers includes costs, low coverage of ICTs and the need to translate advisories into local languages (Sivakumar *et al.*, 2014). Sivakumar and colleagues found that most farmers are illiterate in the study area and as a result are unable to use SMS-based services. The study concluded that local community radios are one solution to this problem but their coverage is not widespread. According to a case study by Archer (2003) in Mangondi village in the Limpopo Province in South Africa, to characterize gender-specific household access to and use of weather and climate forecasts, the study found that gender is a determinant of farmers' ability to accept forecasts. Using group meetings, interviews and a household survey in the study area, Archer study revealed that one significant factor in the ability to accept forecasts is the channel through which forecast information is disseminated. While men indicated they were flexible enough to listen to a radio broadcast at a regular time, women expressed their preference for the provision of forecasts by agricultural extension officers because they are overburdened with household and farm activities and their time is not flexible enough to allow them to listen to a radio program at a fixed time (Archer, 2003). The study findings revealed that women prefer asking questions directly and interacting to receiving one-way information through radio. Archer (2003) concluded that focusing on radio programs alone will exclude vulnerable user groups from weather forecast information.

2.8.2 Interactive Platforms as a Means to Convey SWFI

In Africa, a study revealed that weather and climate information communicated through face-to-face interaction forums such as workshops, community meetings, and religious forums ensures its usability (Roncoli *et al*., 2008). Farmer participatory and climate workshops, Farmer Field Schools (FFS), local climate information centres facilitate rapid dissemination of information products to the farmers and livestock herders (Roncoli *et al*., 2008). Strengthening of community networks, local institutions and norms and relationships is critical for managing climate risks. Local networks shape the farmers' social interactions leading to better participatory decisions (Meinke *et al*., 2006). In terms of workshop participation and forecast uptake, Patt *et al* (2005) found that in Zimbabwe, the main difference appears to be that farmers who had attended workshops learned they could respond to the forecast by planting earlier or delaying their planting and farmers who did not attend such workshops responded to the poor forecast by continuing to plant the most drought-tolerant crops. Empirical study by Kenyan Climate Change Working Group (KCCWG, 2013) revealed high access of weather and climate variability information via interpersonal communication with up to 32.4 % preference by locals to get climate change information through community centres (Village square) and another 19.9% through workshops.

In the western part of Kenya, Kadi *et al* (2011) study findings revealed that meteorologists have teamed up with traditional weather and climate forecasters and a "Climate Resource Centre" has been started and both partner to issue weather as well as climate information to the local communities. According to Kadi and colleagues' study, KMD buys space each month to publish the monthly forecast as well as seasonal forecast once it has been downscaled. The study pointed out that one media house "Kenya Today" usually publishes the 7-day forecast in their paper. The study findings further indicated the Regional Directors of Meteorology in Kenya hold public gatherings with user communities in each

Region and disseminate weather and climate information and obtain direct feedback from users including farmers (Kadi, *et al*, 2011). Wilke & Morton (2015) found that farmers in the US request for the services of meteorologists who often play an extension role and travel to talk with farmer groups. These groups of farmers have the opportunity to interact and clarify issues relating to weather information. Meteorologists on the other hand learn from farmers and further incorporate their views in the ensuing forecasts. Wilke & Morton (2015) observed that the citizen weather observation program in US was especially viewed as a stakeholder participatory process that builds scientific literacy and engages the public in scientific learning.

2.8.3 Use of Intermediaries to Deliver SWFI

A study by Muchunku *et al* (2014) concluded that opinion leaders in Kenya have managed to demystify the complex issues surrounding adaptation to weather and climate variability by providing adaptive climate change information such as weather forecast information that is simple, applicable to the local context and understandable through the overwhelmingly preferred face-to-face mode of communicating climate science information. However, the study found out that those opinion leaders who were knowledgeable in weather variability issues, sociable, trustworthy and frequent communicators, easily approachable and had communication skills were rated as highly effective communicators of weather variability information (Muchunku *et al*, 2014). Farmers' knowledge sharing mechanisms relevant to local context are the key for effective communication of value-added weather information (Meinke & Stone, 2005). Farmers in rural India have self-organized and usually meet with a journalist in order to explain the weather and climate forecast or to help decode forecast information and facilitate discussion and some villages have organized their own climate fora (Ogallo, 2007). Through use of intermediaries such as frontline extension workers enhances the usability of weather and climate information (Roncoli *et al.*, 2008). Ziervogel & Opere (2010) however, cautioned that extension agents are unable to interpret weather forecasts presented in probabilities and concluded that capacity building is therefore necessary to enable extension agents understand weather reports.

2.8.4 Use of Weather Monitoring Tools in Delivery of SWFI

Another study in Niger on "Rainfall recording: a community decision making tool" as part of the assessment of weather and climate Adaptation Learning Program (ALP) in Dakoro and neighbouring Districts, farmers indicated that the installed rain gauges have contributed to helping communicate weather information immediately to farmers in Dakoro and neighbouring communities (Ababale, 2013). The assessment results showed that when it rains, community monitors record rainfall amounts over a 24 hour period and communicate the data to the Dakoro Meteorological Department using mobile phones. The department immediately analyzes the rainfall data and conveys the information to community radio stations for dissemination. The study findings revealed that information disseminated through community radios reaches almost all communities in Dakoro and neighbouring districts in a format that is understood and acceptable to all members of the community. The two community radio stations estimates more than twenty percent of the total population, are likely to receive information disseminated through community radios in 14 communities in Dakoro (Ababale, 2013).

2.9 Effectiveness of SWFI in Food Crop Production

The first major success in climate forecast application occurred in 1992, when the Brazilian state of Ceara warned farmers of an impending El Nino and supplied them with free drought tolerant seeds, resulting in a dramatic increase in their yields over what they would have otherwise received (Golnaraghi & Kaul,1995). A qualitative assessment in Kanya, asked farmers to judge the link between changes in yields and their use of forecast information. The findings concluded that 94% of farmers reported increased in crop output of greater than 5% to decisions they had made differently as a result of improved access to forecast information. About two-thirds felt that the impact was greater than 15% (Njuki, 2013). Using crops model, it has been shown that simulated yields of peanut using El Nino Southern oscillation (ENSO) based selected variety and sowing dates out-yielded those based on indigenous knowledge selection at Akatsi in the Volta Region of Ghana (Adiku *et al.*, 2007a). Following these simulated results, a field test was carried out on a sample of 26 peanut farmers at Akatsi. ENSO-based weather forecast information was communicated to the farmers in February prior to the season that normally begins in April. The forecast information was accompanied with advice on sowing dates and variety choice to maximize the outcome of the coming season whose outlook was good. The results showed that only 15% of the farmers heeded the forecast advice and obtained significantly higher peanut yields than those who rejected the advice (Adiku *et al*., 2007b). Adiku *et al* (2007a) concluded that whereas the proportion of gainers was low, it is conceivable that with consistent education, farmers could learn to appreciate the value of weather forecasts and use them in their decision making.

In another study by Ababale (2013) on "Rainfall recording: a community decision making tool in Niger" as part of the assessment of weather and climate ALP in Dakoro and neighboring Districts, the findings revealed that community rainfall information has had an immediate impact on decision making on farming. This translated into change in community attitude and practice and is supporting communities to make timely decisions like deciding when to plant. According to Ababale study, the "installation of community rain gauges, training on rainfall data collection and dissemination of the resultant rainfall information in Dakoro therefore constitutes an important step for communities to have increased adaptive capacity through better access to information for livelihood decision making and early warning on potential risks, in an uncertain and changing climate". The study concluded that farmers are able to know the rainfall recorded immediately after downpours and this has given them confidence in the decision to plant or not, thus resulting to a reduction of the rate of seed loss due to multiple replanting. Rain gauge information has also enabled decision making on other farming operations such as weeding time, when to apply pesticides and search for pasture by pastoralists (Ababale, 2013). Mwesigwa & Omukuti (2013) assessment of the perception of community members in Kisumu in Kenya, farmers mentioned enhanced food crop production with yield increment of 3 or more times per unit area due to appropriate and timely use of the weather information including other agro-advisories to inform better farming systems as benefits of receiving the forecast in previous seasons. This according to Mwesigwa & Omukuti study had translated into improved food and nutrition security, improved land planning and management, awareness and proper planning, better decision-making and choice of agricultural technologies. The study further revealed that aside food crop production decisions, farmers in Oloitoktok in Kenya made informed decision on grazing schedules and herd movement, improved utilization of water and pasture resources, reseeding of highly degraded pasture reserves, breed improvement through cross breeding and regular culling, diversification of livelihoods through small scale irrigation projects, apiculture, craft-making and pasture seed harvesting (Mwesigwa & Omukuti, 2013).

Another study by Mushore (2013) on "Uptake of Seasonal Rainfall Forecasts In Zimbabwe", using observed rainfall data and seasonal rainfall forecasts from the Meteorological Services Department and employed 3 by 3 contingency tables in the analysis made some revelations especially when compared with data from the Southern African Climate Outlook Forum (SARCOF). The study observed that national seasonal forecasts are finer and more accurate than regional (e.g SARCOF) ones. The study noted limited uptake of the forecast by farmers. Mushore study and other similar studies (Patt, 2001) observed that limited uptake of forecast by farmers in Zimbabwe was attributed to limited access and knowledge of science rather than to the accuracy of the forecasts. The study therefore, recommended that weather and climate expert should reach out to farmers and partners directly (e.g Agricultural Extension Officers) and build their capacity in the area of trainings, since many of them have not received training in meteorology and its applications. Mushore (2013) study revealed persistent dry spell in Zimbabwe and added that research is needed in the area of forecasting extremes such as dry spells ahead of a season as well as the incorporation of other accuracy indicators such as the Indian Ocean Dipole (IOD). The study further concluded that the binary system which indicates whether there will be drought or not should be incorporated into the national forecasting system replacing the current one which uses probabilities and three categories of possible outcomes (Below Normal, Normal and Above Normal) (Mushore, 2013).

Willard (2011) study in Kenya "On Access and Utilization of Agro-meteorological Information by Smallholder Farmers in Perkerra and Lari-Wendani Irrigation Schemes" revealed that majority (76.1%) of farmers perceived the spatial coverage of meteorological forecasts they receive to cover a wide area including Rift Valley Province or Nakuru district making it difficult for them to relate the reports to their particular areas and therefore not able to use the information effectively in food crop production. Another study by Abayomi (2015) on "Access to Risk Mitigating Weather Forecasts and Changes in Farming Operations in East (Ethiopia, Kenya, Tanzania, and Uganda) and West Africa

(Burkina Faso, Ghana, Mali, Nigeria and Senegal): Evidence from a Baseline Survey" showed that 62.7% and 48.4% of the farmers from East Africa respectively received information on outbreaks of pests/diseases and start of rainfall as against 29.2% and 56.4% for West Africa. Abayomi study findings and similar findings (Roudier, *et al*, 2014) using participatory research in two communities in Senegal, Shah *et al* (2012) study on "Options for Improving the Communication of Seasonal Rainfall Forecasts to Smallholder Farmers Kenya" all suggest that there have been several initiatives in many African countries to transmit weather forecasts to smallholder farmers. For instance, the KMD is constitutionally mandated with the responsibilities of providing daily, weekly, monthly and seasonal weather forecasts for households in urban and rural areas.

The study findings (Abayomi, 2015) and Shah *et al* (2012) revealed that despite the above constitutional mandate, the attitude of farmers in the study communities to weather forecasts is directly related to accuracy and reliability. The results further show access to weather forecasts among the farmers is based on gender. In Ethiopia, Kenya, Tanzania, and Uganda 23.5% and 27.6% of the respondents indicated that both sexes had access to weather forecasts on outbreak of pests/diseases and start of rainfall, respectively. Abayomi findings however, noted that male farmers had slightly higher access to weather forecasts than their female counterparts in these countries. On the other hand, in Burkina Faso, Ghana, Mali, Nigeria and Senegal the study also noted that women had very low access to weather forecasts on outbreak of pests/diseases and start of rainfall with 1.3% and 1.0%, respectively, as against 16.7% and 32.3% for men. The study revealed that

Disparity in access to weather forecasts can be directly linked to the medium of forecast transmission (Abayomi, 2015). In a similar study by African Climate Change Resilience Alliance (ACCRA), it was found that women generally were in favor of weather forecast transmission through church, local community groups and markets, while the men preferred radio stations, newspapers and local council meetings. Deressa *et al* (2009) observed that low attainment of formal education often constitutes a major challenge for adoption of innovations and utilization of emerging agricultural development opportunities among African smallholder farmers. The study further observed that household heads' educational status increased considerably the probabilities of engaging in soil conservation and changing planting dates due to weather variability. Roudier *et al* (2014) found that among smallholder farmers from Senegal's two agro-ecological zones, access to weather forecasts encouraged about 75.0% of the farmers to significantly change their farming practices. A study that shows statistical analysis of farmers' responses on research findings in Zimbabwe revealed that the coefficient for the use-forecast variable was positive and significantly different from zero suggesting that farmers who used the forecast had higher harvests relative to their historical amounts, compared with farmers who did not use the forecast (Patt *et al*, 2005).

2.10 Conclusion

From the review of literature above, effective and sustainable SWFI is caused by several factors which can broadly be classified as intrinsic/fundamental, contextual which together largely inform packaging and delivery strategies. Most of these studies reviewed focus on desk study and largely theoretical and the various authors seem not to have focused explicitly on qualitative study. Therefore, in this study, the above factors have been assessed through engagement with farmers to investigate from their perspectives the most appropriate ways of ensuring sustainable SWFI services delivery in the study area. The outcome of the study will fill in the gap in the existing literature on the topic under study ‘Scientific Weather Forecast Information Communication: Perspectives of Rural Food Crop Farmers in the Lawra District”. This leads the discussion on methods and techniques that will be employed to gather data for analysis in the next chapter.

CHAPTER 3

PROFILE OF THE STUDY AREA AND RESEARCH METHODOLOGY

3.1 Introduction

Chapter three covers a description of the research site and methodology. It explains the research philosophical underpinnings, research design, data sources, techniques and data collection tools as well as data analysis.

3.2 The Study Area

3.2.1 Location and Size

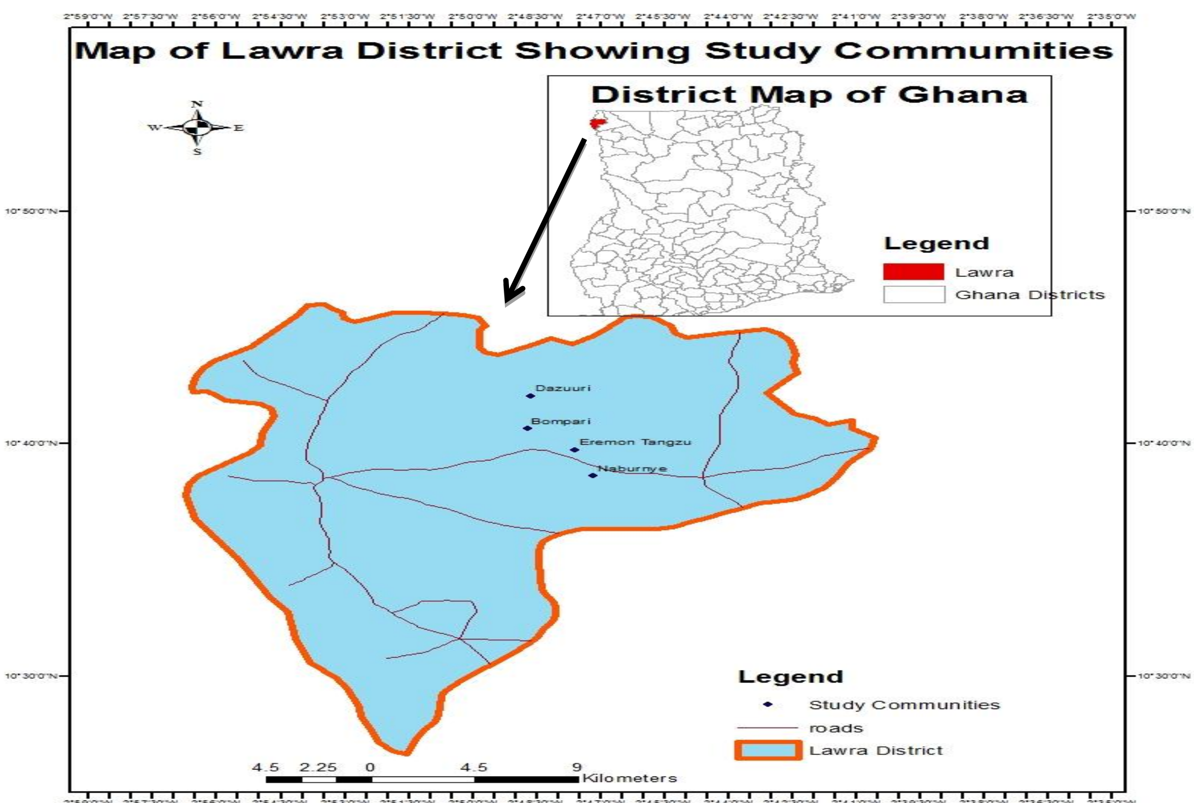

Figure 3.1: Map of Lawra District Showing the Study Communities

Source: Lawra District Assemble (2016)

The Lawra District is located in the North-Western corner of the Upper West Region in Ghana. The District lies between Longitude 10°30 N and 2^0 25 W and Latitudes 2°35 W. It is bounded to the North by Nandom District, to the East and South by Jirapa District and to the West by the Republic of Burkina Faso. The District has a total land area of about 1051.2 square km representing about 5.7% of the region's total land area of about 18,476 square km (Ghana Statistical Service [GSS], 2012). Out of about 153 communities which make up the District, close to 90% of the inhabitants dwell in the rural areas. The population density stands around 83 per square km and it is considered as the most densely populated District in the region (Lawra District Medium Term Development Plan [LDMTDP], 2010-2013). As depicted in Figure 3.1, the study communities are Dazuure, Bompari, Eremong-Tangzu and Nabrunye. These communities are along the same landscape in the Lawra District.

3.2.2 Topography and Drainage

Generally, the District's landscape is flat and undulating in some areas with few isolated hills ranging between 180 and 300m above sea level. The Black Volta River which has its source from southern Burkina Faso divides the district from the Republic of Burkina Faso to the west of the District. The Black Volta River serves as a source of agricultural livelihood to the people in Lawra District.

3.2.3 Ecological Environment and Climate

The ecological belt of the Lawra District lies within the Guinea Savannah agro-ecological woodland zone of Ghana. It is characterized by short guinea grasses and commonly scattered woody plants, drought and fire resistant trees like baobab, dawadawa, acacia and shea trees. However, the natural environment of the District has constantly experienced degradation over the years to the effect that the life support systems have dwindled affecting its functions due to global climate change. The climate of the Lawra District is tropical continental type with two seasons in a year: rainy or wet season and dry season during which most trees wither and shed leaves. The mean annual temperature ranges between 27°C to 36°C with a long term annual precipitation of 900mm and rarely hits 1,200 mm. The period between February and April is the hottest (LDCB, 2013). The rainfall pattern is mono-modal with an estimated 5-6 months spanning from May to October. Between April and October, the tropical maritime air mass blows over the area which gives the only wet season in the year (LDCB, 2013). This results in the District having one farming season. Climatic changes of late, however affects the weather pattern which subsequently affects food security in the Lawra District. The hazy and sometimes dusty harmattan (dry north-eastern trade winds) winds normally accompanies the dry season from November to April during which period visibility generally reduces.

3.2.4 Socio-Demographic Characteristics

ccording to the GSS report (2012) of the 2010 National population and Housing Census, Lawra District has a population of 100,929. This is about 14.4% of the total population of the region. Out of this population, 48,641 are males while 52,288are females representing 48.2% and 51.8% respectively. Based on the statistics from the 2010 population and housing census, over 80% of the district constitutes rural (GSS, 2012).

3.2.5 Agriculture

Agriculture accounts for 80% of the District economy. It is estimated that 83% of the population are engaged in subsistence agriculture (LDMTDP, 2010-2013). The soils are mostly shallow and sandy. The farming systems in the District are categorized into two. They are compound and bush farming systems. The Crops suitable and cultivated include rice, maize, millet, sorghum, cowpea, groundnuts, Bambara beans, white beans, soya bean and tuber crops. Three cropping patterns are recognized and practiced; namely intercropping, relay cropping and mono-cropping (LDMTDP, 2010-2013).The key challenges to agriculture in the District are persistent drought, dry spells and flood. Food production is relatively low due to these unfavorable weather conditions, thus affecting food security in the Lawra District (LDCB, 2013). The recurrent agricultural droughts and floods are among the reasons why Lawra district has higher levels of poverty and famine (Ndamani & Wantanabe, 2013).

3.3 Philosophical Underpinnings of the Research

Prasad (2005 p.13) affirmed that the "interpretative tradition" emerged from a scholarly position that takes "human interpretation as the starting point for developing knowledge about the social world". Another common characteristic feature Prasad (2005) assigned to the interpretive tradition is the emphasis on the social dimensions of reality construction. The qualitative research case study for this thesis is grounded in the interpretive theoretical perspective, which guides and supports the data collection and analysis. Jones *et al* (2006) argued that having a theoretical perspective in qualitative case study research, "adds philosophical richness and depth to a case study and provides direction for the design of the case study research project" (p. 54). In the present research, the epistemological position is formulated as follows: Data are contained within the perspectives of rural farmers that have some form of experience with scientific weather forecast information in the past or are currently using in tactical decision making. As a result, research participants are engaged in collecting the data.

3.4 Research Methodology

A qualitative approach was adopted for this research. This is because of the new field of study as well as its exploratory nature required a more flexible and open research design rather than one that is highly structured and rigid. This research approach involved the utilization of qualitative research methods in addressing the research questions. The methodology involved examination of the perspectives of rural farmers who had used, currently using or had some form of exposure or experience with weather forecast information in food crop production in the Lawra District. Qualitative methodology was chosen and considered appropriate for this study because, as Rossman & Rallis (1998) have noted, "there are few truths that constitute universal knowledge; rather, there are multiple perspectives about the world" (p. 29). By exploring the perceptions of rural farmers who have had experiences with weather forecast information, it is possible to obtain multiple perspectives that can shape understandings and use of weather forecast information. Each rural farmer assigns certain characteristics and attributes to the phenomenon under investigation. This research is therefore, designed to gain in-depth understanding of these variations in the interpretation of weather forecast communication and uptake in food crop production. Merriam (1998 p.1) noted that qualitative research offers "the greatest promise of making significant contributions to the knowledge base" and because it is focused on discovery, insight and understanding from the perspectives of those being studied. The research question for this study centred on the perspectives and definitions of rural farmers who had experiences with weather forecast information; consequently, qualitative method is the most appropriate for this research. The research design employed for the study was exploratory case study design. This is because the study principally focused on homogenous group of farmers who have been exposed to SWFI for uptake in food crop production and therefore have some level of knowledge and experiences in the subject matter.

Also, the communities were selected for the study due to the incidence of persistent dry spell, drought and floods experienced. According to Crowe *et al*

(2011), a case study is a research approach that is used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context. The central tenet is the need to explore an event or phenomenon in-depth and in its natural context. The research sought to explore a contemporary issue on communicating weather forecast information to rural farmers and its effect on food crop production. Again the research will be conducted at the community level or in the natural setting. According to Yin (2009) a case study design should be considered when the focus of the study is to answer "how", "what" and "why" questions. According to Yin, "how", "what" and "why" questions are better answered through case studies. Thus, this design fits into this current research because the research questions are formulated using "how" and "what".

3.5 Sampling Technique

A purposive sampling technique was adopted to select respondents because of the in-depth exploratory nature of the study. A convenience sample of 60 respondents was employed for the study. Each respondent represented a household from 4 different communities. Respondents and discussants' selection was purposive in that it was based on the numbers of years rural farmers engaged in farming (>30years) and familiar with weather variability in the study locality, farmers' knowledge and experiences on the use of SWFI in food crop production. Majority of women farmers who were recruited as respondents were married/migrated to these communities for more than 30years and also have some form of experience with SWFI in food crop production. Respondents were profiled and selected based on the level of exposure, knowledge and experiences on the subject matter. This was done with assistance from the Ministry of Food and Agriculture (MoFA) extension officer (AEA) who is familiar with the research site and the characteristic feature of the farmers involved. The AEA identified a pool of rural farmers who are knowledgeable and willing to provide useful information on the issue under investigation, thus a purposive sampling approach was employed for the study. Arthur & Nazroo (2003) supports this position as they indicated, sample units are chosen because they have particular features or characteristics which enable detail exploration and understanding of the central themes and puzzles which the researcher wishes to study. They may be socio-demographic characteristics or may relate to specific experiences, behaviours and roles.

3.6 Sources of Data

The data were collected from multiple sources both from the field and review of grey literature such as reports and other relevant documents including published peer reviewed articles. Data were obtained from primary sources (farmers) which formed the greater part of the data collected. This is because the focus of the study was to learn from the farmers themselves on weather information uptake in food crop production rather than what has been reported and published. The perspectives of study participants, on weather forecast information uptake in food crop production constituted primary data. Other primary data gathered were from sources such as observations of participants at the field level in terms of how they interpreted and used weather information received, photography of objects and events that directly relate to the study. This approach in data collection helped in deriving meanings. Secondary data on the other hand constituted very little in the study. Secondary data formed part of the study because the data provided support in clarifying some of the issues in the primary data and supported arguments in the study findings. Secondary data were collected from reports of organizations directly involved in disseminating weather information to farmers such as Esoko (private company involved in disseminating weather information to farmers in the Upper West Region) in close collaboration with CCAFS project. These organizations are assisting farmers with weather information in the study communities for anticipatory adaptation purposes. Others include research articles related to the study, audio-visual materials such as cell phone messages, and data on weather monitoring from individual farmers who monitor and record the weather. Key informants interacted with were the regional director of the Ghana Meteorological Agency and Lawra District director of MoFA, the zonal manager of the senders of the SWFI for validation purposes of some aspect of the information provided by the respondents.

3.7 Methods of Data Collection

Prior to the data collection stage, the researcher embarked on community entry and familiarization visits from 2nd to 3rd December, 2015 to the four study communities. These visits paved the way for a successful data collection in that it offered the researcher the opportunity to be well-informed about the people in terms of community protocols and intercommunity relationships since the four study communities are within the same landscape. The process also helped the researcher to identify himself and developed rapport with the people, identified key respondents, volunteers who acted as contact persons in the four communities and translators in some cases; even though the researcher and research assistants are all native speakers, there was some dialectical difference and also because researchers were coming from different Districts in the Upper West Region to conduct the study in the Lawra District. The visits also helped the researcher to discussion with potential respondents agreed on interview schedule dates and locations that are convenient to the respondents since much of it involved one-on-one interviews and respondents may be interested in protecting their private information. In terms of scheduled dates and time, market dates as well as early mornings were mostly preferred by the respondents so that they will be able to catch up with the market activities. These dates and times were preferred because the period of data collection coincided with house construction and rehabilitation works as well as dry season gardening in some of the communities visited. The entire data collection exercise spanned from 10th December, 2015 to 28th February, 2016 and involved a total of 60 respondents.

3.7.1 Data Collection Tools and Techniques

3.7.1.1 In-Depth Interview

The primary source of the data was obtained from the perspectives of rural farmers and involved the use of open-ended questions developed based on the predetermined themes. In soliciting responses from the respondents, technique such as in-depth interview (IDI) was employed with the respondents on SWFI uptake in food crop production. The tool used was an in-depth interview guide. The IDI involved twenty-eight (28) respondents with seven (7) respondents selected from each study community and specifically represented a household. The IDI was conducted first and involved in-depth interaction with the respondents. IDIs offered the researcher the opportunity who probed and delved into the issue under study and helped revealed emerging issues in the course of the interactive sessions with study respondents. This technique was considered suitable for the study because as Brikci & Green (2007) indicated the technique sought to explore in detail respondents' own perspectives and accounts of the issue at stake. Arthur & Nazroo (2003) noted that in-depth interviews creates an atmosphere for in-depth probing and questioning that is responsive to respondents and their individual experiences and contexts.

3.7.1.2 Focus Group Discussion

Following the IDI results, a FGD exercise was necessitated and engaged a total of 32 discussants with eight (8) discussants per study community. Two (2) FGDs were conducted per study community (1 male and 1female). The tool employed was a FGD guide. The essence was to validate the some pertinent issues which surfaced in the course of the data collection. The sex segregation approach offered participants the chance to express themselves freely without fear or panic. In the study area, it is culturally inappropriate to conduct the FGD exercise using mixed groups. This is because women in particular find it challenging to express themselves to the fullest in such conditions. The data gathered from different social groupings helped the researcher understand the findings better and contrast from multiple perspectives and thus enriched the findings. IDI and FGD notes were taken, audiotaped and transcribed verbatim for analysis.

3.7.1.3 Participant Observation

Participant observations on the field were also useful and enriched responses from the IDIs and FGD. The tool employed under this technique was an observation guide. The observation of rural farmers' use of SWFI started in the 2015 farming season and researcher participated in the farm operations and took advantage to observed pre-season, season and post-season farming activities. In participant observation, the researcher observed SWFI farmers have received and through interactive discussion the researcher got to know how farmers decoded the received information and how they intend to apply such information in food crop production processes.

3.7.1.4 Audio-Visual Materials

Examination of audio-visual materials complimented farmers' responses and enriched the study findings. These include cell phone messages and voice message. Others include photography. See some photographs attached as appendix (field photos).

3.8 Pre-testing of Data Collection Tools

The data collection instruments which are the in-depth interview guide and FGD guide were pre-tested before the actual data collection was done. According to Sarantakos (2005) pre-testing of data collection instruments constitute one of the fundamental principles of social research and therefore the researcher found it very necessary to pre-test the instruments. The pre-testing of the instruments was carried out on the 25th November, 2015. The pre-test exercise was conducted in Dazuuri, one of the research communities involving purposively selected rural farmers who have rich experience in weather variability and scientific weather information use in food crop production. One of the research communities was selected for the pre-test because the study focused on specific group of farmers who benefited from the use of SWFI which could not be found in other communities. Two (2) in-depth interviews were conducted involving male and female farmers separately with each interview lasting for an average of 75 minutes. Both interviews were audiotaped, transcribed and analysed based on the predetermined and emerged sub-themes. The effectiveness of the interview questions and prompts were evaluated and ascertained with few errors detected and corrected. Hence, the tools demonstrated consistency and have produced similar results in the full scale data gathering phase.

3.9 Strategies for Validating Findings

According to Merriam (1998) the qualitative investigator's equivalent concept, that is credibility, deals with the question, "how congruent are the findings with reality?". In this thesis, the following procedures were followed to ensure confidence in the data and that the researcher has accurately recorded the phenomena**:** Data triangulation was one of the major strategies used in gathering the data. The researcher employed multiple data sources which helped understand perspectives of rural farmers on weather forecast communication and the resultant effect on food crop production. According to Creswell (2009) triangulation involves the use of different methods, especially observation, focus groups discussions and individual interviews, which form the major primary data collection strategies for qualitative research. Whilst focus groups and individual interviews suffer from some common methodological shortcomings since both are interviews of a kind, their distinct characteristics also result in individual strengths. According to Lincoln & Guba (1985), the use of different methods in tandem compensates for their individual limitations and exploits their respective strengths. Participant checking played significant role and ensured credibility of the thesis findings. Lincoln & Guba (1985) argued that ensuring credibility is one of most significant factors in establishing trustworthiness. They considered the single most important provision that can be made to strengthen research credibility. Checks relating to the accuracy of the data took place “on the spot” in the course, and at the end, of the data collection dialogues. Lincoln & Guba (1985) posit that trustworthiness of a research study is important to evaluating its worth. Trustworthiness involves establishing credibility which involves confidence in the 'truth' of the findings.

Transferability on the other hand involves showing that the findings have applicability in other contexts. Others include dependability which shows that the findings are consistent and could be repeated. Conformability; the degree of neutrality or the extent to which the findings of a study are shaped by the respondents and not researcher bias, motivation, or interest. Researcher engaged participants and they verified the data collected as true reflection of their own and agreed that their words matched what they actually intended, this is because the interviews were audiotaped and transcribed verbatim. Also, feedback and discussion of the researcher's interpretations and conclusions with the actual participants and other members of the participant community for verification purposes and insight was encouraged and was very useful in the outcome of the thesis.

Another important strategy employed by the researcher was frequent debriefing sessions. The researcher held frequent debriefing sessions with research assistants and supervisors on findings. Shenton (2004) indicated that the vision of the researcher may be widened as others bring to bear their experiences and perceptions on the findings. According to Shenton such collaborative sessions can be used by the researcher to discuss alternative approaches and others who are responsible for the work in a more supervisory capacity may draw attention to flaws in the proposed course of action.

To further ensure trustworthiness of the data, the researcher made use of peer reviewers who added their thinking on the data. Examination of the research findings by peers and academics was necessary as feedback offered enabled the researcher refined methods and developed a greater explanation of the research findings and strengthen arguments in the light of the comments and suggestions made. Again, Shenton (2004) posits that, Peers may challenge assumptions made by the researcher, whose closeness to the research frequently inhibits the ability to view it with real detachment. For quality assurance purpose the researcher recruited two external auditors who are both qualitative research experts and who went through the findings and made invaluable contributions to the thesis.

3.10 Data Analysis

The data gathered from the respondents and direct observations were reviewed and evaluated after every day sessions for the purposes of noting the issues that emerged and to assist the researcher build on those issues in the next interactions with respondents to ensure consistency, simplification and harmonization of emerging issues. The data analysis process started with the preparation and organization of all relevant data gathered from the field. All recorded interviews were transcribed from the local language into English, writing and typing up field notes, sorting and arranging the data into different types based on the sources of the information (i.e. FDG, IDI, observations, secondary information etc). The organized data were then examined by reading through thoroughly to have a general sense of the information and overall meaning of the information. Through the deep reflection, it was gathered the kind of ideas participants are putting across and the general thoughts of the information. Following this, detailed analysis was done starting with coding process. According to Rossman & Rallis (1998), coding is the process of organizing the material into chunks or segments of text before bringing meaning to information. In other words it involves taking text data or pictures gathered during data collection, segmenting sentences or paragraphs or images into categories and labelling those categories with a term. Aside the emerged themes, predetermined themes were also crafted based on the key objectives of the issue under study. Responses were then categorized under these themes and a description was then carried out which focused on detailed rendering of information about the respondents, research settings and events. A final step conducted was interpretation of the data which involved the researcher determining the meaning of the information gathered.

The data analysis and presentation detailed descriptive account of events, discussions, patterns or relationship building, exclusions, unanticipated classes of data and interpretive analysis of the responses and issues raised by the respondents during interviews and discussions. The analysis was also conducted and presented in words of the participants by paraphrasing some of the responses of the respondents and discussants. Direct quotations of perspectives of participants were also made in the analysis and presentation of the data collected and the quotations embodied the voices of all identified and interviewed from the ground. Four research assistants who are knowledgeable in this research issue assisted in the data analysis and presentations. This strategy was very significant as it allowed for multiple perspectives on the data. The data analysis plan adopted for the study is shown in the figure below:

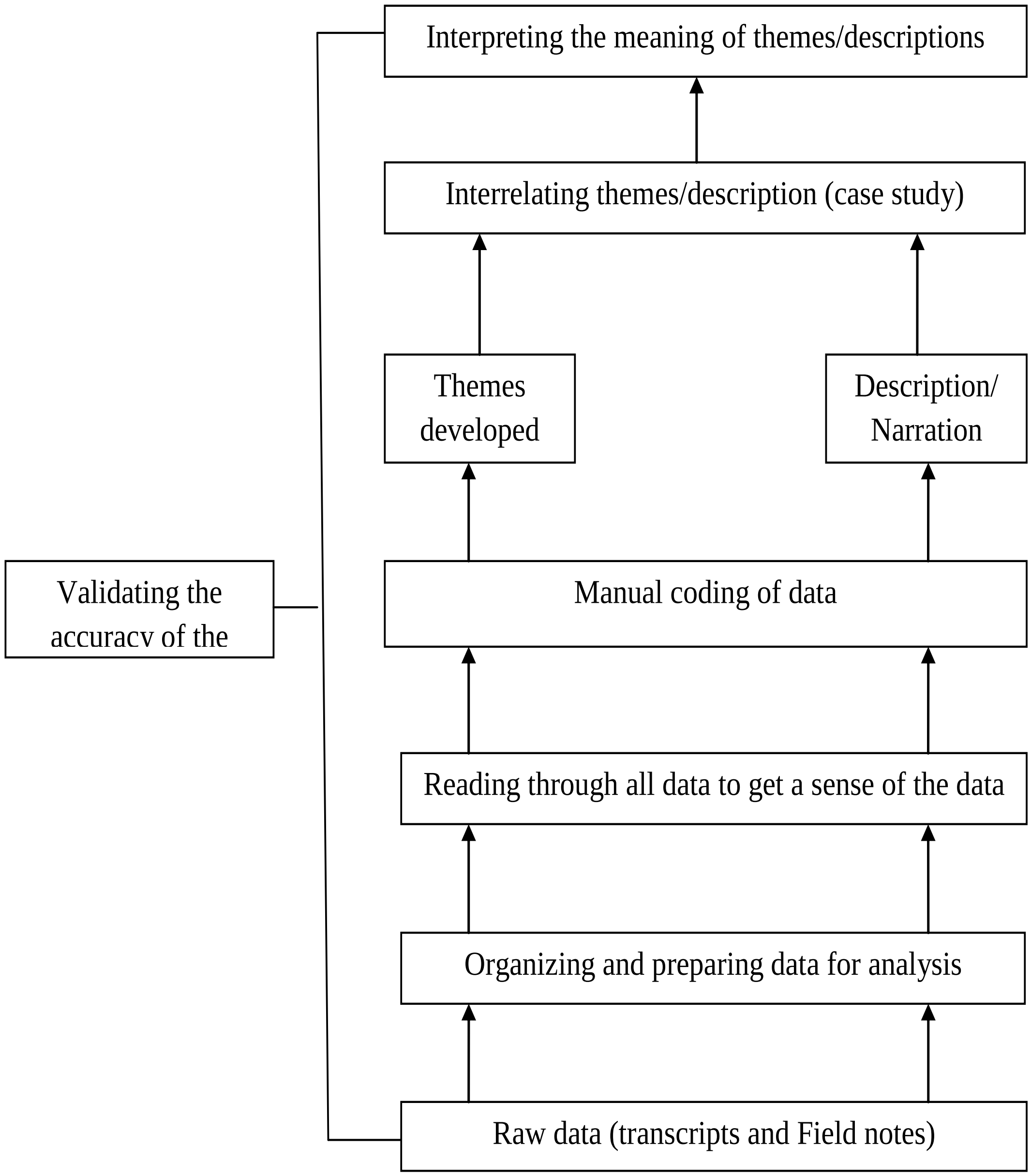

Figure 3.2: Data analysis plan

Source: adapted from Cresswell (2009)

3.11 Ethical Considerations

In qualitative research, observations invade the life of research participants and sensitive information is frequently revealed (Creswell, 2009). This was of great concern for the study. The researcher employed precautionary measures which protected the rights and dignity of research participants. The research objectives were explained verbally to the research participants and were clearly understood. All data gathering devices and strategies put in place were explained and demonstrated to Participants. In most cases audio recorded data were played back to respondents for them to appreciate their contribution to the study findings. Verbatim transcriptions, written interpretations and reports were discussed and made available to the participants and not shared with people not directly involved in the research both within and outside the study communities.

In the data reporting phase, the participant's rights, interest and wishes were considered. The names of respondents were also dissociated from responses during the coding and recording process using pseudonyms for individuals to protect identities. A description of how data will be used was also explained. The researcher made conscious efforts during the writing and disseminating stage of research findings and ensured words that are bias against respondents due to gender, sexual orientation, ethnic group or age were not used. Respondents were made to understand that they may decide to stop participating at any point of the research.

3.12 Conclusion

A research must be carefully planned and effectively executed in order to address the objectives set out for the study. This chapter has spelt out the research site and subjects, sampling approach and how it was carried out, as well as how the data was collected and analyzed. The next phase of the study discusses the data analyzed and the processes involved.

CHAPTER 4

DATA ANALYSIS AND PRESENTATION

4.1 Introduction

In this chapter, results of the study are presented in the form of perspectives of rural farmers on scientific weather information uptake in food crop production. The chapter starts with demographic characteristics of the respondents and followed with a narration and analysis of the issues based on the predetermined and emerged themes.

4.2 Demographic Characteristics of Respondents

In this section, the socio-demographic characteristics of respondents derived from the semi-structured questions are presented. It consists of their sex, age, marital status and educational background. Out of the 60 respondents who participated in the study, female participants constituted 31% while their male counterparts made up the majority with 69% across the four study communities with 80% married. The rest were either single or widowed/divorced. The few women representation was because they (select women respondents) reported that their husbands were not available at the time the study was been conducted for them to appropriately seek consent in order to participate as this forms part of cultural obligation in the study area. With regards to age of respondents, the results revealed that 8% of respondents are within the age group of 30-45years, 46-60years constituted 33% while majority of the respondents fell in the age group of 61-75years representing 53% of the entire respondents. Only 6% of the respondents were 76years and above. The age segmentation helped in enriching the findings as different perspectives on scientific weather forecast information delivery processes was sough and brought to bear on the study outcome. On the other hand, 6% received non-formal education, only 3% of the respondents completed basic school while 2% completed tertiary education. Further, 89% of the respondents who constituted the majority have no formal education in the study area. This attribute of the respondents helped in an understanding of the context of the rural farmer and how intervention could be packaged to better affect adaptive capacity of the farmers.

4.3 Perspectives of Rural Farmers on Scientific Weather Forecast Information Services Delivery Processes:

4.3.1 Objective 1: Farmers' knowledge on scientific weather forecast information services delivery.

Generally, results from the study show that weather forecast information delivery services are not new to the people in the Lawra District and the study area in particular. Both male and female respondents during IDI and FGD reported being exposed to the application of scientific weather information services as a measure in curbing the impact of weather variability on food crop production. A general response during both male and female FGD's on weather prediction situation in recent times was that, predicting the weather in the past was easy and largely due to the presence of the indigenous weather forecasting indicators as opposed to recent times. An elder stated at Male FGD at Dazuuri:

"Look my son, the variability of this our weather in recent times is extensive and have resulted in the disappearance of most of the traditional predicting indicators and made it difficult to forecast the weather but we thank God the 'Whiteman' brought into our community his own way of predicting the weather even though it's not 100%". (Male FGD at Dazuuri, Lawra District February, 2016).

The above finding is an indication of the level of farmers' awareness of the weather variability situation and appreciation of the scientific weather information services provided to them even though the prediction is not hundred per cent as indicated during the male FGD. When asked about sources of weather information both male and female FGDs revealed that farmers' receive weather information from six (6) different sources; the Ghana Meteorological Agency (GMA), Agricultural Extension Agents (AEAs), Savannah Agricultural Research Institute (SARI), Community-Based Weather Monitors, Climate Change Agriculture and Food Security (CCAFS project) and private Companies such as esoko. In both male and female FGD, there were heated debates as to which of the sources of the aforementioned weather information is more or less reliable. The general consensus was that the GMA weather information services in the locality have largely been ineffective in terms of accuracy and reliability and was rated the least important and less preferred during FGDs. This findings explains why most farmers are skeptical about whether forecast information use in the study area. An elder remarked at Eremong-Tangzu during FGD:

"Let me tell you, as for the GMA people forget about them, for the past 3 years now they have not been consistent with the delivery of weather information to farmers in the Lawra District including our community and I believe those people don't even exist and we the farmers do not hear of them anymore" (Male FGD Eremong-tangzu February, 2016).

The above finding suggests that farmers have lost confidence in the services of the GMA. These issues recounted by the smallholder rural farmers could be attributed to the facts that because the Ghana Meteorological Agency is currently managed by the government and also not for profit making organization and there is little or no serious investment in the industry. Key informant at GMA office in Wa-Upper West remarked in an IDI:

"I agree with the farmers about the ineffectiveness of our operations, we at GMA are aware that we are not living up to expectations especially for our farmers and we can only function well if the government and other development partners come to our aid with logistical support with state of the art weather monitoring devices. Look other African countries such as Kenya and others are well resourced and backed by law making their work better than Ghana" (KII Wa Municipal February, 2016).

The finding confirms those of the FGD and IDI that GMA as an organization is experiencing some key logistical challenges in order to function well. In the case of esoko, both male and female FGD ranked esoko as a good weather information services provider. A youth respondent during male FGD at Nabrunye has this to say about the services of esoko in his community:

"esoko has been consistent with the delivery of weather information to farmers through mobile phones in the past 4 years with prompt delivery process which for me is in the right direction and because of that many farmers in my community have purchased mobile phone just to also receive weather updates from esoko"(Male FGD at Nabrunye, February, 2016).

The level of somewhat consistency as evidenced in the above finding means that farmers are beginning to develop confidence in weather information delivery services because of the timely delivery and somewhat accurate and reliable of the weather information from providers of weather information i.e esoko. It further suggests that this will have a positive effect on adoption rate and subsequently lead to sustainable food crop production. A key informant at esoko during an IDI in the field has this to say about the Company operations:

"esoko is a weather information services provision Company operating in Ghana including the Upper West Region and more specifically in the Lawra District. esoko is a profit making organization with state of the arts equipment and had been in partnership with the Climate Change Agriculture and Food Security project for the past four to five years in the study area. The partnership has made it possible to support rural farmers in the study area with weather information as one of the service providers and have remained loyal in the

provision weather information to the farmers”. (KII Wa Municipal February, 2016).

The finding above goes to buttress farmers’ revelation on the somewhat effective weather information services provided by esoko in the beneficiary communities in the Lawra District when compared with other sources. This finding also suggests that the installation of state of the arts equipment have contributed to improving the weather information services in the study area. When asked about the kind of weather information community members usually receive, it was revealed during IDIs and validated in both male and female FGDs in all the four study communities; Dazuuri, Nabrunye, Erimong-Tangzu and bompari that farmers receive weather information on updates on expected rainfall dates and volume, temperature conditions, cloud cover and nature of wind. In the male FGD at Erimong-Tangzu, it was mentioned that the information farmers receive especially from esoko is normally expressed in probabilities and conveyed to rural farmers using SMS alert and sometimes voice messages in the local language. A female discussant during female FGD remarked on the nature of the weather information shared by GMA and esoko:

“*The weather information shared with we the farmers is always generic in terms of content and to a large extent has no value for us as farmers but if am to compare the information from esoko is better, so I think that if the weather people can concentrate their information on staple crops it will be good instead just telling us to it will rain or not, have you now see why I said the people can do* *better to help us?".* (Female FGD at Erimong-Tangzu, Lawra District January, 2016).

These findings suggest that the weather information products are not specific enough and are largely generic in nature and that farmers are unable to maximize the benefits of the information in food crop production. These issues could be due to the lack of active involvement of farmers in the weather information delivery processes and this is affecting adoption of the adaptation strategy in the study area and making most farmers skeptical about the anticipatory adaptation strategy. This finding contradicts Mwesigwa & Omukuti (2013) study in Kenya, observed that dissemination of scientific weather information occurs at the community level in a participatory manner involving farmers thus improved adoption of the services. The involvement of farmer groups or their leadership in matters of adaptation planning facilitates a two-way communication and for both parties (i.e farmers and senders of weather information) to appreciate the processes. A male youth during IDI at Bompari remarked:

"The scientific weather information products generated by esoko in particular even though the information is generic, but the information is community specific". District (Male IDI Bompari, Lawra District January, 2016).

This finding was validated during examination of the SMS alerts sent to farmers and observed that the forecasts were indeed meant for specific locations. This finding further explains why some respondents reported somewhat increased in accuracy of the forecast in the study area. It implies that localization of the scientific weather forecast information could potentially improve trust of the end users and facilitate uptake. This revelation further suggests that ensuring specific and tailor generated information could also potentially increase the appetite of these farmers to adopt and adapt agricultural innovations. During an IDI, a female respondent at Bompari has this to say on the cost aspect of the esoko weather forecast information:

"I pay between 10 to 15 Ghana pesewas as services fee per weather information I receive from esoko on my mobile phone, and for me I think it is not bad provided I get quality services to plan my farm work" (Female IDI at Bompari, Lawra District January, 2016).

This finding is an indication of farmers' willingness to pay and protect their farm investments from the impact of weather variability. Again, the finding also suggests that farmers are willing to pay extra if there is value in what is delivered to them and at the same time weather services that truly reflect farmers' needs they will be willing to pay extra money for such services. During the IDI both male and female respondents mentioned that even though they receive weather information from the aforementioned sources, the information largely lack advisories in the forecast to guide the application of weather information in the food crop production processes and are unable to apply due to the absences of advisories or agro meteorological advice. Further examination the cell phone messages revealed that the weather information and the advisories come in separate messages. A discussant during Male FGD remarked:

"I think one of the key challenges of the service delivery identified with the mobile-based delivery system has to do with the unsustainable nature of the mobile network and coverage including inability to recharge mobile phone batteries due to lack of electricity in Dazuuri, I think that is my only worry, and I have to move to Erimong to Charge my phone". (Male FGD Dazuuri Lawra District, January, 2016).

The above except is an indication that the farmers indeed appreciates the value of the weather information but for the few challenges. In both male and female FGD, it was revealed that farmers in the study area even though have mobile phones but the management of the devices is an issue. It was generally agreed that the following were management issues: replacement of damaged/lost batteries, recharging with voucher cards, and general repairs. This revelation suggests that farmers who are unable to manage mobile phones will not benefit from the weather information services delivered through SMS approach. In an IDI, a male respondent also has this to say on issues with the weather information delivery system:

"Farmers inability to read and write and appropriate interpretation of the weather information products caused most farmers including me not to be able to use weather information or services. This because the SWFI products are packaged in the form of short message service (SMS alert)/text messages using formats that we as rural farmers are not familiar with and expressed in English language. See, my brother, my concern is on the existing packaging of the

scientific weather information which are currently framed in formats not familiar to us". (Male FGD at Nabrunye Lawra District February, 2016).

These findings in the above except agree with Sivakumar *et al* (2014) study results in West Africa which found that due to farmers' background e.g formal education and level of exposure to technology and as a result are unable to use the SMS-based services delivery of information. These issues serve as disincentives to farmers to effectively maximise the mobile-based strategy of delivering SWFI services to the farmers even though farmers acknowledged its importance. Despite these challenges some farmers have been able to explore the mobile-based communication strategy and have appreciated it. For instance, this is what a female respondent has to say at Bompari during IDI session:

"Officer, in my view the mobile-based delivery strategy is convenient and reaches farmers at any time and place provided there is good network coverage and the availability of electricity including support services such as interpretation but let me add that the approach will fit perfectly when it comes to issues of disasters and early warning periods such as extended dry spell, drought and floods". (Male IDI at Bompari Lawra District February, 2016).

The above finding is in consistent with Wickramasinghe (2011) case study findings in Sir Lanka, where it was noted that information communicated through cell phone short text message is preferred when used to disseminate timely and urgent climate information that enhance quick action, such as flood related information. In the male FGDs, the respondents noted that farmers in the area have no option than to rely on intermediaries who are graduates of first and second cycle institutions. As in the case of the male FGD, the female FGD revealed that the intermediaries help illiterate farmers in accessing messages on their mobile phones, reading and translating from English into the local language i.e Dagaare and interpretations of the messages. In a related finding during an IDI with a female respondent, it was noted that farmers are comfortable with the intermediaries since they are their colleague farmers from the same community. Again both male and female FGD revealed that farmers however, cannot be sure of their colleague farmers as to whether they are indeed saying what is meant to be said. A youth at Nabrunye remarked in Male FGD on expertise of intermediaries:

"I have always doubted the available intermediaries' expertise, they are not up to the level at which they can confidently interpret such information and help farmers to make informed decisions, because their level of education is either Junior High School (JHS) or Senior High School and are not exposed to technology and skills training on weather interpretations". (Male FGD at Nabrunye, Lawra District December, 2015).

Findings in the above except buttress the point why farmers attitude towards weather information usage is quiet skeptical. This revelation implies that there might be the need to reconsider framing scientific weather information products in qualitative form or in a form that can easily be understood by farmers. It therefore means that for community-based intermediaries to effectively function well they should be empowered with skills training. Braun & Islam (2012) also noted similar observation that information delivered by intermediaries is often preferred by communities because intermediaries are known and trusted by community members except that intermediaries lack the requisite capacity to effectively function. In a male FGD at Nabrunye, it was also revealed that farmers are unable to interact fully with the senders of scientific weather information. Situation tends to frustrate farmers and is affecting sustainable uptake of scientific weather information products and service delivery. A male discussant at Nabrunye remarked in a FGD session as follows:

"The weather people call me from time to time to tell me the expected weather conditions for my community in the local language (Dagaare) which I think is a good thing, but I can only listen to them and cannot interact fully and the woman who call me also talk very fast and sometimes I cannot hear her very well and this making me and my colleagues farmers to losing interest in this forecast things" (Male FGD Nabrunye Lawra District February, 2016).

The above excerpt buttresses the point that the mobile-based delivery approach could benefit farmers to the fullest if farmers could have the opportunity to interact meaningfully with the senders of scientific weather information products and for farmers' concerns to be addressed. The implications are that farmers are unable to make certain pertinent clarifications regarding the weather products which make uptake in food crop production challenging. An opportunity for farmers to interact meaningfully will improve trust and uptake of the scientific weather information products by the rural farmers. These findings suggest that most farmers identified trust as key regarding the use of the scientific weather information products. It means that to further improve farmer attitude towards weather forecast information trust building is key when there is meaningful and regular interaction between farmers and senders of weather information where both sides can appreciate each other in the partnership. To further validate some emerged interesting issues, the research team spend some time with select farmers during peak farming season in the research communities and observed that farmers within the age group of 30-45 were conversant in manipulating the mobile phone devices and could locate the message box and read the text messages with ease, interpretations were however challenging due to the form it is framed. However, it was observed that this was not the case of farmers above 60 years. Farmers above 60 years had difficulty in manipulating the devices implying that other delivery strategies could be adopted for such category of farmers which should be user friendly. A female discussant at Erimong-Tangzu narrated during in-depth interview session:

"When I was a young girl so many years ago I didn't know what mobile was because they were not even there but now mobile is common and the young people can have access to them and use. See because of this, I find it very difficult to use the mobile phone, unless somebody helps me. I sometimes give it to my son's daughter who is in JHS 2 to read and explain to me what the message is all about. As for me I cannot do it and I have never done it too". (Female FGD Erimong-Tangzu Lawra District January, 2016).

This finding supports the fact that early exposure of farmers to these devices and the requisite training conducted regularly including other communication channels goes a long way to build the confidence level of farmers to be able to identify themselves with these devices as well as with the process. The finding further implies that when designing and disseminating climate change adaptation information, efforts must be taken to assess the key characteristic of the target groups such that the appropriate communication approach is adopted so that the information can reach those specific groups with minimal challenges and therefore ensure sustainable uptake. The study also noted unanticipated information which includes indigenous weather forecast (IWF) practices in the study area. An elder during male FGD sessions mentioned that IWF practices still exist in a subtle way. The sources mentioned by the elder include diviners; rain makers/rain prophets. However, the male respondent was quick to mention that the potency of their god (*bambaa*) is gradually fading away explaining why they no longer get rains when call on the god. This revelation was attributed to the culture of the youth which the god is not comfortable with.

4.3.2 Objective 2: Farmers' Perspectives on Ways of Delivering Scientific Weather Forecast Information.

This objective focused on investigating processes and forms that are farmer friendly when it comes to scientific weather forecast information delivery services to the rural farmers. Responses on ways of delivery sustainable weather information services were summarized and categorized into sub-themes and discussed below:

4.3.2.1 Scientific Weather Forecast Information Products and Appropriate Content Development

In the male FGD at Dazuuri for instance, it was revealed that the most valued and preferred scientific weather forecast information is rainfall onset and cessations dates. The male respondents noted that this should precede the daily and weekly updates. It essentially means that farmers' prior knowledge regarding the onset and cessation dates will help them plan in advance for the entire season. The planning might take the form of type of crop to cultivate and other farm activities that require prior knowledge about the weather. In response to back this finding, a male respondent during the FGD cited instances where in the past 5 years, rainfall onset dates either shifted to April or May or even in June while the cessation dates occurs in the last week of September or in October and sometimes in first week of November. The male respondent further mentioned that the issue of inconsistency in onset and cessation dates have affected farm production as farmers only relied on weather updates even though the updates helped them to some extent. Consequently, rainfall onset and cessation dates were ranked as priority including the weather updates. An elder in a Male FGD at Dazuuri remarked:

"Water is the only farm input that without it a farmer cannot farm, you cannot buy water or beg for water to farm, unlike buying or borrowing seeds, fertilizer and other inputs water is from nature (God), so if I know in advance when the rain will start and end for the farming season it will be a great relief to me and my colleague farmers. It is now difficult for me to tell when it will rain and when the rains will end unlike when I was a young man. Have you now seen

why I ranked rainfall onset and cessation dates as my number one priority?" (Male FGD Dazuuri Lawra District February, 2016).

The finding it is evident that farmers preferred rainfall regime for specific farming seasons and that should be presented to them in the form of onset and cessation dates. It means that farmers are better adapted to the impact of weather variability when the weather information is generated to cover the entire season followed with intermittent updates of rainfall and other weather information in the course of the forecasted season to the farmers. A female respondent noted in in-depth interview process at Bompari:

"For me as a rural farmer in this community what is important to me is that, it is better to have a fair idea about the weather conditions for the coming farming season including when the rains will start and end, than to walk through the season like a blind man because those days of easily forecasting the weather are gone and we need to strongly get prepared". (Female IDI at Bompari Lawra District February, 2016).

The above finding implies that farmers could develop a better attitude to weather information use if they are provided with their preferred information in a form that is acceptable to the farmers. Across both male and female FGDs, as part of content of weather information it was revealed that specific crop information should form part of the forecast information. This finding implies that focusing on crop specific information in terms of agrometerological advice will be helpful especially when tailored to staple crops such as maize, millet and groundnuts. For instance, it became evident during FGDs that all the households in the study area engage in maize production which is one of the staple crops in the area. Repackaging weather information to reflect specific crop information targeting the staple crops will benefit a lot more people than the current form of the information. It can therefore be inferred that if meteorologists or senders of the scientific weather information could team up with the appropriate agencies like the Ministry of Food and Agriculture to develop crop specific weather information to guide farmers in their production process will be a great relief to a lot more farmers. In male FGDs at Nabrunye it was pointed out that farmers' role in the process of the content development is very critical when it comes to the content of weather information since farmers constitute a repository of information on the specific information requirements of the various staple crops including other relevant information about the study communities. It further implies that through a structured system of information flow farmers can better be positioned to participate actively in the process. Some of the advisory information farmers cited during FGDs and in-depth interview sessions that could form part of the forecast are pest and diseases incidence and the specific weather conditions that can trigger the emergence during the cropping season such that farmers could adopt precautionary measures. Others mentioned included planting time**,** good farm management practices, choice of inorganic fertilizers and use of farm manure, suitable crop types and varieties to be planted, weeding and produce drying regimes, the available seed suppliers, prevention. In contrast to these findings, Mwesigwa & Omukuti (2013) study in rural kanya they found that the contents of the weather products are accompanied with advisories and are tailored to the needs of the farmers.

4.3.2.2 Voice Message in Local Language (Dagaare)

When asked about framing weather information to become user friendly, both male and female FGD sessions revealed that the voice messages are preferred to the text messages in the local language. The general consensus from all the FGD is that farmers are calling for regularizing framing of weather information in the local language as the approach is appropriate to all categories of farmers irrespective of their educational level. In the male FGD in particular at Dazuuri, a discussant remarked:

"Scientific weather information disseminated to us in the form of voice message in the local language i.e. Dagaare actually shows that the senders of the information have recognized the culture of the Dazuuri people and then we can also see how best we can identify ourselves with the process". (Male FGD at Dazuuri Lawra District February, 2016).

This finding implies that weather information uptake could be enhanced and sustained if the process could incorporate the local language when framing weather updates will received widespread acceptance as this approach has some cultural dimension. This is because male respondents in a FGD reported been comfortable with the few cases that weather information got to them in their local languages. A female discussant at Female FGD at Dazuuri has this to say on the use of voice message approach:

"Look the use of the voice messages in which the information is in Dagaare which is my local language in my view will be the appropriate approach, in that case I will not need the assistance of interpreters who themselves are not trustworthy and do not have any training or education in weather information interpretations, also the voice message can be played back from time to time without the assistance of anybody unlike in the case of SMS alert where one need to look for an intermediary for assistance" (Female FGD Dazuuri at Lawra District February, 2016).

Further, it is evident from the findings that integrating 'Dagaare' voice messages in the delivery services process of scientific weather information could go a long way to benefit large segment of the farming communities in the study area. Again, as reported by the female FGD discussants, it can be deduced that they are not benefiting from the full potential of weather information in the study area due to the monopolistic nature of the delivery process where SMS alerts are mainly promoted. It further means that to take things forward in a sustainable way, it might be necessary to undertake some level of reforms to ensure that greater percentage of farmers benefit from weather forecast. In concluding this segment, the general finding has been that the illiterate farmers preferred only voice messages in Dagaare while the literate farmers preferred both SMS alerts in English and the voice messages in Dagaare or English. This suggests that more concentration on SMS alert will only benefit a few farmers who are able to read and write. However, the right interpretation cannot be guaranteed despite been educated since they lack the technical ability.

4.3.2.3 Regular Face to Face Interaction among Farmers and Senders of Weather Information.

A male youth respondent in an in-depth interview at Erimong-Tangzu suggested that regular interaction with scientists or senders of scientific weather information is an appropriate strategy in collecting and incorporating farmers' perspectives in weather prediction and formulation of the appropriate contents tailored to specific user groups. This finding suggests that the perspectives that will be presented by farmers could potentially help senders of weather information to improve upon forecast production and delivery strategies and hence shape the process of weather forecasting and increased adoption. Additionally, an elder also noted during an in-depth interview at Nabrunye that regular interaction with farmers at the field level shows some level of recognition for farmers and therefore meteorologists can better respond to their needs in terms of weather information packaging and delivery strategies and farmers on the other hand will have the confidence to use the weather products. For example, in the Female FGD at Nabrunye, a respondent reported that lead farmers who participated in weather and climate change workshops significantly changed their farming practices and adopted scientific weather information and application in food crop production. This finding is in consistent with patt *et al* (2005) study in Zimbabwe who noted that farmers who have attended weather and climate change workshops learned and responded to the forecast by either planting earlier or delaying their planting while farmers who did not attend such workshops responded poorly to the forecast instructions. It is therefore evident that farmer participation in such interactive platforms is necessary to ensuring weather variability and climate change resilience building. A male respondent in an in-depth interview at Nabrunye has this to say:

"Meteorologists holding 2 to 3 interactive sessions especially during pre-season, season and post-season with rural farmers at least before the year ends will be ideal for smallholder farmers in the study area and many of us have challenges with the scientific weather information that we receive and will be happy to see these weather people to interact with them and ask questions for clarification and also for them to learn from our experiences with the weather in the past seasons and meteorologists could know something about we the farmers needs and be better informed to produce forecast that is acceptable to us the farmers" (Male IDI at Nabrunye Lawra District February, 2016).

The finding stated, implies that when it comes to issues of the weather farmers have a wealth of experiences in that regard and meteorologists could potentially learn from farmers which can inform development of the appropriate weather information contents, formats and the appropriate delivery channels for the poor rural smallholder farmers to adopt.

4.3.2.4 Weather Interpretation Agents (WIA)

The issue of scientific weather information interpretation has remained significant especially for the rural smallholder farmers in the study area. The study revealed that even the literate farmers in some cases are unable to make sense of scientific weather information due to packaging of the content of the weather information in the study area. As stated in objective one, the existing packaging in the study area is not fully appreciated and farmers are not exploiting the full potentials of the scientific weather information in food crop production. In response to these concerns, a female respondent in an in-depth interview at Nabrunye made the following remarks:

"I think government need to recruit and send WIAs for the rural communities to assist in interpretation particularly when promoting mobile-based communication delivery strategy and in which products are framed in formats not farmer friendly. Look we farmers are aware of the fact that forecast is probability but it is better to be prepared against the weather conditions than having no knowledge about the weather conditions and I think the major concern is about clarity with the information and the ability to make sense out of what is provided". (Female IDI at Nabrunye Lawra District February, 2016).

In the male FGD at Nabrunye on the other hand, noted that just like the Agricultural Extension Agents (AEA), WIA should be deployed by the government or any development organization for that matter with technical expertise in the area of meteorology and weather forecasting. These technical personnel job will be to assist farmers in understanding the weather from climate change point of view and helping to address challenges farmers face in the use of scientific weather forecast information in food crop production. The male respondents in FGDs at Nabruny further noted that the AEAs who sometimes help farmers in product interpretation are not so much conversant. It means the WIAs strategy will be useful to farmers if successfully implemented. A Male discussant during FGD at Dazuuri narrated this:

"I am beginning to lose confidence in scientific weather forecast information because those who can help use to understand these things are living in the cities only give us the information expect we as illiterate farmers to understand and use, it is our problem though and not theirs even though they are helping, but then I want to say that they should just send people who really understand this weather thing to come to the rural communities and help us understand and be able to use them in a practical manner. We are not saying if they come to help us we will have a perfect forecast system or there will be 100% accuracy in the forecast delivery process, but it will in a way contribute to improving the process" (Male FGD at Dazuuri Lawra District February, 2016).

The above finding is an indication that a good number of farmers are getting frustrated with the products. However, it also indicates some level of acceptance of the information except that some barriers are limiting farmers from potentially benefiting from the products.

4.3.3 Radio Broadcast

Male and female respondents during in-depth interview sessions across the 4 study communities cited radio announcement of scientific weather forecast information as a good idea and noted that it will complement the mobile-based delivery process. One female respondent at Nabrunye during in-depth interview sessions noted emphatically that the incorporation of radio announcement will go a long way to ensure that the large numbers of rural farmers readily have access to improved weather information delivery services at minimal or no cost benefiting most farmers when done in the local language. When asked about specific time of the day suitable for radio broadcast on weather updates for the ensuing day (s), this was what a female discussant during female FGD at Bompari has to say:

"Because we get busy with our farm work specific time of broadcast is important to farmers. I can say that over 80% of farmers in this community normally listen to radio broadcast after evening meals usually between 6:00pm and 9:00pm but women preferred to listen to the broadcast at 7:30-8:00pm by which time they will be done with cooking and other household chores while the men preferred any time from 6:00-9:0 pm since they have nothing doing after farm activities". (Female FGD at Bompari, Lawra District February, 2016).

The finding implies that time to the rural farmers is important and should be factored in when using radio as a means of delivering weather forecast to rural farmers since many of them will listen to the radio in the evening. Again, in the female FGD at Bompari, it was noted that the use of radio announcement will be much more helpful to farmers relative to the use of mobile phone in delivering weather information because the phone is only useful to the owner and the immediate family and its use comes with a cost. It therefore means that the use of radio announcement in conveying scientific weather information services as this delivery strategy has a positive impact on the wider community rather than an individual and the family at minimal or no cost. Shah *et al* (2012) study in Kenya on the other hand found out that broadcasts at 7 a.m., 1 p.m. during the lunch break and 7 p.m. are more appropriate to farmers' schedules. A female discussant during FGD at Bompari has this to say on the radio announcement as an option to mobile phone use as a delivery option:

"The use of radio and in which the local language is used, in conveying scientific weather forecast information is the best option for us as poor rural farmers because it will help us identify ourselves with the process in terms of culture and also reach out to a wider large numbers of the people, for now it is only few of us who are on the mobile sms platform and it is not all the time I can go about informing other farmers or looking for an intermediary person who you may sometimes not hear of. A good example is nearby community such as Buree could have also been benefiting if the weather updates passed through the radio and again, I think that if the scientific weather information is delivered through the radio in a language such as Dagaari which can be understood and appreciated by all, switching on my radio everybody in the house including others in the community will hear the scientific weather information and have a better appreciation and believe for themselves instead of another person". (Female FGD at Bompari, Lawra District February, 2016).

The above finding buttresses the point that the use of radio as a delivery option will have much more coverage and impact on farm productivity and profitability relative to the use of mobile phone. The findings also suggest that farmers already have some misconception about the mobile phone use which includes benefiting an individual or at best a household and the impression that owners of the devices could refuse to share the information with them. The finding further implies that the confidence level and for that matter trust of the farmers is enhanced when scientific weather information is delivered using mass media approaches and strategies. The female FGD revealed that majority of female farmers preferred that the scientific weather information should be delivered through radio announcements in the evening because they are overburdened with a number of household chores from morning till evening. They (female respondents) however, indicated that weekends were their less busy periods except market days where they would prefer to have some interactive engagements with senders (scientists/meteorologists) of scientific weather forecast information to clarify some of the issues for the women farmer groups. Contrary to this finding, the male FGD at Dazuuri, noted that male farmers listen to their radio sets while in the farm and at home and have enough time after they return from farm and could potentially engage in other sophisticated forms of accessing scientific weather information services. This finding is indicative of the fact that men are more advantageous in terms of adaptive capacity than their women counterparts. The male FGD at Dazuuri also revealed that woman per the culture of the community women does not own anything even the women are the men 'property'. This finding serves as a barrier in limiting women farmers to access the full potential of the scientific weather information in the study area. This further implies that gender sensitive weather information delivery strategies should form the core of climate change communication programmes for rural smallholder farmers. Across all the FGD sessions, it was mentioned that integrating mass media communication strategies with the prevailing method (Short Message Service) could help reach out to large numbers of farmers with the appropriate weather information.

4.3.4 The Use of Rain Gauges

The use of rain gauges is an important weather monitoring tools in adaptation to weather variability and the approach has salvaged some farmers from total crop. In the male FGD for instance at Nabrunye, it was revealed that the few farmers who are benefiting from the rain gauges in addition to weather updates using the mobile phones have reported increased in yields. A male respondent during in-depth interview at Nabrunye remarked:

"In Nabrunye here I and my colleague farmers are able to delay or plant early with confidence because they can tell the adequacy of soil moisture which further informs us the type of crop to even chose for planting especially after the first few rains, fertilizer application schedules etc and you see officer, this way it complements the forecast which makes farming reliable and easy for farmers to engage in, this explains why I think if we get more rain gauges it will be good for us". (Male FGD at Nabrunye Lawra District February, 2016).

Again, a male discussant who is a rain gauge reader and interpreter has this to say during male FGD at Erimong-Tangzu, after benefiting from rain gauge use in food crop production for the past two years:

"We used to dig the soils to the height of the forearm in order to know the depth of moisture and then decide whether to plant or not after the first rains. Now that we have rain gauge in the community and our awareness has been

raised on beneficial rainfall amounts, we only plant when conditions are right. Farmers in this village and those from surrounding areas no longer rush to the fields as soon as the first rains fall. They first come to get information on rainfall amount recorded before deciding to plant" (Male FGD at Erimong-Tangzu, Lawra District February, 2016).

Clearly from the above findings, farmers have seen value in the weather monitoring tools because they no longer rush to plant because it appears that farmers can now tell weather conditions are right or not. In the male FGD for instance at Nabrunye the respondents have indicated that the approach is practical and farmer friendly and only requires a little bit of training to be able to take readings. These responses suggests that farmers intend to mainstream this practical approach in addition to the weather forecast information they receive and have indicated that they will require some basic training on the approach to effectively participate in the processes. During male FGD at Nabrunye, a male discussant revealed that farmers who have quitted farming because of persistent crop failures are being attracted back into farming because of the introduction of weather monitoring tools i.e rain guage. A female respondent during in-depth interview session at Dazuuri mentioned that to get the illiterate farmers to appreciate and use rain gauge as adaptation tool different colours should be used to designate readings to make it easy for every farmer to the rain gauge to read and proceed to making farm level decisions. A male respondent during in-depth interview at Dazuuri remarked:

"It is not enough to tell me as a farmer that I should expect that by tomorrow it will rain. The question I want to ask the weather people is that if it will rain by what volume of water do we farmers expect? So that if I want to carry out any form operations like sowing of a particular crop then I will know whether to do it or not". (Male FGD at Dazuuri Lawra District January, 2016).

The above finding implies that farmers are ever ready to adapt appropriately if they are empowered with the requisite information and tools. Again respondents reported that linking community monitors to the meteorological departments/stations in the study area where such data can be relayed to them for validation with the expected weather conditions and subsequently pass on to many farmers via the radio. The finding is in line with those of Ababale (2013) who noted that in rural Niger farmers have reported that the installed rain gauges have helped in communicating weather information immediately to farmers who applied the information in their farm operations which have eventually translated into increased yields.

4.4 Objective 3: Farmer Perspective on Application of Scientific Weather Forecast Information in Food Crop Production.

In both Female and Male FGD across the four (4) study communities, it became evident that indeed farmers have begun applying scientific weather information in earnest in food crop production processes. The kind of information received in the study communities as revealed during in-depth interviews and validated in both male and female FGD are categorized into three forms based on the time of the year. The following categories were identified: Pre-season, season on-going and season ending scientific weather forecast information.

4.4.1 Pre-Season Activities

In terms of pre-season usage of the scientific weather information, the general response from both male and female FGD across the 4 communities revealed that the information serves as a guide to farmers in the planning for the season's activities. The planning as revealed by the FGD sessions across the 4 communities include negotiating and securing appropriate farmlands particularly women farmers, clearing of new and old farmlands, repairing and replacing obsolete farm tools, organizing cash to pay for mechanization services and others inputs costs, placing orders for certified and improved seeds including pesticides and chemical fertilizers. A Male discussant during FGD at Erimong-Tangzu remarked:

"The pre-season scientific weather forecast information updates is helpful in our farming activities in that it help me in particular to place order for fertilizers, chemicals including tractor services, because in the year 2011 when farmers in this community did not even know of this scientific weather forecast thing we were guessing to farm and because of the guess farming many of the farmers including me were afraid to invest our little monies into fertilizers and other chemicals and expand our farmlands since we had no idea about how the weather and the season might look like. Unlike those days we used to use migration of certain birds to determine the start of the season and those birds

have all died. But now with the advent of scientific weather information like pre-season me and my colleague farmers are always prepared for the season's activities and I can advise myself on my investment budget". (Male FGD at Erimong-tangzu Lawra District February, 2016).

The above finding suggests that rural farmers are benefiting from the pre-season weather updates prior to the season's activities in the study communities. This is an indication of farmers' appreciation of the significant contribution of the pre-season information as such information assisted them in planning and investment decisions and subsequently translated into improved yields. The finding above is an indicative of the fact that farmers are gradually building their adaptive capacity in recent times with the integration of scientific weather information.

4.4.2 Season on-going and Season Ending Activities

In the case of season on-going use of the scientific weather information, both female and male FGD noted that, farmers indeed apply the weather updates in the choice of cultivars, early and late maturing crops depending on the consistency of a particular forecast such as the volume of water anticipated. In the female FGD in particular at Nabrunye, the respondents indicated that the season on-going weather information provide guidance in choosing planting dates for crops such as planting of early and late maturing crops. The FGD sessions however noted that this is peculiar to farmers benefiting from the use of rain gauges as complementary adaptation tools to the weather updates. The female FGD respondents noted that the integration of the weather updates and the use of rain gauges is the best option rather than only the weather updates. The male FGD on the other hand at Bompari and Nabrunye reported that other farm operations that they apply scientific weather updates include: scheduling of weeding and application of chemical fertilizers and pesticides. Again, it was noted at the male FGD both at Bompari and Nabrunye that a clear three to four day forecast of no or low millimetres of rainfall and slightly high temperatures are appropriate to schedule weeding. They also indicated that this applies to spraying schedules where a clear weather for about 36 hours is ideal. A Male cowpea farmer who schedules spraying after receiving a forecast of the weather remarked during in-depth interview session at Eremong-Tangzu:

"During the 2015 farming season, I cultivated about 3.5acres of cowpea with the use of the scientific weather information; I was able to schedule spraying times of my cowpea. Those days when I use not to benefit from the scientific weather information, it was always guess spraying because the rains are erratic and comes without cloud formation and in most cases rains will come wash the chemicals away shortly after the spraying which eventually affects yields due to insect pest infestation and increase my cost of production due to second spraying. So I think it is good I am one of the beneficiaries of the scientific weather updates in this community". (Male FGD at Erimong-Tangzu, Lawra District February, 2016).

From the above finding, the scientific weather information use in farm operations is indeed significantly helping farmers in the study communities to improve their adaptive farming activities and therefore improved yields. During in-depth interview sessions with a male respondent at Dazuuri, it was mentioned that in the case of fertilizer application, scientific weather information updates plays a significant role as farmers are able to plan when to apply fertilizers and the methods of application to adopt. The fertilizer application methods revealed by Male and Female FGD discussion include: burial method, top dressing and broadcasting. The FGD sessions further revealed that depending on the volume of water in the soil farmers make a choice of a particular application method. But the FGD respondents were quick to add that the ability to determine the moisture levels in the soil applies to farmers with opportunity to benefit from rain gauge readings in addition to the scientific weather information updates. In both Male and Female FGD across the 4 study communities respondents are of the view that farmers also apply scientific weather information in season ending activities (post-harvest activities). For instance, the Male FGD respondents indicated that they apply scientific weather information in drying of their farm produce especially drying groundnuts which constitutes one of the main cash crops in the study location. Depending on the forecast groundnut farmers plan and dry their groundnuts including other farm products. These findings are in line with Patt *et al* 2005 study findings in Zimbabwe who observed similar application of scientific weather information updates.

4.5 Objective 4: Farmer Perspective on Effectiveness of Scientific Weather Forecast Information Uptake in Food Crop Production.

In addressing this objective, FGD and in-depth interview responses were categorized into sub-themes and discussed below. The responses centred on farmers' views on the outcome of applying weather forecast information in food crop production in the study area. The emerged themes focused on accuracy and reliability of scientific weather forecast information including farmer perception on yield increase.

4.5.1 Accuracy and Reliability of Scientific Weather Information

When asked about perception on accuracy of the scientific weather forecast information in food crop production, responses from the Male FGD at Dazuuri were that, accuracy is the degree of closeness of a forecast value to perfection. In other words the Male FGD described accuracy to mean what they receive as a forecast for the weather for the next few hours to weeks and anticipate happening and what actually happens. In assessing accuracy which was purely subjective during IDIs and FGDs sessions, the male respondents mentioned that the time farmers were not receiving the scientific weather forecast information; they used to practice guessed farming or planting. However, with the advancement in modern weather prediction farmers can now farm with some degree of confidence in the study location. In examining farmers' perspectives on the effectiveness of the scientific weather forecast information, and more specifically on accuracy, both male and female FGD revealed some degree of confidence about the accuracy of the forecast and hence its contribution to farmers' changing their farming practices and therefore improving adaptive capacity. A male respondent at Dazuuri narrated this during in-depth interview session.

"The first time I was innocent about this cultivation thing the time that I will start and this weather people when they came 4 years ago they show me when to start or when to do everything and like the first time I will just do it or farm anytime like when you stick lotto and everything will die or it will not yield well for me but now with the use of weather information in my farm activities it is yielding a lot because I am informed when to start farming because of the unpredictable nature of the rains in my community and I think it is good and is not always but most at times like 65%(ranked out of 10) accurate for the rains when they announce on my mobile phone that it will rain. Look when I was not a beneficiary of the SWFI, I will cultivate 3 acres of land and only harvest 4 to 4.5 bags of maize and groundnuts. As I talk to you now for the past three years that I have benefited from the scientific weather forecast information, I only farm 2 acres and harvest up to 7 bags. This is good for me because am able to reduce some cost" (Male IDI at Dazuuri, Lawra District February, 2016).

It is evident from the finding that rural farmers value weather forecast information and no matter the accuracy level they perceived, having a fair idea about the weather seems to be very much important to the farmers than having no idea. As a way of measuring farmers' perception on the accuracy of scientific weather forecast information, male FGD discussants ranked weather forecast accuracy to be 70% (scored/ranked out of 10) in the study area while inaccuracy was ranked to be 30%.This revelation suggests that to a larger extend scientific weather forecast information accuracy is somewhat effective and have contributed to improving food production. Also, another attribution to this revelation is that the senders of the scientific weather forecast information have largely improved upon their monitoring techniques with state of the art monitoring equipment and thus improve upon the accuracy of the forecast especially when compared to that of the Ghana Meteorological Agency forecast products including other sources which farmers benefited in the past. It further suggests that farmers who have quitted farming and ventured into other livelihood activities could be attracted back to farming. A male discussant and an enterprising farmer during FGD at Bompari has this to say on the accuracy of the weather forecast in his farm operation.

"I use to farm using 'lottery' and whether it will yield well or not…but now when this weather forecast thing came to my community four years ago, 'lottery farming' is a history" because am able to farm mostly without fear because now the accuracy is about 65-75% from say 20-30% which used to come from the meteorology people. For example, I received a message on my mobile phone on impending rain in July last farming season so I quickly prepare my sweet potato plots and followed the forecast, I got lots and lots and lots of sweet potatoes and the harvest was far better than other farmers who were not getting weather information. I also advised a passer-by farmer about the forecast who followed the forecast instructions and also made a lot of harvest in the last season" (Male FGD at Bompari, Lawra District February, 2016).

The finding confirms the rankings made during the FGDs and further suggests that the confidence level of the farmers on the forecast has been enhanced. The finding also confirms the fact that forecast information potentially helps in food crop yield improvements in the study area and demystified some misconceptions with the the scientific weather forecast information in recent times. These findings are attributed to the downscaling of the scientific weather information for specific communities from esoko in recent times.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section presents a summary, conclusion and recommendations of the study on the perspectives of the rural farmers in relation to the uptake of scientific weather forecast information products or services in the production of food crops in the study area.

5.2 Summary

The summary is intended to highlight the key findings of the study: Firstly, the study revealed that rural farmers in the study area receive scientific weather forecast information from six (6) different sources which are the GMA, esoko, Ministry of Food and Agriculture, Agricultural Extension Agents, Non-governmental Organizations, Savannah Agricultural Research Institute and Community-Based Weather Monitors. The study also revealed that the kind of scientific weather forecast information delivered to the rural farmers include weather updates on likelihood of rainfall onset, anticipated rainfall amounts, temperature conditions, nature of wind for specific locations. These updates are however generic. The study also found out that farmers preferred weather updates information from esoko as a relatively good source of scientific weather forecast information in supporting food crop production. Rainfall onset and cessations dates are valued and the most preferred scientific weather forecast information (SWFI) in the study area. However, in all the sources of information they are largely not supported with any form of farm operations advice. The study established that the inclusion of advisories in the SWFI should be considered as priority in getting rural farmers to use the updates in decision making. Further, the study revealed that advisories should be tailored to crop specific information especially the staple crops in the study area. Additionally, the study established that farmers lack formal education and technological skills making it challenging for farmers to explore the full potential of the SWFI because SWFI is mostly delivered to farmers in English and framed in formats not friendly to the rural farmers. Again, in terms of the channel of delivery of scientific weather information to the rural farmers, the study found that mobile-based delivery strategy largely dominates the study area with information delivered to farmers using SMS alerts formats and in rare cases in voice messages. The study noted further that the following SWFI delivery strategies as appropriate for rural farmers: voice messages in local language (Dagaare) using mobile phones and the radio, farmer-meteorologist regular meetings, well trained community-based weather interpreters, integration of practical approaches such as the use of rain gauge to determine amount of rainfall data and relay to meteorologist and radio stations for onward broadcast for the benefit of large number of farmers within those specific locations. The study revealed that indeed rural farmers use SWFI during pre-season, season on-going and season ending time periods in critical decision making processes. The weather information on pre-season is used in making the following critical decisions; planning farm level operational activities, season on-going usage include choice of cultivars and planting dates, choice of fertilizer application methods, scheduling spraying and weeding regimes. Season ending usage of SWFI on the other hand is for scheduling drying for farm produce such as groundnuts. In terms of the effectiveness of the weather forecast information, the study established that SWFI has been downscaled to specific communities resulting in accuracy and reliability been enhanced and continue to improve the adaptive capacity of the rural farmers.

5.3 Conclusion

The ultimate goal of this study was to explore the perspectives of rural farmers on weather forecast information uptake in food crop production. Based on the key findings of the study, the following conclusions are drawn.

5.3.1 The study identified that a good number of the rural farmers are knowledgeable about weather forecast information delivery process and use in food crop production and are making conscious efforts to adapt to the impact of weather variability. The study can also be concluded that the level of trust varies from one service provider to another. Farmers in the study area are developing trust for private service providers (esoko) other than those managed by the government (GMA).

5.3.2 The study identified factors that influence adoption of scientific weather forecast information generation and delivery processes: integration of farm advisories tailored to staple crop, framing of scientific weather forecast information using voice messages in the local languages (Dagaare), regular interactions between farmers and providers of scientific weathe forecast information, well trained and resourced community-based weather interpretation assistants, using radio to broadcast weather information in the local language (Dagaare) and use of rain gauges to complement weather forecast information delivered using radio and mobile phones.

5.3.3 The generic, quantitative nature and the existing language of expression (English) of the forecast make it challenging for rural farmers to explore the full potential of the SWFI in the study area and eventually affects adoption of the SWFI. A single approach such as the use of mobile phones of delivering SWFI to farmers tends to benefit a small segment of farmers due to contextual and intrinsic factors (high illiteracy levels, no technological skills in using modern gadgets, etc). These two conclusions confirm the 'compatibility" component of the Diffusion of Innovation theory. This is because the values and needs of the farmers are largely not taken into consideration in designing the SWFI. Again, farmers' inability to interpret SWFI because the information is framed in an unfriendly manner makes the process complex for farmers. This conclusion confirms another component of the Diffusion of Innovation theory which notes that when innovations are complex it affects adoption.

5.3.4 Further, it can be concluded that farmers have seen the relevance of the weather information in critical decision making processes and have begun using the information as a guide in food crop production processes which range from pre-season use/planning stage, season on-going activities and post season activities.

5.3.5 Lastly, the study also identified accuracy and reliability to have been enhanced because of the downscaling of the SWFI to specific communities and further deepening farmers' adaptive capacity in food crop production. This conclusion is in line with the arguments made by Rogers (1995) in his Diffusion of Innovation theory, an aspect of the theory that talks about 'relative advantage' of innovations. The study noticed that farmers have seen that benefits of the SWFI services in building resilience against weather variability, when compared with the indigenous weather practices in the study area.

5.4 Recommendations

Based on the findings, the following recommendations are made to facilitate delivery of weather forecast information to rural smallholder farmers:

5.4.1 The Ghana Meteorological Agency (GMA), esoko and Ignatia Ghana should support farmers to adopt multiple weather forecast information delivery strategies. This has the potential for increased adoption by all segments of farming communities. This should be done by firstly carrying out audience segmentation analysis which is critical to determine the appropriate weather forecast information delivery strategy to adopt for specific target groups based on contextual issues.

5.4.2 Government should support AEAs in the rural communities with training in short courses on weather forecasting and interpretation since they spend much time with farmers in the field.

5.4.3 Formal education and technological skills is a key to maximizing the use of the mobile devices and application of the content. Government through the District Assemblies should ensure that greater percentage of the population in rural communities have access to at least second cycle education and at the same time esoko, GMA and other providers of weather information should improve the technological skills of the people through training.

5.4.4 To facilitate adoption of weather forecast information there is the need to for providers of weather information i.e esoko, GMA and others to add value to the services provided by repositioning the processes to actively involve farmers and services rendered to reflect farmers' needs in farm operations

5.4.5 Government should resource the Ghana Meteorological Agency with the right logistics including technical persons to deliver on their mandate.

5.4.6 The Ghana Meteorological Agency should explore public-private partnerships (PPP) opportunities with stakeholders already in the industry e.g. esoko, Ignatia Ghana to leverage on their investments to deliver quality and reliable services to the smallholder farmers.

5.4.7 Government of Ghana through the Ghana Meteorological Agency should work closely with telecommunication Companies e.g Vodafone Ghana, MTN, Tigo, Airtel etc to improve network coverage in beneficiary communities.

5.4.8 The Ghana government should fast track the rural electrification programme to all farming communities. This will be very helpful for farmers who are beneficiaries of the mobile-based deliver strategy to be able to charge mobile phones regularly.

5.4.9 Providers of scientific weather information; esoko, Ignatia Ghana and the Ghana Meteorological Agency should incorporate and promote the use of symbols as weather information delivery strategy for farmers that lack formal education.

5.4.10 Providers of weather information; esoko, Ignatia Ghana, Ghana Meteorological Agency should integrate practical delivery strategies such as the use of rain gauges weather information dissemination initiatives.

5.4.11 Providers of scientific weather forecast information should consider incorporation of agro-meteorological advice in weather updates for all categories of information (i.e pre-season, season on-going and season ending weather information).

5.4.12 The Ghana Meteorological Agency, esoko etc. should support rural smallholder farmers with solar powered mobile phone devices should be introduced in rural areas without electricity for climate change delivery strategies that require electricity.

5.4.13 The ministry of Gender and Social Protection should collaborate with Ghana Meteorological Agency, esoko and other organizations supporting rural farmers with weather and climate change communication intervention to help minimize or eliminate cultural barriers to ensure that women explore the full potential of scientific weather information using gender sensitive delivery approaches.

5.5 Direction for Future Research

Based on the study findings, new issues emerged and could be researched into. They include the following:

5.5.1 The study found that the level of trust in SWFI differs from one service provider to another (e.g farmer trust and preferred products from esoko than GMA and the other sources). This variability in level of trust in the scientific weather information being communicated affects both how it is understood and used. The next study could therefore explore the level of trust in scientific weather information generated by different service providers: research and scientific communities, governmental agencies, and private weather information service providers, and how this influences the use and adoption of weather information.

5.5.2 Issues of trust also raise questions on how weather information generation and communication are governed. While it is acknowledged that "co-production" and delivery strategies of scientific weather information generation and delivery enable better understanding and use of information, there is little research that looks at governance aspects of weather information generation and delivery. The next research could therefore examine how weather information generation and delivery is governed. Here, research could address issues of who is involved, through mechanisms and what are the decision making procedures.

5.5.3 While the study has taken a general view of contextual factors, it is highly likely that the contextual factors in Lawra District and for that matter the study area vary from those of other Districts.

5.5.4 Given the contextual differences between Districts, future study could also explore how the use of weather information as well as adoption of adaptation compares between different geographical locations. The next study could compare the level of use of weather information and adoption of adaptation action between different localities such as urban verses rural including livelihood practices, for instance agricultural verses pastoral, irrigation verses food crop farming.

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APPENDICES

APPENDIX A: IN-DEPTH AND FOCUS GROUP DISCUSSION GUIDE

UNIVERSITY FOR DEVELOPEMNT STUDIES

FACULTY OF INTEGRATED DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES-WA

SCIENTIFIC WEATHER FORECAST INFORMATION COMMUNICATION: PERSPECTIVES OF RURAL FARMERS, LAWRA DISTRICT

Dear respondent,

I am an Mphill student at the University for Development Studies in the Department of Environment and Resource Studies, Wa campus and currently carrying out a field research in the Lawra District and particularly in your community. The focus of the research is on scientific weather forecast information communication: perspectives of rural farmers. The views provided here will be used for only academic purposes and shall be treated as confidential. Anonymity of respondents is also assured. It will take approximately 60 minutes to complete the discussion.

Kindly respond to the questions as honestly as possible to make this research a success

Yours sincerely

Yelevielbayire Angzene Jonathan.

Demographic Characteristics of Respondents				
Community				
Name				
Sex	M		F	
Age				
Education level	Non-formal	No formal	Basic school	Tertiary education
Marital status	Single	Married	Devoiced	Widowed

PERSPECTIVES OF FARMERS ON THE SWFI IN THE STUDY AREA (THE EXISTING SITUATION)

1. In your opinion, how will you describe SWFI services provision in your community? Prompts: content, sources, format/packaging, delivery strategies etc
2. How do farmers in your community react (attitude) to SWFI and its use in farm level operations? Prompts: willingness to adopt, factors accounting for that etc

PERSPECTIVES OF FARMERS ON ALTERNATIVE DELIVERY STRATEGIES OF SWFI

1. In your opinion, how will you prefer SWFI services provision approaches to be? Prompts: content, format/packaging, delivery strategies etc.
2. In your opinion, how/in what ways do you see yourself contributing to the approaches proposed? Prompts: roles and decision making processes.

APPLICATION OF SWFI IN FOOD CROP PRODUCTION

1. In your opinion, how/in what ways do you use SWFI in food crop production? Prompts: various farm decisions.

EFFECTIVENESS OF SWFI IN FOOD CROP PRODUCTION

1. How have you perceived SWFI services in your farm production for the past three to five years? Prompts: accuracy, reliability, scale
2. In your opinion, how different are farmers who employed the SWFI in farm level decision making from their colleague non adopters? Prompts: yields increases, adaptation planning etc.

Thank you for your attention and participation in the interview. I assure you once more of the confidentiality of the information you provided.

APPENDIX B: OBSERVATION GUIDE

Areas of observation

1. Observe and document farm level information farmers receive
2. Document farmers' reaction/attitude toward the information received
3. Note in what form, format and channel does the information come
4. Note farmers' preferences for as stated in point 3 above and reasons for such preference. This should be done through carefully interacting with the farmers.
5. Ask questions for clarification on emerging issues observed
6. Note and document key farm level decisions farmers take
7. Probe further to understand why such decisions are taken, taking note of factors influencing such decisions.
8. Note after every session of observation, undertake reflexive comments
9. Other areas of observation

APPENDIX C: INFORMED CONSENT FORM

UNIVERSITY FOR DEVELOPEMNT STUDIES

FACULTY OF INTEGRATED DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES-WA

CONSENT FOR PARTICIPATION IN INTERVIEW RESEARCH

I volunteer to participate in a research project conducted by Mr. Yelevielbayire Angzene Jonathan from the University for Development Studies. I understand that the research is designed to gather information about academic work. I will be one of approximately 60 people being interviewed for this research. My participation in this project is voluntary. I understand that I will not be paid for my participation. I may withdraw and discontinue participation at any time without penalty. If I decline to participate or withdraw from the study, no one on my campus will be told. I understand that most interviewees in will find the discussion interesting and thought-provoking. If, however, I feel uncomfortable in any way during the interview session, I have the right to decline to answer any question or to end the interview. Participation involves being interviewed by researchers from the University for Development Studies, Wa campus. The interview will last approximately 60 minutes. Notes will be written during the interview. An audio tape of the interview and subsequent dialogue will be made. If I don't want to be taped, I will not be able to participate in the study. I understand that the researcher will not identify me by name in any reports using information obtained from this interview, and that my confidentiality as a participant in this study will remain secure. Subsequent uses of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions. Faculty members and administrators from my campus will neither be present at the interview nor have access to raw notes or transcripts. This precaution will prevent my individual comments from having any negative repercussions. I understand that this research study has been reviewed and approved by the supervisor (Mr. Jefferey S. Makain) of the researcher of the University for Development Studies. I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study. I have been given a copy of this consent form.

Signature_____________________________ Date_________________________

Signature of the Research _____________________________

Mr. Yelevielbayire Angzene Jonathan (Researcher)