UNIVERSITY FOR DEVELOPMENT STUDIES

WEST AFRICAN CENTRE FOR WATER, IRRIGATION AND SUSTAINABLE AGRICULTURE

UNDERSTANDING THE HYDRO-CLIMATIC INFORMATION NEEDS OF LOWLAND RICE FARMERS IN SAVELUGU MUNICIPALITY OF NORTHERN REGION, GHANA

AHMED, HAJARATU

[THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY IN IRRIGATION AND DRAINAGE ENGINEERING]

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BY

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(BSc. Agriculture Technology, MPhil. Irrigation and Drainage Engineering)

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SEPTEMBER, 2021

DECLARATION

STUDENT

I hereby declare that this 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, due acknowledgement is made to the work of others:

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

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ABSTRACT

Rice farmers in Northern Region of Ghana are vulnerable to hydro-climatic variability, partly because the region is dry and experiences unimodal rainfall. The livelihood of these farmers is directly affected by rainfall variability and its effect on crop production. Reliable, timely and area specific hydro-climatic information services could play a significant role in poverty reduction and increased food security and nutrition. There is the need to understand the hydro-climatic information needs of farmers and the role of such information in farmers' decision-making processes, using the bottom-up approach. This study employed a mixed method approach where the quantitative method involved questionnaire administration to 75 lowland rice farmers in three communities in Savelugu Municipality whereas Focus Group Discussion with farmers and Key Informant Interviews with experts providing information services to farmers were used to obtain the qualitative data. The study results indicate that the information services available to farmers in the study area are technical, financial, and capacity building. Rice farmers have access to information on seasonal weather forecast and water availability in addition to local forecast knowledge of farmers. This information is disseminated via mobile phones, face-to-face, radio and television by experts as well as from colleague farmers. The rice farmers highlighted their need for information on area-specific rainfall, temperature, relative humidity and storm occurrence. Averagely, farmers perceive the available hydro-climatic information to be of good quality and reliable, despite occasional failures and plays vital role in farmers' agricultural decisions in areas of agro-input selection, planting and harvesting times and time to carry out other farming activities. The study therefore recommends an integration of scientific and local weather forecast system/ tool to help address prediction failures associated with weather forecast and to enhance farmers' agricultural decision making process to help boost rice production in the study areas.

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DEDICATION

This work is dedicated to my family, especially my lovely father, Ahmed Mahmud.

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CHAPTER ONE

1.0 Introduction

1.1 Background

Agriculture is the key sector that produces food needed to support the livelihood of people around the globe. The sector is vital to the economic development of most African countries, where agriculture contributes 35% and 65% to the gross domestic product (GDP) and employment, respectively (FAO, 2019). Over 90% of Africa's agriculture is rain-fed with no artificial irrigation aid and only 5% of arable land is cultivated under irrigation, compared with 38% of Asia's arable land (Veras, 2019, as cited in FAO, 2019). The sector is thus highly dependent on climate and weather and Ghana is no exception.

In recent times, mineral, oil and gas, service, manufacturing and industrial sectors contribution to Ghana's GDP seem to be relatively more significant than that of the agricultural sector. However, the livelihood of over 60% of the population depends on the agricultural sector (Government of Ghana, 2017) while about 28.46% of Ghanaians are employed in agriculture directly (www.statista.com/statistics/447530/employment-by-economic-sector-in-ghana). Agriculture contributes about 54% of the country's GDP and 40% of the export earnings. Although agriculture is mainly practiced on farms with an average size of less than 1.6 hectares, the sector provides about 90% of the country's food needs (www.farmerline.co/2019/05/29/securing-the-future-of-agriculture-in-the-face-of-an-ageing-farmer-population).

Despite rain-dependent agriculture, the reliability of meteorological predictions for agriculture in Ghana is generally low, and the degree to which climate variability may affect crops is uncertain. This is largely because of the significant dependence of the agricultural sector on rainfall. For instance, climate variability and climate change are recorded as the major contributors of stress on food production and availability. About 20 to 80 percent of inter-annual yield variation is attributed to variation in weather, whiles the estimated annual agricultural losses caused by variation in weather are 5 to 10 percent (Oerke, 2006).

Hydro-climatic information services significantly impact agricultural activities in Ghana and play relevant role in farmers' decision-making process. More so, a timely production, transition, and application of available hydro-climatic information at individual and group levels are relevant for agricultural production and adoption of mitigation measures on climate change and variability (Kumar et al., 2020). It further helps farmers develop a nexus between production efforts and output benefits including increased income, decreased production cost, and economic losses associated with climate change and uncertainties (Carr et al., 2020, Kumar et al., 2020). Agriculture in the northern part of Ghana in particular is vulnerable to climate variability because farmers have limited resources and the region experiences erratic mono-modal rainfall pattern. Lowland rice farmers form the bulk of smallholders in this region. Such farmers depend mostly on indigenous/local knowledge to guide them in main farming operations, as well as information from agricultural extension agents to inform their decision-making.

However, the available information is insufficient to solve farmers' information needs associated with increasing climate change variability. This is partly because the lack of collaboration between actors limits current hydro-climatic information flow, interpretation and use (Nyadzi *et al*., 2018). Challenges associated with farmers' use of weather/climate information services include language barrier, inability to interpret forecast results and untimely information delivery (Feleke, 2015).Rice is among the main staple crops cultivated across all ecological zones, with continuously increasing consumption in Ghana (Nantui et al., 2012). The Northern part of Ghana accounts for half the country's paddy rice production, with Tamale and Bolgatanga serving the key feeder markets, whereas Kumasi serves the key processing market for unbranded rice (Ayeduvor, 2018). Ghana Statistical Service, GSS (2018), recorded rise in annual per capita rice consumption from 24kg in 2012/2013 to 35kg in 2016/17. Similarly, Ragasa et al., (2020), reported an increase in per capita expenditure on rice from 3.3 to 4.1 times that of maize in 2012/13 and 2016/17, respectively. The annual estimate for paddy rice output growth between 2008 and 2019 was around 10 percent, with a sharp increase of 25 percent in 2019 (MoFA, 2018). One of the most important concerns in this regard is the increase in rice yields (Donkoh et al. 2010; Kranjac-Berisavljevic et al. 2003). The production of rice needs to increase significantly to meet rising demand under the variable climatic conditions (SARI, 2011, as cited by Nyadzi et al., 2019). Thus, farmers have to make several climate-sensitive decisions months in advance of every rice farming season (Asante & Amuakwa-Mensah, 2015).

Demand for rice in Ghana far exceeds quantity supplied domestically, raising the percentage of imported rice to over 50 percent (MoFA, 2018) and creating imbalances and vulnerability to international rice price stocks. This signals the need to achieve equilibrium in quantity demanded and supplied through increased rice production and the adaptation of appropriate strategies to curb rice production deficit in Ghana.

Under the prevailing climate change and variability, the rice paddy is vulnerable to incidence of floods and drought, too humid temperatures increase incidence of diseases, whereas, rice growth can be brought to a halt by too much heat waves. Similarly, climate change/variability, has distorted the planting pattern and farming calendar as a result of the changes in the onset of rains, duration and the end of rainy season (Ambani & Fiona, 2014). Consequently, farmers' agricultural decision-making processes are significantly influenced by the prevailing hydro-climatic factors and the information services currently received. On the contrary, Onyango et al., (2014) reported that the currently available weather/climate information services are inadequate to significantly inform farmers' agricultural decision-making process. There is therefore the need for service improvement.

Better and more reliable hydro-climatic information has the potential to improve agricultural productivity (Nyadzi *et al*., 2018) by being able to predict the weather and climate, especially rainfall, which is indispensable for guiding farmers in their agricultural decision making (Logah *et al*., 2013). Agriculture in Africa can better be transformed by integrating local knowledge and modern scientific knowledge (African Development Bank Group, 2018). Hence, incorporating indigenous and the scientific knowledge is necessary to improve societal resilience to climate change. This process should commence with understanding farmers' hydro-climatic information needs and the role of such information in farmers' agricultural decision-making process, the purpose for this paper.

1.2 PROBLEM STATEMENT

Information is acknowledged as a key agricultural input for successful production (Aker 2011; Tadesse and Bahiigwa 2015). Lowland rice farmers in Savelugu make hydro-climatic decisions based on traditional information, indigenous forecast, as well as advice from peer farmers, private organizations and agricultural extension agents. These sources are not sufficient to deal with the hydro-climatic variability that governs their success or failure in crop production.

Recent interventions by some organizations such as Ghana Meteorological Agency, Esoko, Meteoblue and Friday Harbor Labs (FHL weather) involve production and distribution of model based forecast information using ICTs and traditional platforms such as farmer-based organizations and local radio stations. They aim to aid farmers in making climate sensitive decisions. Application of this information and services is limited due to the fact that many of the farmers are illiterate and cannot use or do not have smartphone and access to the web-based platforms. Moreover, Inwood and Dale, (2019), stated that information needs of farmers and other agricultural actors are context specific and based on farm location, crop type, season, market, production system, technology access. Hence, there is the need to understand the context/ area specific hydro-climatic information needs of rice farmers and to assess the role of information in how farmers' respond to weather and climate related stresses, using the bottom-up approach as in this study.

1.3. RESEARCH OBJECTIVES

1.3.1 MAIN OBJECTIVE

To assess the role of information in farmers' response to weather and climate related stresses and to understand the hydro-climatic information needs of farmers.

1.3.2 SPECIFIC OBJECTIVES

1. To identify the currently available hydro-climatic information to farmers in the study areas.
2. To identify the hydro-climatic information needs of farmers' in the study area.

3. To evaluate farmers perception on the quality of the available information.

4. To evaluate farmers perception on the role of the available information.

5. To analyze the influence of the available information on farmers' agricultural decision-making process.

1.4. RESEARCH QUESTIONS

1. What are the currently available hydro-climatic information to farmers in the study areas?

2. What are farmers' hydro-climatic information needs in the study area?

3. What are farmers' perception on the quality of the available hydro-climatic information in the study areas?

4. What are farmers' perception on the role of available hydro-climatic information?

4. How does the available hydro-climatic information influence farmers' agricultural decision-making process?

1.5. JUSTIFICATION

The results of this study will highlight the hydro-climatic information needs of farmers and the role of information in their decision-making process in the study area. The researchers will then be able to modify/adjust the farmer-support app to meet their hydro-climatic information needs, and ultimately, to boost rain-fed rice production.

1.6 Limitations of Study

This research was conducted amidst the COVID-19 pandemic and its challenges. Although necessary precautionary measures were taken, respondents were difficult to contact, especially where the expert interviews were concerned. Language barrier was another challenge faced by the researcher who had to employ enumerators speaking local language to assist in data collection.

1.7 Report format

The report is organized in five chapters. The first chapter is the introduction which consists of background of the research that included overview of the agricultural sector, climate change and the state of rice production in Ghana. The problem of rice production under the prevailing climate change is covered. The general and specific research questions and the objectives of the study have been discussed. The significance of the results of the study to the Farmer Support-App is titled as justification. The study area is highlighted and finally, the challenges faced by the researcher, indicated as limitations has also been discussed.

The second chapter deals with the review of literature on topics relevant to the study, including definition and concept of hydro-climatic information, farmers information needs, farmers perception on available hydro-climatic information, the role of the available information and the influence of the available information on farmers' agricultural decision-making.

The third chapter presents the study methodology. The data sampling and methods of data collection among others have been discussed. The fourth chapter brings forth the results and discussions from the study and the final chapter presents conclusions and recommendation.

CHAPTER TWO

2.0 Literature review

This chapter reviews various literature related to the objectives of this study. Key items examined are; climate and agriculture; agricultural information services, types and sources of agricultural information, farmers' perception on available information and format of information delivery, mobile phones and information services, indigenous weather forecast knowledge, water and weather-related stresses and threats to livelihood of farmers among others.

2.1 Definition and Concept of Climate and Agriculture

This section explores the various concepts and definitions of the key words in this study; Climate, Weather, Hydro-climate, Information, Agriculture and indigenous knowledge.

2.1.1 Basic definitions

Weather is defined as the condition of the atmosphere at a specific place over a short period of time, while climate refers to the weather pattern of a place over a long period of time enough to yield meaningful statistical averages (en.m.wikipedia.org). The elements of weather include pressure, temperature, relative humidity, atmospheric pressure, wind, solar radiation and precipitation. Therefore, climate represents the prevailing weather conditions of specific elements over a long period of time (averagely 30 years) together with their variation or frequency of occurrence of extreme weather conditions.

Agriculture is basically concerned with the cultivation of crops, rearing of farm animals and fish for human consumption and to feed the industries. Spedding (2012) defined agriculture to encompass all systems such as crops, aquaculture, and livestock; as primary activity for food production, fuel, fiber and other commodities by the use of plants and animals.

The concept of information varies in different context. This study will focus on the definitions of agricultural and hydro-climatic information. According to Tadesse (2008), agricultural information is concerned with the relevant sets of information and messages needed by farmers in agricultural production activities, including animal production and management, crop production and protection, as well as natural resource production and conservation. Similarly, Aina (1990) defined agricultural information as data collected systematically, either published or unpublished pertaining to the agricultural sector. Agricultural information is used by farmers, researchers, students, policy makers and instructors. Hydro-climatic information may be defined as information needed to inform farmers' agricultural decision-making processes pertaining to climate and water bodies. According to Vaughan & Dessai, (2014) climate services involve the generation, provision, and contextualization of information and knowledge derived from climate research for decision making at all levels of society. The researchers further mentioned that these services are mainly targeted at informing adaptation to climate variability and change, widely recognized as an important challenge for sustainable development.

2.2 Climate and Agriculture

In recent times, concerns of climate and agriculture have risen to public interest due to the intertwining effects of both on each other and the consequent impacts on the livelihood of people particularly, the rural poor. The relationship between climate and agriculture have heighten national and international concerns to give much focus on weather and climate information (Gumucio et al., 2019).

Previous studies have mentioned that Africa is likely to be challenged with uncertainty in the onset of rainy seasons and an extreme weather events (such as frequent extreme droughts and floods) arising from projected increased in climate variability (Alemaw, 2020) leading to reduction in yields and livestock counts, decreased food supply and consumption, post-harvest losses as a results of the negative impacts of water and heat stresses, pest and diseases outbreak, and distortion of the ecosystem (Vermeulen et al., 2010). On the other hand, some agricultural activities have been proven to contribute significantly to the prevailing uncertainty in weather events. For example, agricultural activities such as livestock production, rice farming, use of chemical fertilizers and biomass burning are key sources of methane (CH4) and nitrous oxide (NO2) emissions (Brown & Crawford, 2008) which increases the amount of greenhouse gases in the atmosphere and consequently distorting the natural climate system.

The vulnerability of Africa's agricultural sector to the prevailing climate change effects or impacts is mainly due to the continents over dependence on rain-fed agriculture, limited resource based and adaptation measures. This is backed by the findings of Yaro, (2010), who state that Ghana's agricultural sector like that of most countries in Sub-Saharan Africa is highly vulnerable to climate change because of the sectors over dependence on rainfall, particularly, the northern part. Similarly, Dasgupta & Baschieri (2010); Stanturf, (2011) reported that agriculture in the Northern parts of Ghana is vulnerable to climate change variability compared to other regions because the regions are dry and experiences erratic mono-modal rainfall pattern. Rainfall variation is likely to utter the seasonal and inter-annual sequence of agricultural activities where Ghana is likely to experience seasonal alternation in drought and flood, as long-term changes and trends take place (Challinor et al., 2007).

2.3 Agricultural Information service

This section highlights studies on farmers' access to agricultural information service, types and sources of the available agricultural and hydro-climatic information services.

2.3.1 Farmers access to information services

A vital input for a successful agricultural production is information (Aker 2011; Tadesse & Bahiigwa, 2015). It is the pivotal element, basic and essential promoter for agricultural development, as well as aid for the farmers.

Information plays a significant role in farmers' agricultural decision-making processes, especially decisions on production risk and uncertainties. Farmers' therefore source information from diverse areas in this regard (Aldosari et al. 2017; Citroen 2011; Mittal & Mehar (2016). In addition, farmers depend on hydro-climatic information to inform their short- and long-term decision-making (Haigh et al., 2015).

A successful management of climate risks in agriculture is through continuous adaptation and innovation (Melillo et al., 2014) which can be achieved through farmers' access to knowledge and information (Moss et al., 2013). A sustainable approach to reduce agricultural economic losses, increase profits, and enhanced strategic and tactical agricultural decisions is by increasing farmers' access to and use of climate information and forecast (Haigh et al., 2015). Furthermore, a timely and reliable hydro-climatic information can lead to better agricultural decision making by farmers (Bruno et al., 2018).

Despite the relevance role of hydro-climatic information in agricultural production, there are still challenges with farmers' access to and interpretation of information. Some of these challenges include high illiteracy rate among farmers, difficulties associated with understanding the technical information due to the format in which hydro-climatic information are presented as well as the doubt in the extent to which the few literate farmers adopt information and new knowledge received (Sam & Dzandu, 2016). Although Feleke (2015) argued that on average, majority of farmers have access to hydro-climatic information services and they do so via radio and local administration; rice farmers in Northern Ghana are reported to have limited access to hydro-climatic information which has led to the vulnerability of agriculture to climate change variability leading to threats on farmers' food production and livelihood (Kranjac-Berisavljevic et al., 2003; Nyadzi, 2016).

The currently available weather and climate forecasts information are limited to enhance farmers' agricultural decision making, there is the need for service improvement (Onyango et al., 2014). It is estimated that about 43.5% of rice farmers in Northern Ghana depend on local knowledge in respect of climatic information, (Nyadzi et al., 2019).

2.3.2 Types and sources of weather/climate information services

Farmers across Africa access different types of agricultural information such as technical (information on inputs, seasonal weather/ climate forecast, and markets availability and accessibility, good agronomic and livestock practices), capacity building (agricultural education and sensitizations) and financial (in-kind and cash support), among others. Information on climate/ weather includes the onset, duration and intensity of rains, occurrences of flood and droughts, duration of cropping season among other indicators. The findings of Anaglo et al., (2014) revealed that farmers in Central Tongu district of Volta Region in Ghana, for example, receive technical (market availability, choice of inputs, storage) and capacity building (planting in line and records keeping) information via radio stations, agricultural extension agents and agro-input dealers. However, these farmers lack information on climate/weather, group development, value chain development as well as entrepreneurial skills. Information on capacity building (utilization of fertilizer), technical services (information on pest and diseases control, market availability and prices) and financial services (availability of credit and loans facilities) are other types of information available to farmers (Oduwale & Ikhizma 2003, as cited in Adio et al., 2016). Other types of information services available to farmers include technical, social/cultural, legal and commercial (EkojaI.I. 2000, as cited in Adio et al., 2016).

Literature reveals that farmers' source weather/climate forecast information from varied channels. For example, Radeny et al., (2019) stated that farmers and pastoralists in East Africa sourced weather information from indigenous knowledge experts, relatives, friends, neighbors, farmers own observations, service providers such as NGOs, extension agents and researchers' via media (radio) and village and clan meetings. Similarly, all farmers interviewed in Central Tongu district of Volta Region in Ghana sourced agricultural information from colleague farmers, followed by agricultural extension agents, (68.3%), mobile phones (58.9%), radio (23.9%), input dealers (20.6%) and lastly traders (20.0%) (Anaglo et al., 2014). However, the study further highlighted that the degree of information accessed from agricultural extension agents varied from community to community.

McNew et al., (1991) estimated about 63% of all types of weather forecast information was sourced via television, whiles 25% of farmers sourced weather information via radio in the US. Furthermore, Kumar et al., (2020) revealed mobile phones, leaflets, brochures, television, and internet, as information sources for farmers in Bangladesh. A variety of sources of information dissemination was highlighted by Okunade (2007). The findings revealed that all respondent reported demonstrations, field and home visits, results and method demonstration, office calls and agricultural videos as information dissemination methods employed by agricultural extension agents in addition to television, radio, cinema, leaflet, letters, group discussions and meeting, and circulars. Also, Opera (2008) stated that about 88.1% of farmers in Imo State (Nigeria) sourced information from agricultural extension agents, 71.2% from peer farmers, 63.2% from radio, 43.3% from television, 22.9% from friends and relatives and 18.6% from farmer groups.

Kumar et al., (2020), investigated the role of information in farmers' response to weather and water related stresses in Bangladesh and reported five main information sources available to farmers; informal contacts (development partners and farmers own experience, information from peer farmers and input dealers); formal contacts (Agricultural Extension Agents and Non-governmental organizations); education and training formal contacts (Agricultural Extension Agents and

Development practitioners); traditional mass media (radio, television and newspapers); and ICT/social media (phone call, smartphones and social media). Also, Farook et al., (2007) showed that print media, peer farmers and radio were sources of agricultural information to farmers in Pakistan.

Similarly, in Ghana, Nyadzi et al., (2019), in their work estimated about 56.6% of farmers sourced climate information from government, private and local knowledge. The government agencies consulted were Ghana Meteorological Agency (GMET) which provides information via radio and TV, as well Ministry of Food and Agriculture, via agricultural extension agents. Private organizations such as ESOKO provided relevant information via mobile phones. In addition, farmers rely on their indigenous weather/climate forecast knowledge. The national meteorological services reach out to farmers with technical information through television, radio, newspaper and internet. Kumar et al. (2020) concluded that farmers access hydro-climatic information via newspaper, radio, television, agricultural extension agents, and mobile phones and from peer farmers.

2.4. Farmer perception on available information sources

Farmers' perception about a technology influences their adoption decision. Their decision to either accept or reject weather/climate information services depends on how they perceive that information. A study conducted by Kumar et al., (2020) revealed that rice farmers in the lower Bengal Delta in Bangladesh, perceived an inverse relationship between hydro-climatic variability and the quality of available hydro-climatic information (i.e., high hydro-climatic variability and poor hydro-climatic information). The researchers mentioned that majority of respondents perceived the quality of the available hydro-climatic information to be very poor, whereas few accepted the information and very few perceived the available information as very good. Furthermore, farmers perceived their own knowledge and information from input dealers to be of very high value, whereas information from peer farmers, and agricultural extension agents were perceived to be of high value and medium value respectively. Farmers perceived information from ICT and private organizations to be of very low quality. Similarly, women farmers' in Osum State ranked their perception on the reliability of information sourced in the order of high to low as; farm and home visit, office calls from extension agents, radio, leaflet, videotape, audio-cassette, slides, posters, results demonstrations, field days, television and telephone calls (Okunaden, 2007).

2.4.1 Preferred information channel

Government, non-governmental organizations and development practitioners are contributing to farmers' access to information via variety of sources. Farmers also have preferred format through which they like to source information which varies from location to location. For example, Anaglo et al., (2014) stated that farmers most preferred information media in descending order are via agricultural extension agents, colleague farmers, mobile phones, input dealers, radio and traders, respectively, for farmers in Central Tongu District of Ghana. Similarly, farmers in Savelugu district mentioned radio, mobile phones and television as their preferred information channels (Ibrahim et al., 2019). Other farmers in Lesotho preferred printed information sources written in farmers' local language, regardless of their educational level (Mokotio & Kalusopa, 2010). In their study, Kumar et al., (2020) showed the difference in youth and older farmers' preference to information. Whereas the youth preferred mobile phones, the aged preferred face-to-face information delivery.

2.5 Mobile phones and agricultural information services

Farmers agricultural information needs can be met through the use of ICT tools, such as mobile phones, internet and email. However, the use of these tools is faced with challenges such as high illiteracy rate among farmers and economic factors. This section seeks to highlight findings from previous studies on; farmers' access to mobile phones and their usage, challenges farmers face to access agricultural information via phones and the format of information dissemination via mobile phones.

In their study, more than half of the respondent owned mobile phones but very few accessed agricultural information with their phones through phone calls and internet and website of some agricultural organizations which were less valued by farmers. The reason been that most farmers had limited knowledge on ICT, high illiteracy rate and poverty. However, the youth and middle-aged farmers who owned smart phones expressed interest in using their phones to access agricultural information (Kumar et al., 2020). Similar results were recorded by Tadesse & Bahiigwa (2015), where majority of farmers did not access agricultural information via phone. Lack of mobile phone knowledge was again recorded as the hindrance to farmers' access to information. Farmers equally received information via phone in the form of SMS and voice mails.

2.6 Farmers information needs and preferred lead time

Previous studies have shown differences in information needs of farmers in relation to farming systems, input selection, cropping seasons and types of crops cultivated. As better put by Inwood & Dale (2019), information needs of farmers and other agricultural actors are context specific such as farm location, crop type, season, market, and production system and technology access. Despite the available information, not all farmers' information needs are met. For example, in India, farmers prioritized information on weather (specifically on rainfall), diseases and pest control, pesticides, market prices and information on seeds as the most pressing information needs (Mittal et al., 2010). Similarly, Lizumi & Ramankutty (2015) identified rainfall and temperature as the most relevant information needs of farmers. Furthermore, key information needs of farmers in order of priorities are rainfall, storm surge, hailstorm, temperature, fog and relative humidity (Kumar et al., 2020).

Inclusive in the challenges with accessing hydro-climatic information services is untimely delivery of information. Some researchers have delved in to highlight the advanced information need of farmers across the globe. Among them is Kumar et al., (2020) who showed that most farmers' preference to be equipped with hydro-climatic information decreases from two weeks to one week, in real times, to seasonal, to one month, then 2/3 days and lastly a day ahead of time. On the contrary, farmers in Same district of Tanzania prefer to weather forecast information at least a month ahead of time to inform their key agricultural decision-making including crop and seed selection, time of planting and type of agro-inputs to purchase Ziervogel & Opere (2010). The researchers further mentioned that farmers stick to the indigenous weather forecast when their preferred information lead-times are not met.

2.7 Forecast methods and indicators

Weather and climate forecast is either achieved through local and or scientific method. Hence, this section seeks to focus more on local forecast knowledge, to highlight gaps in both scientific and traditional forecast methods, local indicators used in weather/ rainfall forecast, and the need for integrated climate/ weather forecast.

2.7.1 The need for climate and weather forecast integration

Agriculture in the Northern part of Ghana is vulnerable to climate change variability because of the difficulties associated with weather and seasonal climate forecast leading to threats on farmers' food production and livelihood (Kranjac-Berisavljevic et al., 2003; Nyadzi, 2016). This is especially laudable when rain-fed smallholder farmers are at peak of vulnerability to climate change (Gbangou et al., 2019). Most of these farmers depend on local forecast knowledge to inform their agricultural decision-making process.

There is a growing demand for rainfall and other weather-related forecast to support agriculture in rural areas (Gbangou et al., 2019). Furthermore, farmers' agricultural decision making may be supported through the availability of seasonal rainfall/weather forecast (Nyadzi et al., 2019). According to Nakashima et al., (2012); Parry et al., (2007), local knowledge can serve as foundation for developing adaptation and natural resource management strategies, cost-effective, participatory and sustainable adaptation strategies for weather/ climate forecast. However, increasing disappearance of indigenous knowledge and inconsistencies in the gathering of climate information have necessitated the implementation of climate services (Buizer et al., 2016; Gupta et al., 2011; Ranger et al., 2011) from scientific sources for climate/ weather forecast. Nevertheless, both weather/climate forecast methods are challenged with intermittent prediction failures and there is the need for timely, user-friendly, location specific climate and seasonal weather forecast information for effective decision making (Radeny et al., 2019). Vaughan & Dessai, (2014), suggested in their work that a development in weather and climate services is a potential risk management tool for climate change and variability. The development could be integration of local and scientific forecast systems. As Manyanhaire (2015) in her study indicated that the basis for understanding farmers' response to climate change impact is by integrating traditional and scientific knowledge system. In other words, high adoption of new technology by farmers is realize in technologies that builds upon farmers existing knowledge. This is clear in the findings of Patt & Gwata (2002) where more farmers were willing to apply an integrated scientific and traditional seasonal weather forecast in Zimbabwe. There is therefore, the need to integrate scientific and indigenous weather forecast system to ensure effective forecast predictions.

2.7.2 Indigenous forecast knowledge

Local knowledge is defined by Gyampoh et al., (2009), as the knowledge, wisdom and practices by local people which is acquired over time through experience and verbally transferred from generation to generation. The application of technology and scientific knowledge to predict the atmosphere in a particular place is the scientific weather forecasting method. Mostly, scientific forecast system is not area specific and are often not downscaled (Radeny et al., 2019), whereas the opposite is true for indigenous knowledge system. However, indigenous weather forecast knowledge is challenged with insufficient documentation of knowledge or records keeping, unstructured and/ or weak knowledge transfer systems, death of weather forecasters, influence of modern education and religion, and lack of coordinated research to investigate its accuracy (https://ccafs.cgiar.org/news/indigenous-knowledge-weather-forecasting-lessons-build-climate-resilience-east-africa-0).

In Ghana, most farmers rely on indigenous knowledge to predict weather/ climate occurrences. They do so base on observation and longtime experiences (Nyadzi et al., 2019). These farmers acquire more insight on weather predictions as they advance in age. However, majority of farmers in Bangladesh stated their knowledge on local weather forecast was poor (59.7%). Other farmers mentioned they somewhat (36.82%) understood the local forecasting system, whereas very few farmers had excellent knowledge on indigenous weather forecast (Kumar et al., 2020).

2.7.3 Indigenous forecast methods

Farmers in Ghana and across Africa adopt diverse indicators to predict weather and climate occurrences. For example, Nyadzi et al., (2020) highlighted indicators used by farmers in Northern Ghana to predict occurrences of rains. According to the researchers, the formation of dark clouds coupled with strong winds, gathering of clouds at north-east direction, the rapid flapping and stretching of the wings of ducks, the burrowing of caterpillars into the soil among other signs as indication of rains. Similarly, Salite, (2019) grouped traditional forecast indicators for predicting drought into celestial bodies, climate and weather, biological and physical environment. The researcher cited examples of celestial bodies' indicators as rising of an incidence of clear moon, a clearly visible sun with no clouds around, occasions of numerous stars in the sky; blowing of wind in one direction without response from the opposite direction and a very hot temperature throughout the year are indications of drought; indicators of physical environment include no dew formation in the morning and short time appearance of fog; also, animal behavior such as dullness and staying home without scavenging for food are some examples of biological indicators used by farmers in Mozambique. Furthermore, farmers in Same district in Tanzania observe and forecast the onset of rainy season upon hearing a lot of noise by frogs, ants moving and spreading across the roads. These indicators tell a decrease in rains during the rainy season, especially in May Ziervogel & Opere (2010). In some countries, farmers are advanced in indigenous knowledge forecast, such that the farmers are able to predict the intensity and duration of rains in each season. For example, in Western Kenya, the appearance of stars and bubbles in pots in shrines indicate the onset of rains in the second week of August. The forecast further tells that there will be light rain from Mid-August to end of September, increased rainfall intensity from October to early December, and then light rains from second week of December to Mid-January. In addition, the forecast predicts a heavy storm alongside the rains with the early rains been polluted. However, the season will experience a good distribution of rains Ziervogel & Opere (2010). Moreover, Ziervogel & Opere (2010) mentioned that farmers in Zambia and Zimbabwe locally predict weather/ climate occurrences in accordance to the fruiting pattern of some trees, movement of wind, the emergence of some weeds and leaves. The farmers highlighted when either the male (wind movement from North to South) or female (wind movement from South to North) is strong is an indication of rainfall occurrence.

2.8 Water and weather-related stresses

Water stress may be seen as a situation where the availability of water is constrained on human activities. A major hindrance in crop production is water and weather-related stresses. Among the major hydro-climatic stresses faced by farmers were incidence of flood, erratic rainfall, irrigation water scarcity or drought, abnormalities in weather, occasions of storm, pest outbreak, and temperature stresses (Kumar et al., (2020). Similarly, Mondal et al., (2013) recorded incidence of flood, salinity and cyclones as the main hydro-climatic stresses faced by farmers in south-west coastal Bangladesh. Globally, the occurrences of drought and flood is reported to be more frequent and severe, and undergo alternation which subject agricultural production to more threats (Ding et al., 2018; Wu et al., 2018).

As mentioned in the recently released US National Climate Assessment, that the continuous adaptation and innovation of farmers is fundamental to achieving success in managing climate risks (Melillo et al., 2014).

Farmers have adopted varieties of adaption and mitigation measures to survive the climate variability in response to water and weather stresses. This ranges from farmers taking no mitigation/ adaptation initiative to climate/ weather stresses to land area expansion and farm enterprises (Morton et al., 2017). Some farmers do nothing when faced with climate stresses (Arbuckle et al., 2013).

Among these mitigation measures are farmers practicing and increasing supplementary irrigation, early application of pesticides, on-time or adjusting to appropriate harvesting and planting times in response to weather/ climate forecast which influences farmers decisions (Kumar et al., 2020). Other strategies include planting short or long season crops, change in planting dates, crop variety selection, increasing or supplementing irrigation, changing planting and harvesting dates, and soil and water management (Nhemachena & Hassan, 2007). Furthermore, crop variety selection, staggering the sales of rice, engagement in off-farm work, and switch in crop cultivation are some more measures (Kabir et al. 2019). Mitigation measures against drought adopted by rice farmers in Madagascar include change in planting dates, crop variety selection and change in crop types grown, change in cropping land, practice irrigation and rain water harvest technology. Whereas, flood adaptive strategies include, replanting after flood occurrence, adopt drainage systems or open bunds, crop variety selection and type, abandon flooded lands (Harvey et al., 2014).

2.9 Threats to livelihood of farmers

Several studies highlight the important role of agriculture to global economic growth. However, the sector is faced with climate variability which has posed serious threats to sustainable economic growth (Gebreegziabher et al., 2012). It is expected to disproportionately affect smallholder farmers and make their livelihood even more insecure, especially in Africa where majority of smallholder farmers depend mostly on rain-fed agriculture.

In Madagascar, the livelihood of rice farmers is threatened with frequent diseases and pest outbreak, cyclone, severe flooding and drought, market access and price volatility (Harvey et al., 2014). Incidences of flood and drought are recorded to adversely destroy cropping lands and the ecosystem upon which the livelihood of most Ghanaian rural poor depends (Akudugu & Alhassan 2012). Similarly, Amisah et al., (2009) reported high temperatures, droughts, reduction in rainfall and variation in rainfall pattern as major contributors of poverty and hunger in rural Ghana.

In attempt to survive these threats, farmers in Bosomtwe district of Ghana have resulted to alternative livelihood activities such as engagement in off-farm activities (trading, food vending, livestock production) whiles other farmers do nothing, their livelihood solely depends on agriculture (Yamba et al., 2017). Similarly, Harvey et al., (2014) discussed that most farmers do nothing amidst these threats due to lack of jobs and poor infrastructure, whiles others migrate from rural areas to cities to look for greener pastures.

CHAPTER THREE

3.0 Methodology

This chapter highlights the various methods used in gathering and analyzing data. It captures a description of the study area, sampling procedure and instruments as well as methods of data analysis.

3.1 Study Area

The study area was conducted in the Savelugu District of the Northern region of Ghana. The District has population of 38,074 people, with Savelugu as the District capital (GSS, 2012). It is estimated that about 89.3% of households are engaged in agriculture out of which about 97%bare involved in crop production (GSS, 2010 population and housing census report). Savelugu is one of the Districts from which young females travel to southern Ghana looking for labor on the markets, acting as head porters.

Savelugu District experiences uni-modal rainfall, alongside other parts on Northern Ghana. Dry season is prevalent each year between November and March. The district has an average daily maximum temperature of 34 degrees centigrade. The grassland is the main vegetation type in the District, alongside drought-resistant trees, which all form part of Guinea Savanna Agro ecological zone. Majority of the farmers are engaged in small-scale production of food and cash crops and domestic animal rearing. Three out of the 149 communities in the district were chosen for this study, namely; Nakpanzoo and Yapalsi and Diare. Nakpanzoo and Yapalsi are two communities where the researchers had executed a project before and hence engaged with project beneficiaries (rice farmers) whiles Diare is a neutral community with no previous engagements with rice farmers. However, Diare was selected for this study because of its intense rice production. The choice of the district and communities for this study is attributed to the communities' high engagement in rain-fed lowland rice production in the valleys and the vulnerability to climate change and variability.

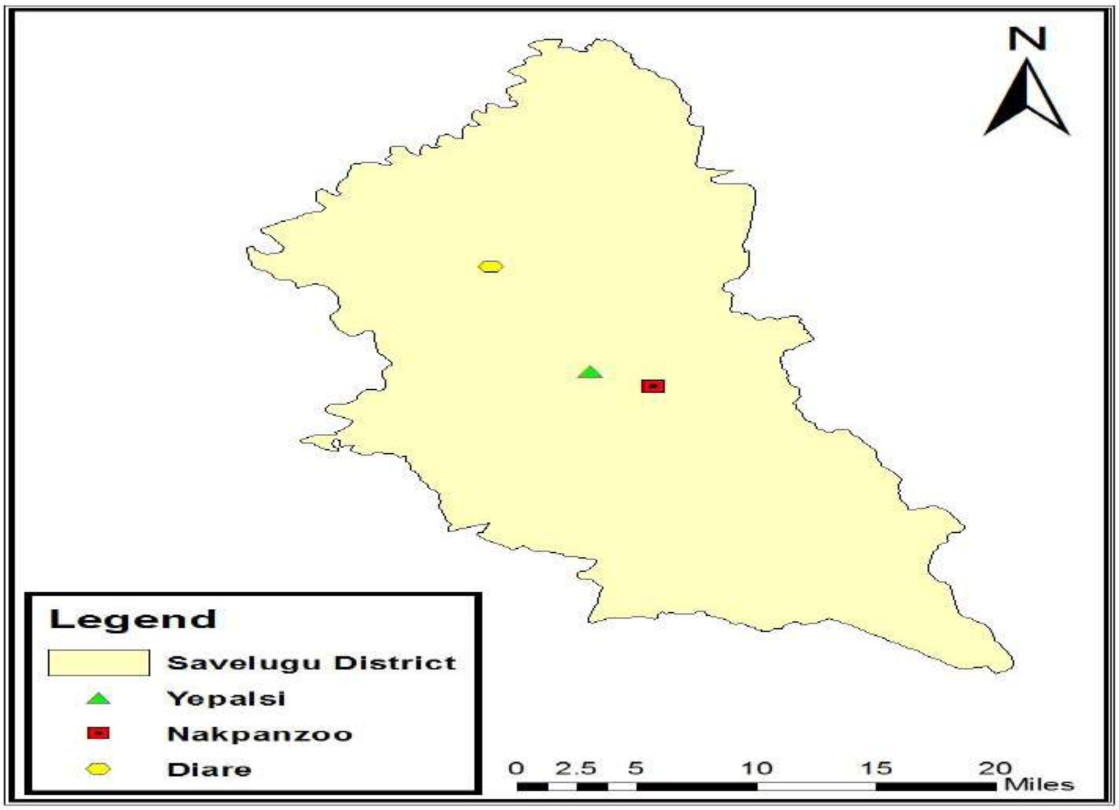

Figure 1: Map of study areas showing three communities (Nakpanzoo, Yapalsi and Diare)

Source: (Field data, 2020)

3.2 Sampling procedure and instruments

This study was a mixed-method study involving both qualitative and quantitative research approaches. The qualitative approach involved Focus Group Discussion (FGD) with farmers and Key Informant Interview (KII) with experts providing information services to rice farmers, whereas quantitative approach was used to administer questionnaires to individual rice farmers. FGDs were held in Nakpanzoo and Yapalsi communities only because these communities benefited from previous project carried out by the researchers and this current study was a continuation of the previous one. Nonetheless, Diare was added to this study because of the community's immense engagement in lowland rice production and also as a non-beneficiary community to enable me compare the results in Diary with those of the other two beneficiary communities (Nakpanzoo and Yapalsi). Two FGDs each were held in the project communities on gender bases with project beneficiaries. In Yapalsi seven and six women and men respectively participated in the FGDs while five and seven women and men respectively took part in FGDs in Nakpanzoo community. The low number of participants was to ensure intensive and all inclusive discussion whereas the difference is number of participants resulted from farmers' availability and willingness to participate in FGDs amidst the early stages of COVID-19 cases recorded in Ghana. Using check-list, the study interviewed nine experts (from organizations rendering agricultural services to farmers). The low number of experts interviewed was because most organizations were working remotely amidst the pandemic.

Semi-structured questionnaires were administered to thirty rice farmers each purposively selected from Yapalsi and Nakpanzoo communities because those farmers had benefited from a previous project carried out by the researchers with fifteen rice farmers randomly selected from Diare community. Again, farmers could not avail themselves because of the fair of COVID-19 pandemic. In total 75 rice farmers were interviewed from all three communities. The study primarily targeted rain-fed rice farmers in the valleys. In addition, secondary data was extracted from literature and available documents to obtain relevant empirical information related to the study. Interview results were summarized with quantitative data descriptively analyzed using Microsoft Excel software versions 2013. Below is a brief summary of each research approach adopted in the study.

Focus group discussions: a total of four focus group discussions with gender segregation were held in Nakpanzoo and Yapalsi communities. Two meetings guided by the same checklist were conducted in each project community. In Nakpanzoo community, five women and seven men participated in the group discussion whiles seven women and six men participated in the focus group discussion in Yapalsi community. The meetings took place in the farmers communities. Inclusive in the checklist were topics on; the current cropping practices, access to weather and water related information for agricultural decision-making, key agricultural decisions and specific times for executing those decisions, indigenous knowledge and farming practices, and measures to address weather and water related challenges. Focus group discussions were held in Nakpanzoo and Yapalsi communities amidst the COVID-19 pandemic.

Individual farmer interviews: seventy-five farmers were selected for this study. With 30 each from Nakpanzoo and Yapalsi communities and the remaining 15 from Diare community. Semi-structured questionnaires were administered amidst the COVID-19 pandemic where all necessary precautionary measures were observed. The questionnaire included demographic information of farmers', water and weather stresses, farmers' access to and the quality of agricultural information services, farmers' information needs, weather forecast methods and use of mobile phones and Apps among others. Five trained enumerators were deployed to the study areas for the data collection. Two enumerators each collected data in the two project communities and while another enumerator administered questionnaires to fifteen farmers in Diare community. Data from the meetings were summarized and entered into Microsoft Excel versions 2013, for further analysis and interpretation.

Expert interviews: checklist was used to interview nine (9) experts in Northern Region of Ghana. The questions captured information on the types of services provided to farmers, the need for hydro-climatic information and the medium of delivery, as well as the effect of the information on farmers' agricultural decision-making. The factors influencing the uptake of these information, the challenges faced by both experts and farmers regarding hydro-climatic information, the current available information and information needs of farmers among other relevant questions were discussed in the interview. Interview results were summarized and analyzed using Microsoft Excel software versions 2013. None of the nine experts interviewed provides only weather services, but they were doing it in addition to other core business.

3.3 Method of data analysis

Objective one, two and five were analyzed descriptively. The Likert type scale was used to gather data for objective three and four. The data were analyzed using frequencies and percentages and the results were presented in tables and graphs.

3.3.1 Descriptive statistics

Descriptive statistics refers to the analysis, summary and presentation of findings related to a data set derived from a sample or entire population (corporatefinanceinstitute.com). Similarly, Mann (1995) defines descriptive statistics as a summary statistic that quantitatively describes or summarizes features from a data set. Descriptive statistics enhances data visualization and present data in a meaningful and a comprehensive way which yields a simplified interpretation of data.

Three main groupings of descriptive statistics are frequency distribution; measure of central; tendency; and measures of variability (corporatefinanceinstitute.com). However, this study employed frequency distribution for presenting data in a more summarized, structured and organized format.

Frequency distribution can be used for analyzing both qualitative and quantitative data by depicting the number of counts or frequencies for different outcomes in a sample or data set. Data are often presented graphically or in tabular form with the assigned frequencies of the values occurrences, in either interval, range or specific groups (corporatefinanceinstitute.com).

3.3.2 Likert type scale

Researchers employ a number of scaling techniques to measure socio-psychological constructs such as perception, attitude among others. In this study, a five-point Likert scale was developed using the method of summated ratings as suggested by Likert (1932) and Edwards (1957). In an ascending order from one to five, the scale was measured as Very good = 1, Good = 2, Acceptable = 3, Poor = 4 and Very poor = 5. According to the researchers, a summated rating scale is a set of statements which are considered or approximated to have equal values, and to each of which subjects respond with degree of agreement or disagreement carrying different scores.

The Likert type scale was used in this study to unravel farmers' perception on the available hydro-climate information services. The Likert type scale was chosen because it enables the use of several statements as indicators, all representing different dimensions of the concept to provide better perspective, whiles avoiding the use of single statement to represent a concept. Thus, farmers' response to several questions enabled the researchers to better understand of farmers' perception on the available hydro-climatic information services.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Demographic and Socio-economic Characteristics of Respondents

The total sample size for the study in three communities (Diare, Yapalsi and Nakpanzoo) was seventy-five. Thirty farmers each were interviewed from Yapalsi and Nakpanzoo with the remaining fifteen from Diare, the control community. The results are represented in Table 1 below.

Table 1: Sample size distribution in study communities

Communities	Frequency	%
Diare	15	20
Nakpanzoo	30	40
Yapalsi	30	40
Total	75	100

(Source: 2020 Field survey)

4.1.1 Age distribution of respondents

The study categorized respondents' age into six groups. The youngest and oldest age groups of rice farmers interviewed were below twenty-five and above sixty-four years, respectively. The age groups of farmers in the three communities are shown in Figure 2 below. The study revealed that majority of rice farmers (29 respondents = 38.7%) were aged between forty-five and fifty-four years. Only two farmers were aged below twenty-five years. Nakpanzoo community had the oldest farmers. The results further revealed that majority of rice farmers (69 respondents = 92%) in the three communities are within the active working age, implying that the majority of rice farmers in the study areas are mostly the energetic groups. The results contradict the findings of Kumar et al., (2020) who found out that few youths engaged in agriculture. However, Nyadzi et al., (2019) recorded parity in age distribution of farmers engaged in agriculture.

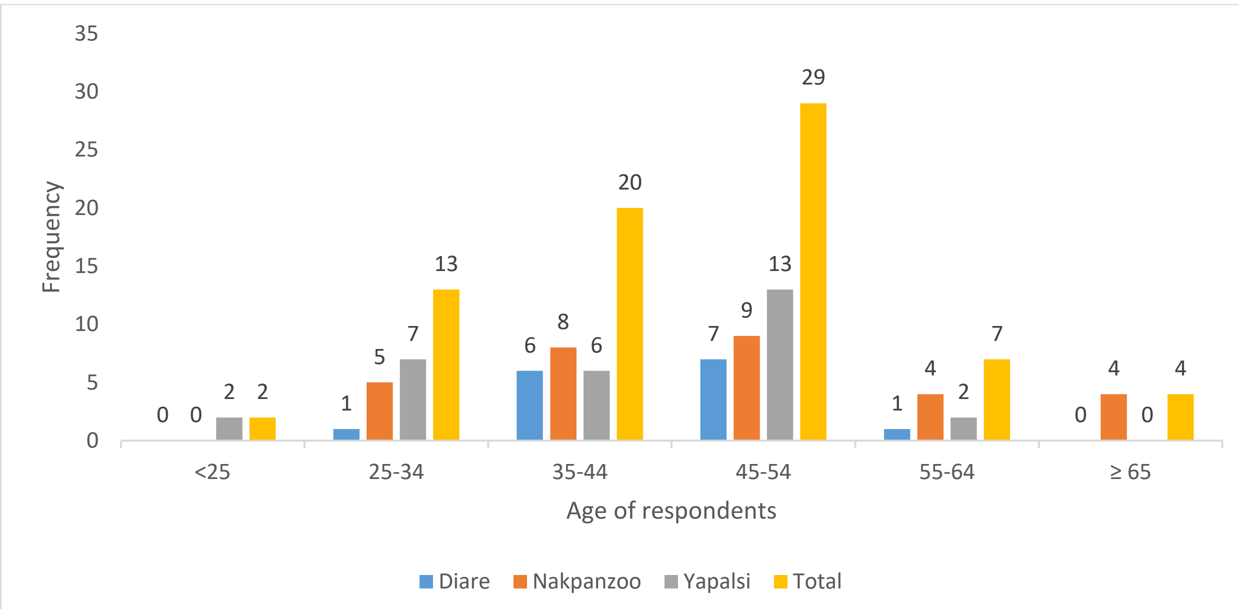

Figure 2: Age distribution of respondents in Diare, Nakpanzoo and Yapalsi communities

(Source: 2020 Field survey)

4.1.2 Descriptive statistics of categorical variables in the study

Table 2 below shows the distribution of gender, marital status, level of education, engagement in off-farm activities, membership of farmer group, and access to credit, extension services and subsidy available to respondents in the study areas. The results show that majority of farmers were men, representing 74.7 percent of the total sample. Nakpanzoo community recorded twenty-five

(83.3%) male respondents (the highest), followed by Yapalsi with twenty four (80%). The highest number of female rice farmers (8 respondents = 53.3%) resided in Diare community. The study revealed that majority of females do not own rice farms and women assist their husbands on rice fields. Women in the three communities are mostly engaged during rice sowing, harvesting and post-harvest handling, processing and marketing alongside the other activities in rice farming. Furthermore, the rice cultivation provides diverse employment opportunities and sources of income to the women in the study areas. For example, the women's group highlighted during focus group discussions that women farmers work both on their husbands' rice fields and as laborers on other rice farmers' field where they were paid either in cash or mostly in kind (rice paddy). The women farmers also sourced income through selling of cooked rice. The findings show that although majority of women do not own rice fields, they play significant role in rice production and source income to support the livelihood of the families. Hence, innovations in rice production such as the developed Farmer Support App should focus more on women farmers.

Seventy respondents were married (93.3%). The results show that rice farming in the selected communities is mainly done by couples where men are land owners and women support their husbands as indicated by farmers during FGDs. The findings are in line with the statements of farmers' during focus group discussions that *"rice production is labour intensive and large families are mostly advantaged"*. Furthermore, the findings of this study buttress farmers' observations. For example, all thirty interviewed farmers in Nakpanzoo community were married and the same community recorded the largest household size with a mean of 18.1. The result is in line with the findings of Martey et al., (2013) who stated that rice cultivation in northern Ghana is carried out mainly by married individuals.

Fifty-two (69.3%) out of seventy-five farmers interviewed had no formal education. However, findings in Yapalsi proved that very few educated farmers also engaged in rice cultivation. The highest frequency of twenty-two non-educated farmers were found in Yapalsi community (73.3%), and also all three farmers with tertiary education resided in the same community. The result is in agreement with the findings of Martey et al., (2013) and Nyadzi et al., (2019) who mentioned that majority of rice farmers were less educated in northern Ghana.

Thirty out of the total respondents (40%) engaged in off- farm work/employment. On the contrary, Martey et al., (2013) found out that more than half of the respondents in their study engaged in off-farm income generating activities. Diare had the highest number of farmers (9) engaged in off-farm activities (60%) in addition to rice farming. The results indicate that quite a number of farmers (40%) have other sources of income in addition to rice farming, but notwithstanding this, majority of farmers' (60%) livelihoods depend on rice cultivation.

Out of the seventy-five respondents, fifty (66.7%), fifteen (20%) and forty-six (61.3%) had access to agricultural extension services, credit and subsidized fertilizers, respectively. The results show that access to agricultural extension services is likely to influence farmers' agricultural decision-making process. The study further revealed that majority (80%) of the respondents did not have access to credit. The reason could be that the number of rice farmers (40%) engaged in off-farm work are able to partially finance their rice production activities from off-farm income, whiles the full-time rice farmers plough back part of their profit into rice farming, as stated by some farmers in Diare community. The result is inconsistence with Martey et al., (2013) who identified majority of rice producers had access to credit than non-rice producers. Furthermore, rice farmers' (61.3%) access to government-subsidized fertilizers is an indication of reduction in cost of rice production in the study areas.

Thirty six farmers (48%) in the three communities were members of farmer-based organizations. The results for these three indicators are impressive; thus, number of rice farmers who had access to agricultural extension services (66.7%), thirty-six farmers (48%) being members of farmer groups and farmers access' to subsidized fertilizers (61.3%). This is because farmer groups have been identified as channels for information and technology dissemination, hence farmers have access to agricultural extension services. In addition, strong farmer groups are able to provide benefits to its members in variety of forms, such as access to subsidized fertilizers. Table 2 highlights the findings.

Table 2: Descriptive statistics of categorical variables in the study

		Communities			
		Diare (n=15)	Nakpanzoo (n=30)	Yapalsi (n=30)	Total (n=75)
Variables	**Indicators**	**%**	**%**	**%**	**%**
Gender	Males	46.7	83.3	80	74.7
	Females	53.3	16.7	20	25.3
Marital Status	Married	93.3	100	86.7	93.3
	Unmarried	6.7	0	13.3	6.7
Level of Education	No formal education	73.3	63.3	73.3	69.3
	Basic	13.3	23.3	0	12
	JHS	13.3	10	13.3	12
	SHS/ Vocational/ Technical	0	3.3	3.3	2.7
	Tertiary	0	0	10	4.0
Off-Farm Work	Yes	60	46.7	23.3	40.0
	No	40	53.3	77.7	60.0
FBO membership	Yes	40	50	50	48.0
	No	60	50	50	52.0
Access to Extension Services	Yes	66.7	86.7	46.7	66.7
	No	33.3	13.3	53.3	33.3
Access to Credit	Yes	26.7	26.7	10	20.0
	No	73.3	73.3	90	80.0
Access to fertilizer Subsidy	Yes	60	56.7	66.7	61.3

No	40	43.3	33.3	38.7

(Source: 2020 Field survey)

4.1.3 Descriptive statistics of continuous variables used in the study

The study captured data on household size, years of farming experience and farm size of respondents. The mean household size of the farmers in the study areas was 16, with a maximum and minimum values of fifty and five, respectively. Comparing Diare and Yapalsi communities, the former recorded the highest records for both household size (50 people) and married respondents (93.3%) whiles the opposite is true for the Yapalsi community (household size =5 and marital status =86.7%). The results indicates that household size increased for communities with higher marital status and vice versa in these two communities (Diare and Yapalsi). Furthermore, a large household size is an indication of labor availability. Both Diare and Yapalsi communities came at par with farm size (maximum = 8ha; minimum = 0.4ha).

The least and largest farm size for rice cultivation in the study areas were 0.4 and 8 hectares, respectively. Comparing Yapalsi and Nakpanzoo communities, Nakpanzoo has the more extension visits (24) per season and the smallest farm sizes (6 ha). This confirms the findings of the focus group discussions, where farmers stated that they were advised by agricultural extension agents to cultivate smaller farm plots intensively in other to observe good agronomic practices and have higher yields.

The study recorded thirty-five years of farming experience as the highest and two years as the lowest among the respondents. All four farmers aged above sixty-five years lived in Nakpanzoo community, where the highest years of farming experience (35 years) were also recorded. Similarly, the youngest farmers below twenty-five years of age resided in Yapalsi community, where the least years of farming experience (2) were observed. The results are presented in Table 3 below.

Table 3: Descriptive statistics of continuous variables in the study

		Community			
Variables	**Indicators**	**Yapalsi**	**Nakpanzoo**	**Diare**	**Total**
Household size	Mean	10.7	18.1	10.0	15.5
	Min	5	6	6	5
	Max	25	38	50	50
Years of Farming Experience	Mean	9.6	12.6	5.1	10.9
	Min	2	3	2	2
	Max	25	35	20	35
Farm size (hectares)	Mean	2.2	2.0	1.4	2.2
	Min	0.4	0.4	0.4	0.4
	Max	8	6	8	8

(Source: 2020 Field survey)

4.1.4 Rice farming practices

The following practices were identified during focus group discussion:

Land clearing: rice farmers use weedicide to clear the land (so called 'Condemn', as they do not know the actual name of this product). In addition, they remove shrubs, debris and grass using cutlass.

Land preparation: This consists of ploughing and leaving the land for about a month, followed by the harrowing.

Cultivation: Sowing of rice is done by broadcasting. This takes place when moisture level in the fields is adequate in the opinion of the farmer.

Post-emergence weedicides are applied after the rice germinates.

First fertilizer application is carried out three weeks after sowing, at adequate soil moisture level (when the palm gets moist upon forming a ball of soil and water does not drain from the ball of soil formed)

Weed control: rice farmers uproot weeds manually and spray weedicide when rice crop is about two months old.

Second fertilizer application (Urea) is in the third month of development. The urea boosts the growth of the rice and enables it to produce and fill grains.

Rouging off rice types: the off-type rice varieties are either removed by hand or allowed to stay till harvest time. These mature early and can be harvested for home consumption.

Frequent field monitoring by farmers is carried out in this period to observe progress of the crop and the water level in the farm.

Harvesting: rice is harvested when panicles turn brown.

4.2.0 Objective one: To identify the currently available hydro-climatic information to farmers in the study area

Introduction

In order to successfully achieve objective one, there was the need for the study to unravel vital indicators where the researchers may term as preliminary/ preambles to objective one. These included topics captured as rice farmers' access to information services, types of information services currently received by rice farmers in the study areas, nexus between expert information services and types of information services accessed by rice farmers and sources of currently available information services among others.

4.2.1. Rice farmers' access to information services

Previous researchers have elaborated on the importance of information in agricultural production. A sustainable approach to reduce agricultural economic losses, increase profits, and enhance strategic and tactical agricultural decisions is by increasing farmers' access and use of climate information and forecast (Haigh et al., 2015). Hence, this study aimed to identify rice farmers' access to agricultural information and found out that majority of rice farmers in the study areas had access to agricultural information services. Details of types of information services accessed by farmers are also elaborated in this study. The study showed that sixty-seven farmers' (89.3%) had access to information services out of which twenty-nine were from Nakpanzoo community. Yapalsi recorded the highest number of farmers (16.7 %) who did not have access to information services. More than three quarters of respondents have access to information services because the three communities are known for their active involvement in rice production and therefore are engaged by several organizations who provide farmers with agricultural information services among others. On the contrary, Onyango et al., (2014) and Kumar et al., (2020) reported that farmers lack access to weather and climate forecasts information, although, they had access to other information services such as inputs, production technologies, mitigation and adaption measure to climate change and disease control. The results are shown in Figure 3 below.

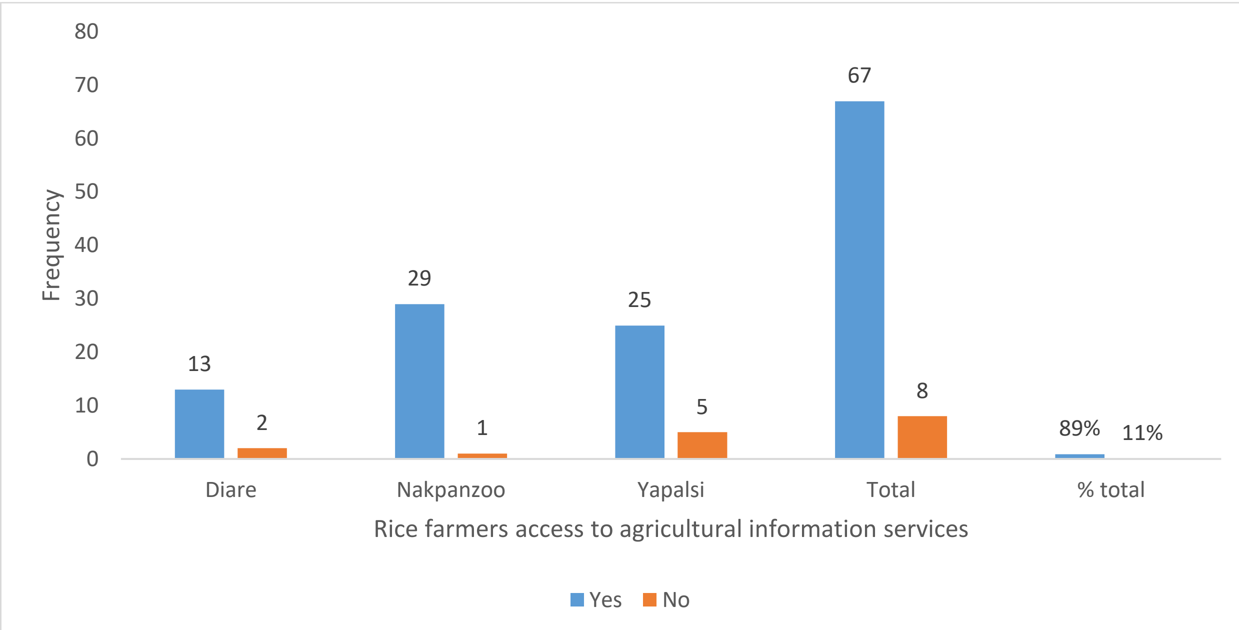

Figure 3: Rice farmers' access to agricultural information services in the study areas

(Source: 2020 Field survey)

4.2.2 Types of information services currently available to rice farmers in the study areas

Three main types of information services were identified in the study, namely: technical, financial support and capacity building. Technical support services comprise information on water availability, seasonal weather forecast (rainfall, relative humidity, storms and atmospheric temperature) input prices and availability, crop variety selection and market prices and availability. Capacity building services/support includes agricultural education and training on good agronomic practices. Financial support services are in-kind and cash services provided to farmers to help them adapt to the varying climate changes such as providing of suitable crop varieties per season, and fertilizers to combat identified new weed species. The study revealed that sixty (80 %) out of the seventy-five respondents received information on seasonal weather forecast, representing the highest level of the information services received. The second highest information service received by farmers was advice on crop variety selection with a frequency of fifty-six (74.7%). Farmers' sourced technical support more often because of increased in climate change variabilities and high vulnerability of the study areas because farmers depend highly on rain-fed agriculture. However, farmers in Central Tongu district were reported to lack access to information on climate and weather, notwithstanding, information on market availability, input selection, and capacity building were available to these farmers (Anaglo et al., 2014). Moreover, in Bangladesh, farmers received both technical and capacity building information services (Kumar et al., 2020). Access to credit is the least type of information received by farmers in this study with fifteen (20%) positive responses as shown in Table 4 below.

Table 4: Descriptive statistics of continuous variables in the study

		Communities			
		Diare (n=15)	**Nakpanzoo (n=30)**	**Yapalsi (n=30)**	**Total (n=75)**
Information services received	**Indicator**	**%**	**%**	**%**	**%**
Water availability	Yes	0	73.3	53.3	50.7
	No	100	26.7	46.7	49.3
Seasonal weather forecast	Yes	73.3	83.3	80	80
	No	26.7	16.7	20	20

Input prices and availability	Yes	40	56.7	76.7	61.3
	No	60	43.3	23.3	38.7
Crop variety selection	Yes	46.7	90	73.3	74.7
	No	53.3	10	26.7	25.3
Agricultural education and training	Yes	26.7	73.3	76.7	65.3
	No	73.3	26.7	23.3	34.7
Market prices and availability	Yes	26.7	36.7	13.3	25.3
	No	73.3	63.3	86.7	74.7
Access to Credit	Yes	26.7	26.7	10	20.0
	No	73.3	73.3	90	80.0

(Source: 2020 Field survey)

4.2.2.1 Nexus between expert information services and types of information services accessed by rice farmers in the study area

All nine experts interviewed provided technical support to rice farmers. Five provided capacity building and two experts provided financial support to farmers through their respective institutions. Majority of rice farmers (80%) received technical support in the form of seasonal weather forecast, followed by capacity agricultural training (65.3%). The least number of farmers received agricultural credit services (20%). The study identified that as the number of experts providing a particular information service increased, likewise an increase in the number of farmers accessing that information service. For example, where all nine experts provided technical support services about 80% of farmers accessed/ received such information service. Similarly, where only two experts supports farmers financially, 20% of farmers had access to credit services. The higher the number of experts providing services, the higher the number of farmers receiving that particular service. Therefore, more experts from different institutions are needed to reach out to a large number of rice farmers. Figure 4 represents percentage of individual farmers accessing available information services from experts.

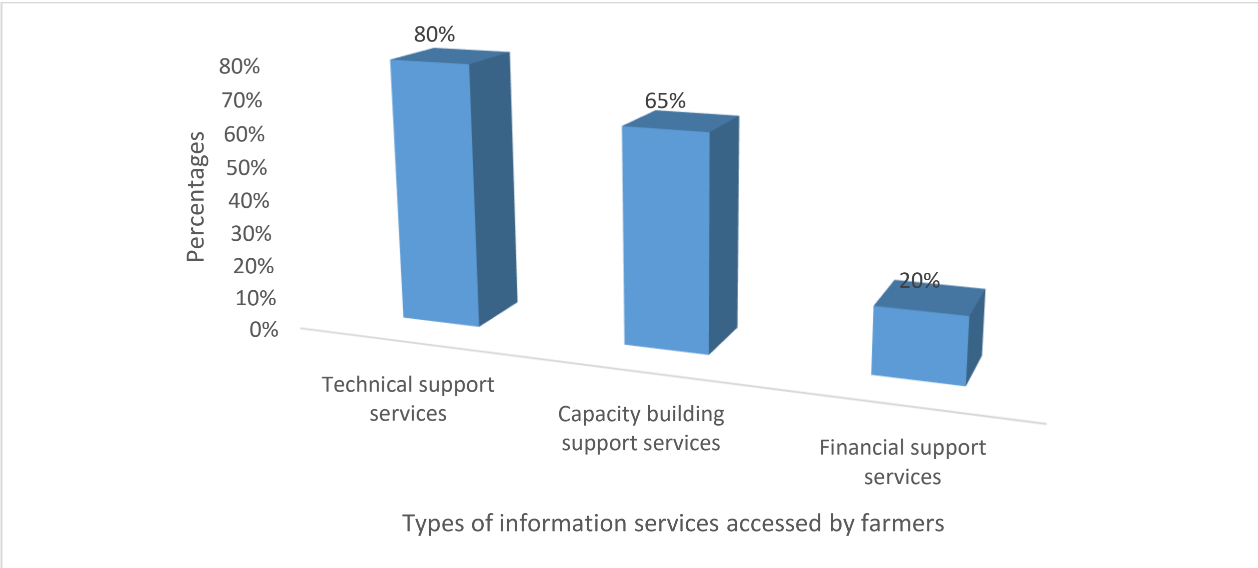

Figure 4: Types of information services accessed by farmers from experts

(Source: 2020 Field survey)

4.2.3 Source of currently available information services to rice farmers in the study areas

Relevant to this study was the identification of sources of information to farmers. Interactions with respondents revealed that rice farmers currently source agricultural information from radio stations, agricultural extension agents, agricultural organizations/institutions, peers, television and mobile phones, in addition to farmers' local knowledge on weather forecast. The study further revealed that radio stations and agricultural extension agents are the main providers of agricultural information to fifty-four (72%) and forty-seven farmers (62.7%), respectively. Farmers listen to Zaa radio (a local radio station accessed by the three communities) broadcast on weather and climate information every Sunday. The few farmers who did not access information via radio stated they were challenged economically to purchase batteries, in addition to cost of radio devices, lack of mobile phones, and high cost of electricity bill. The study identified that most of the farmers who sourced information from agricultural extension agents were members of farmer-based organizations. Mobile phones, television and some government, agricultural and research organizations (MiDA, WASCAL, ADVANS and Ministry of Food and Agriculture) provide information services to twenty-four (32%), nineteen (25.3%) and eleven farmers (14.7%), respectively. Only six farmers (8 %) out of the total number of respondents' source information from their colleague farmers. Similar information sources have been identified in different farming locations, however, the preference for one source over the other differs. For example, in the U.S., McNew et al., (1991) estimated about 63% of all types of weather forecast information was sourced via television whiles 25% of farmers sourced weather information via radio. Similarly, Nyadzi et al., (2019), estimated majority of farmers sourced climate information from government, private and local knowledge. Again, Radeny et al., (2019) mentioned that farmers in East Africa sourced weather information from indigenous knowledge experts, relatives, friends, neighbours, farmers' own observations, media (radio), village and clan meetings, service providers such as NGOs, extension agents and researchers. Other sources included mobile phones, leaflets, brochures, television, and internet (Kumar et al., 2020). Figure 5 represents the results.

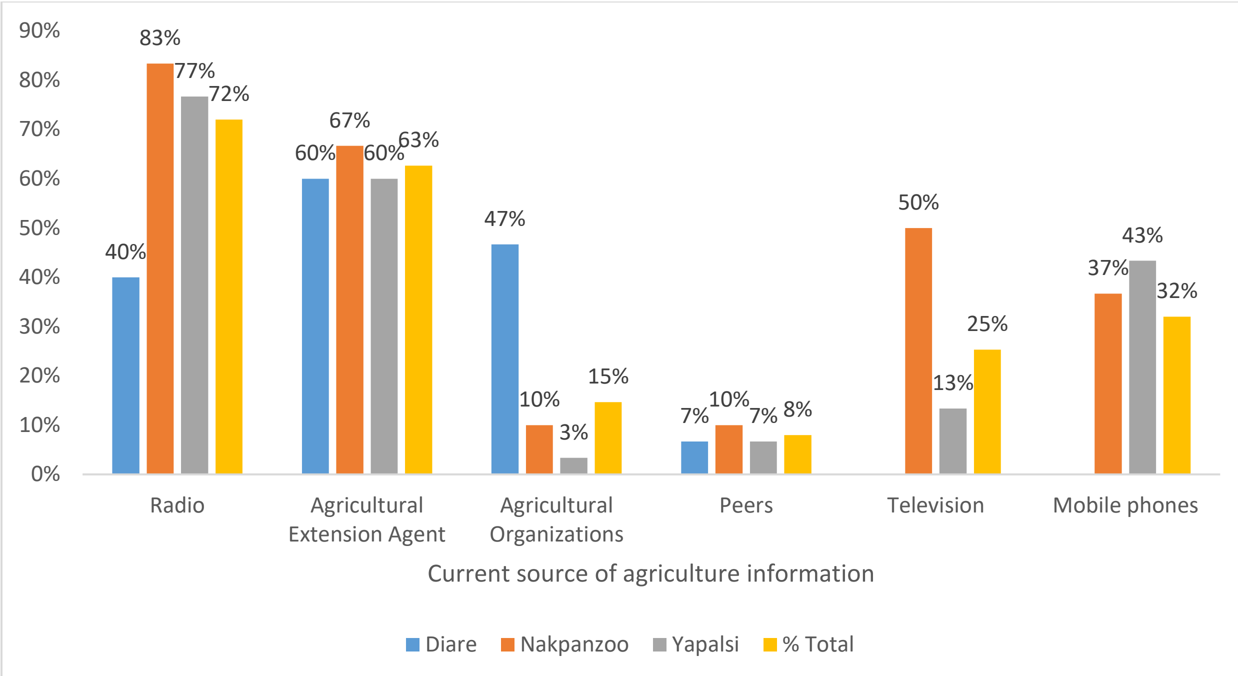

Figure 5: Source of currently available information services to farmers in the study areas

(Source: 2020 Field survey)

4.2.3.1 Integrating findings from individual rice farmers and focus group discussions

The integration of findings was done in Nakpanzoo and Yapalsi, where the focus group discussions were held. Both individual farmer responses and FGDs showed that radio stations are the most important source of weather information for rice farmers, followed by agricultural extension agents. The quantitative results from individual farmers revealed that approximately 7% of rice famers sourced weather information from their colleague farmers and some agricultural organizations which were not mentioned during the focus group discussions. It can be observed that farmers in the study areas provided similar information when in groups and in single interviews which could reflect the importance of the study topic. For instance, it was revealed during focus group discussions that only men sourced information from television and mobile phones, consequently, results from individual farmers indicated that about 25% of respondents sourced information via television station and these farmers happened to be all men. Figure 6 represents results the quantitative responses from individual farmers.

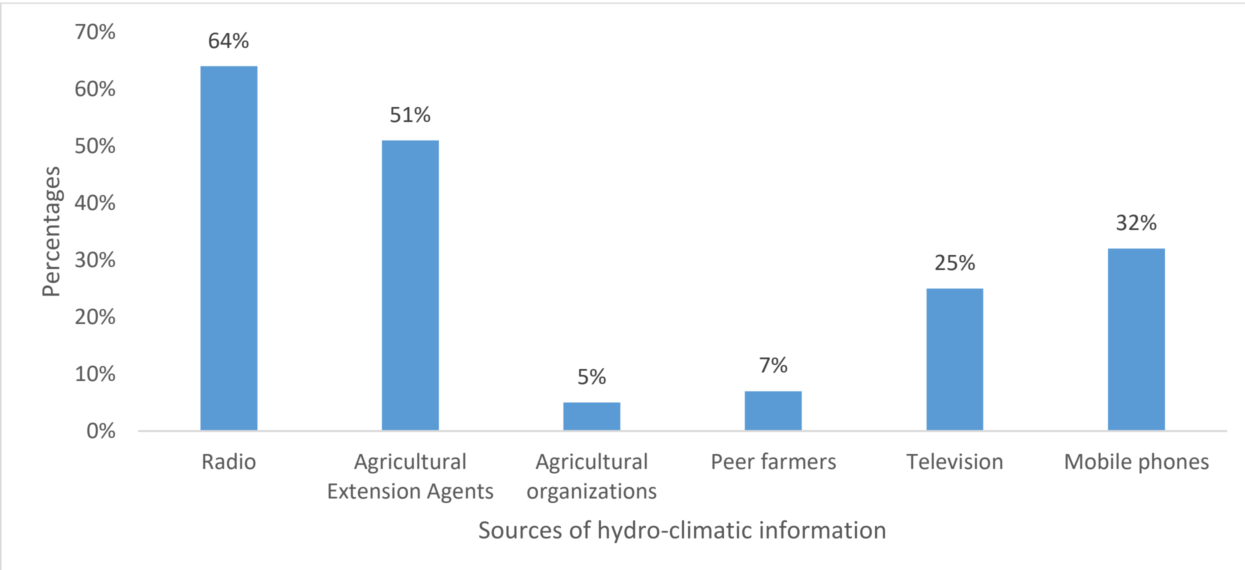

Figure 6: Sources of available hydro-climatic information to rice farmers; Note that farmers could source information from multiple sources

(Source: 2020 Field survey)

4.2.4. Rice farmers' access to mobile phones

Mobile phones comprises both smartphones and other phones in this study. Seventy-two (96%) out of the total number of farmers have access to mobile phones. Out of the 72 farmers with access to mobile phones in the study areas, 78% represent men with the remaining 22% being females. The three respondents who did not own mobile phones were all females in Yapalsi community. Although, poverty is known to prevail in rural communities, farmers in the study areas could afford mobile phones. The reason could be that either family members who travel to Southern Ghana for greener pasture buy phones for farmers or farmers themselves could afford to buy mobile phones.

The result coincides with the findings of Kumar et al., (2020) who stated that more than half of the respondents had access to mobile phone. The results are presented in Figure 7 below.

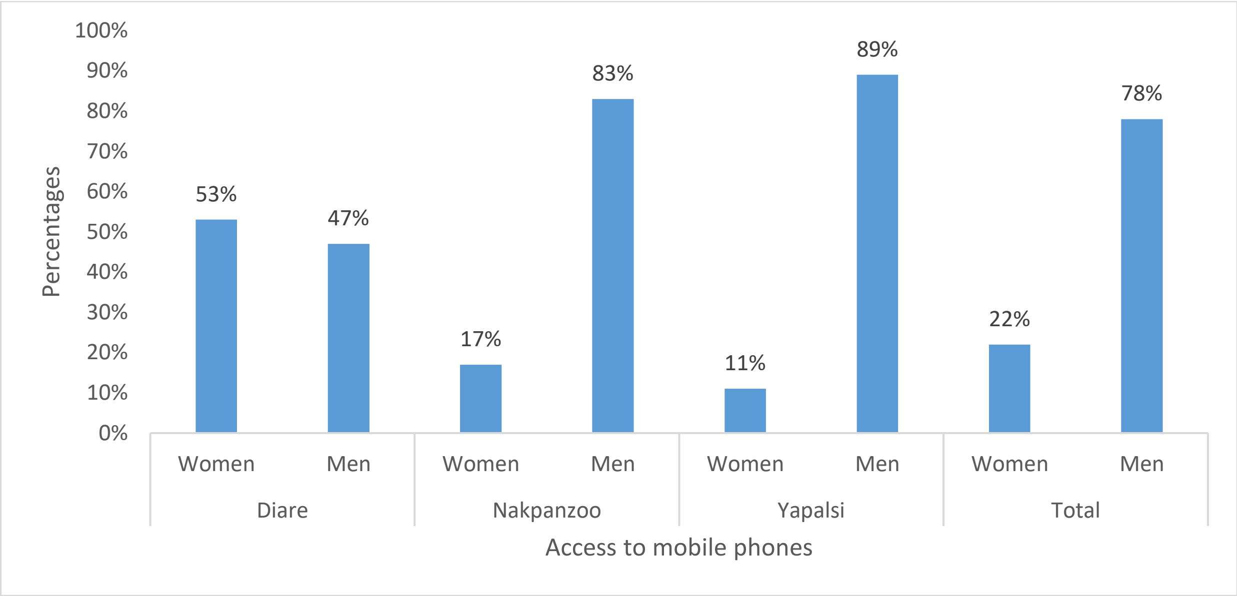

Figure 7: Rice farmers' access to mobile phone in the study areas

(Source: 2020 Field survey)

4.2.4.1 Access to weather/ rainfall information via mobile phones

The study discovered that not all farmers who owned mobile phones used them to access agricultural information including weather/rainfall information. Thirty-six (50%) out of the seventy-two farmers who owned mobile phones used them to access weather/rainfall information. The findings are in agreement with the study by Kumar et al., (2020) and Tadesse & Bahiigwa (2015) who mentioned that few farmers who owned mobile phones accessed agricultural information via the phones. However, only two out of the sixteen women respondents access weather/rainfall information via mobile phones. These findings serve as base to adopt mobile phones as agricultural communication channel to farmers, but more emphasis needs to be on female farmers when using this type of technology. The results are shown in Figure 8 below.

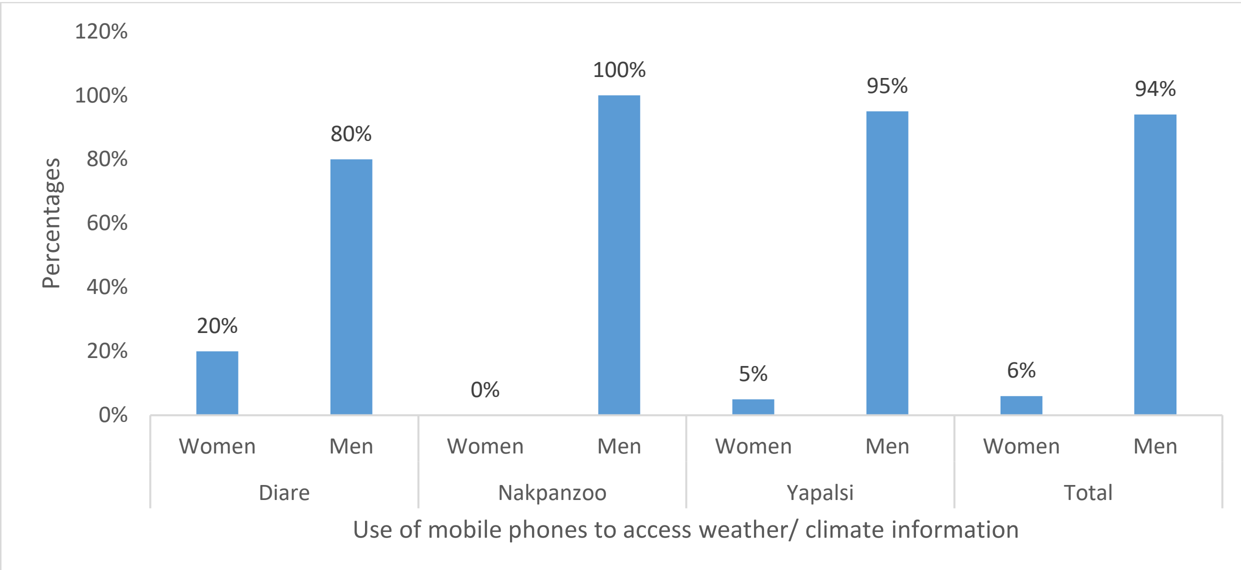

Figure 8: Access to weather/ rainfall information via mobile phones

(Source: 2020 Field survey)

4.2.4.2. Integrating results from focus group discussion and individual farmers' on access to and use of mobile phones for weather/ rainfall information.

The study sought to compare responses of farmers when in group (FGD) and when individually interviewed. Access to mobile phones and their use for weather/rainfall information was dominated by men. During the focus group discussions, ten (76.9%) out of the thirteen men had access to mobile phones and three of them accessed weather/rainfall information via their phones, whiles only one out of the twelve women had access to mobile phone but did not access weather/ rainfall information. Similarly, results of individual interviews revealed that fifty six men (74.7%) had access to mobile phones out of which thirty four (60.7%) accessed weather/rainfall information via the phones. Only two (12.5%) out of the sixteen women who had access to mobile phones accessed weather/rainfall information via the phones. Although less women had access to mobile phones for weather/rainfall information, these women showed interest in accessing weather/rainfall information via mobile phones when initiated. The results are highlighted in Figure 9 below.

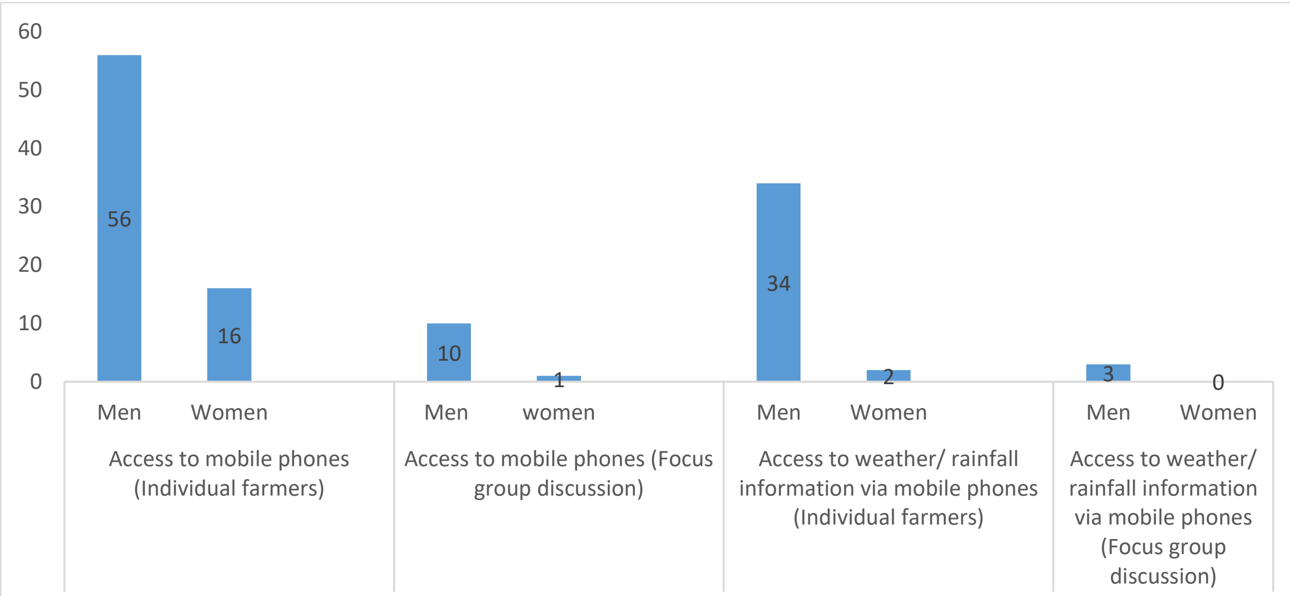

Figure 9: Focus group discussion in (Diare and Nakpanzoo communities) and individual farmers' in (Diare, Nakpanzoo and Yapalsi communities) access to and use of mobile phones for weather/ rainfall information

(Source: 2020 Field survey)

4.2.4.3 Format of weather/rainfall information communication via mobile phones

The study sought to identify ways through which weather/rainfall information are communicated to farmers via mobile phones. The findings were that rice farmers received weather/rainfall information via mobile phones either by SMS, phone calls from Agricultural Extension Agents either to individual farmers or leaders of farmer groups, Internet, Mobile Apps or calls from their peers. In addition, some farmers had more than one format of sourcing weather/rainfall information via mobile phones.

Out of the thirty-four men who had access to weather/rainfall information via mobile phone (Figure 7 above), in descending order, the format for weather/rainfall information access for the men were; calls from Agricultural Extension Agents (26 = 76.5%), SMS (20 = 58.8%), Mobile Apps (2 = 5.9%), Internet (1 = 2.9%) and calls from peer farmers (1 = 2.9%). Only one woman (Diare community) out of the two who had access to weather/rainfall information via mobile phone, sourced information from Agricultural Extension Agents calls. The other woman (Yapalsi community) with a phone did not utilize the service. The lead farmers are mostly responsible for receiving calls from Agricultural Extension Agents then pass on the message to colleague farmers. Although, majority of farmers were illiterate, SMS messages were sometimes read by relatives of farmers who interpret the message in the local language (Dagbani). Some studies reveal farmers sourced information on mobile phone in the form of SMS and voice mails (Tadesse & Bahiigwa 2015)

All three farmers who had tertiary education resided in Yapalsi community, the same community recorded farmers who sourced weather/rainfall information through internet and mobile Apps. It can be argued that education is positively correlated with technology advancement. Table 5 below shows the results.

Table 5: Mode of accessing weather/ rainfall information via mobile phones

Community name	Gender	Response	Communication format: Calls from Agricultural Extension Agents	SMS	Internet	Mobile App	Calls from Peer Farmers
Diare	Men	Frequency	4	1	0	0	0
		Percentage	80%	20%	0	0	0
	Women	Frequency	1	0	0	0	0
		Percentage	20%	0	0	0	0
Nakpanzoo	Men	Frequency	6	9	0	0	1
		Percentage	50%	75%	0	0	8.3%
	Women	Frequency	0	0	0	0	0
		Percentage	0	0	0	0	0
Yapalsi	Men	Frequency	16	10	1	2	0
		Percentage	88.9%	55.6%	5.6%	11.1%	0
	Women	Frequency	0	0	0	0	0
		Percentage	0	0	0	0	0
Total	Men	Frequency	26	20	1	2	1
		Percentage	76.5%	58.8%	2.9%	5.9%	2.9%
	Women	Frequency	1	0	0	0	0
		Percentage	50%	0	0	0	0

(Source: 2020 Field survey)

7.4. Smartphone's availability in the family/household

The study further sought to specifically identify households with smartphones and the type of mobile Apps used to access weather/rainfall information. The purpose for this is to unravel the potential of smartphone as a media for providing area specific weather forecast information. The focus was not solely on rice farmers, but also on the immediate household/family of the rice farmers. This was to help unravel farmers' knowledge on smartphone use. The results show that forty (55.6%) out of the seventy-two farmers had smartphones in their households. Twelve (75%) and twenty-eight (50%) out of the sixteen women and fifty-six men, respectively, had access to smartphones in their respective homes. The farmers stated that the smartphones either belonged to them or a member of the households. The results are presented in Figure 10 below.

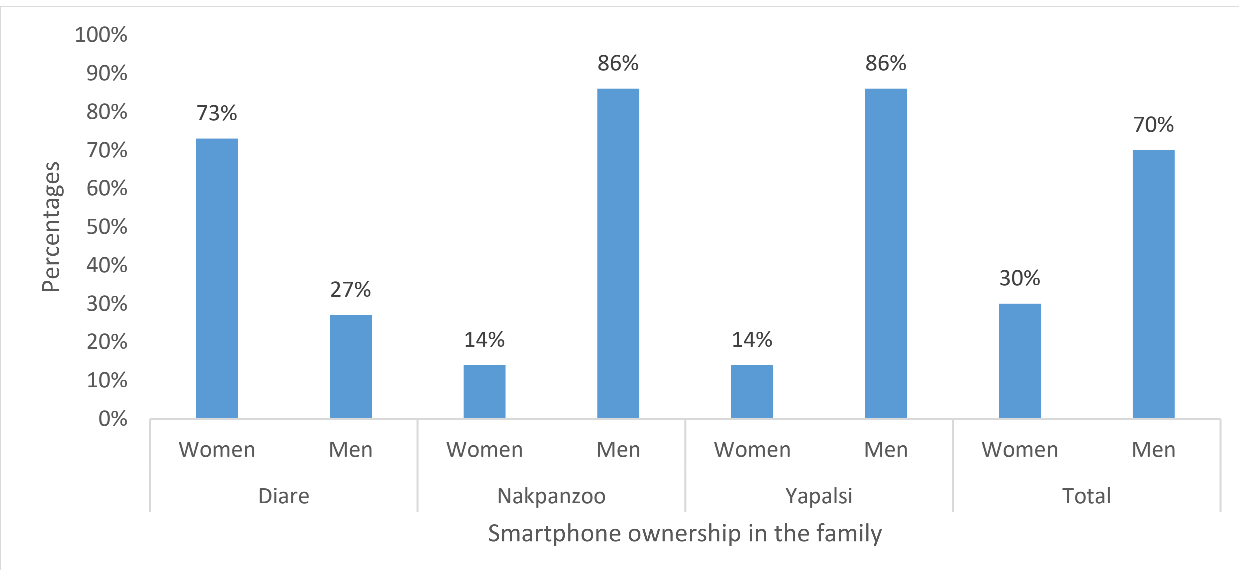

Figure 10: Availability of smartphones in the study areas

(Source: 2020 Field survey)

4.2.4.4 Access to weather/rainfall information via smartphones and types of Mobile Apps

Only nine out of the twenty-eight male farmers used smartphones to access weather/rainfall information. Furthermore, six (out of the nine farmers used either climate/weather app (4 farmers) or Agricultural News App (2 farmers) to obtain weather/rainfall information. The reason could be that farmers do not own the smartphones themselves and rather sought weather/rainfall information from smartphone owners in the household. The remaining three farmers stated that they did not use any Mobile App but they rather google to know the weather forecast for the day. None of the women in the study accessed weather information via the smartphones. Smartphones were owned by members of the household (for example, their offspring and husbands) and not the women themselves. Secondly, the women had no idea about the sources (television, smartphones, etc.) of weather information received from members of their household (husbands, in laws, children, etc.). Nevertheless, during focus group discussions and individual interviews women showed interest in the use of smartphones. The results are presented in Figure 11 below.

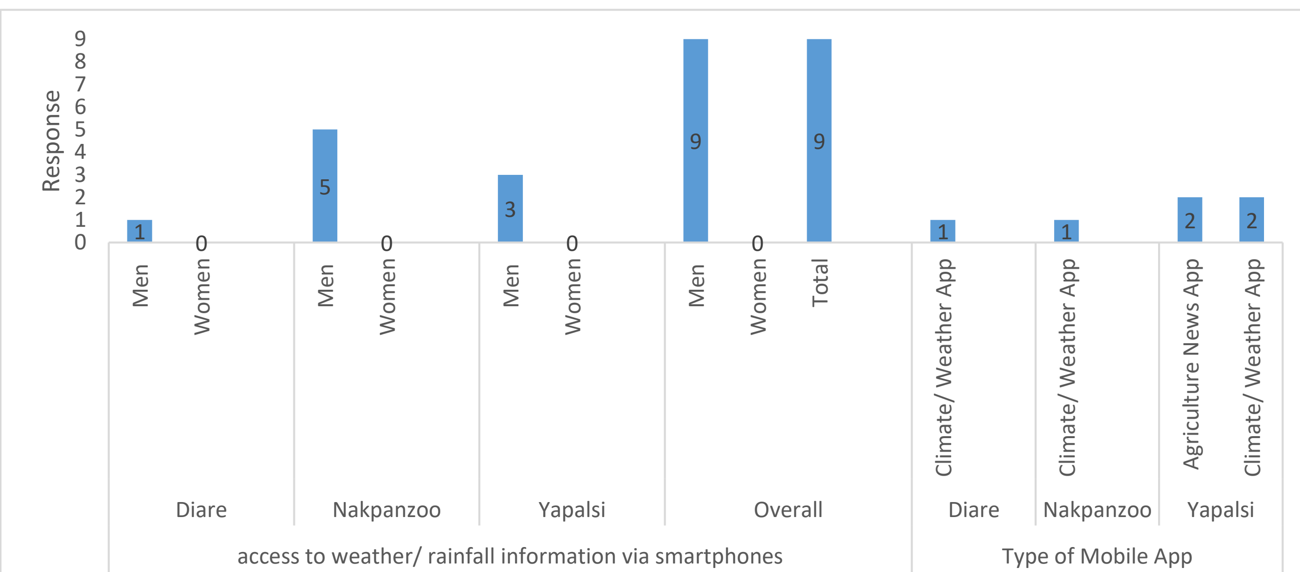

Figure 11: Access to weather/rainfall information via smartphones and types of Mobile Apps

(Source: 2020 Field survey)

4.3.0 Objective two: To identify the hydro-climatic information needs of farmers' in the study area.

Introduction

The researcher gathered information on rice farmers' knowledge on local/ traditional/ indigenous weather forecast, local weather forecast methods and indicators used, to support findings on farmers information needs. Note that the terms local, indigenous and traditional forecast knowledge or methods are used interchangeably.

4.3.1 Rice farmers' knowledge of local weather

The study sought to first highlight rice farmers' understanding on local weather and the methods of weather/climate forecast, before unravelling their needs. The results revealed that only two farmers had poor understanding of local weather information. Twenty-five farmers (33.3%) had excellent understanding of local weather and majority of farmers (64%) somewhat understood local weather. A contradictory response was recorded among Bangladesh farmers where most of the respondents reported to have poor understanding of local weather whereas few somewhat understood local forecasting and very few had excellent knowledge on indigenous weather forecast (Kumar et al., 2020). Figure 12 below represents the results. Figure 13 indicates that advancement in age does not necessarily guarantee farmers experience in local forecast knowledge. The reason being that both the aged farmer (above 60 years) and one of the youngest farmer (below 25 years) came at par with excellent knowledge on local weather forecast. The majority within the working class mentioned that they had somewhat knowledge on local weather forecast.

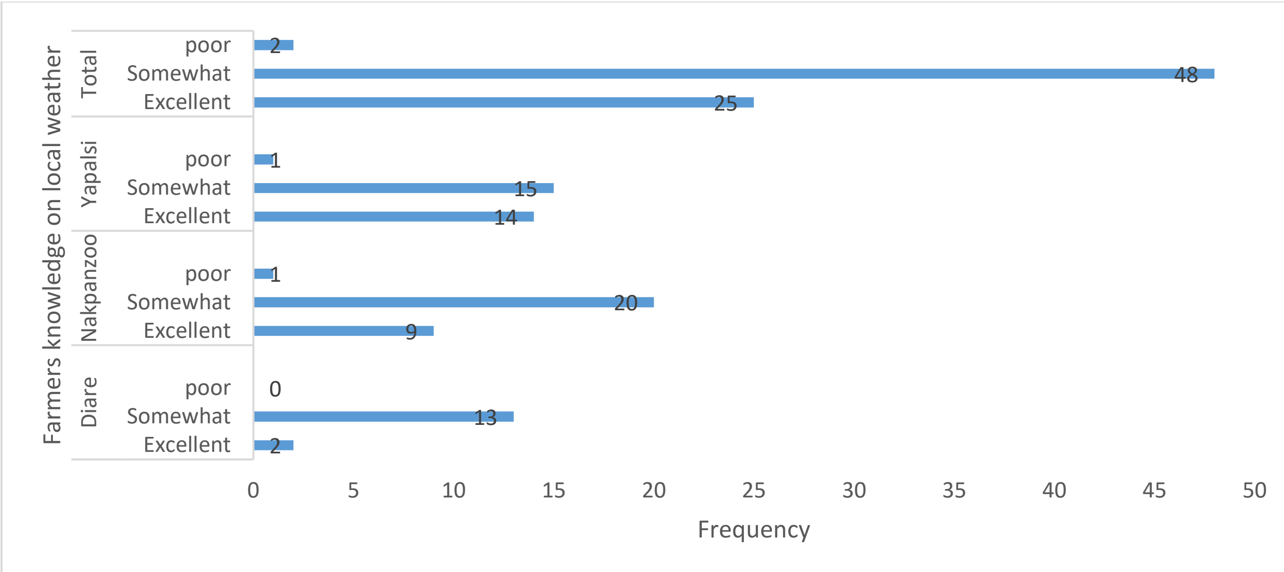

Figure 12: Farmers' knowledge on local weather forecast

(Source: 2020 Field survey)

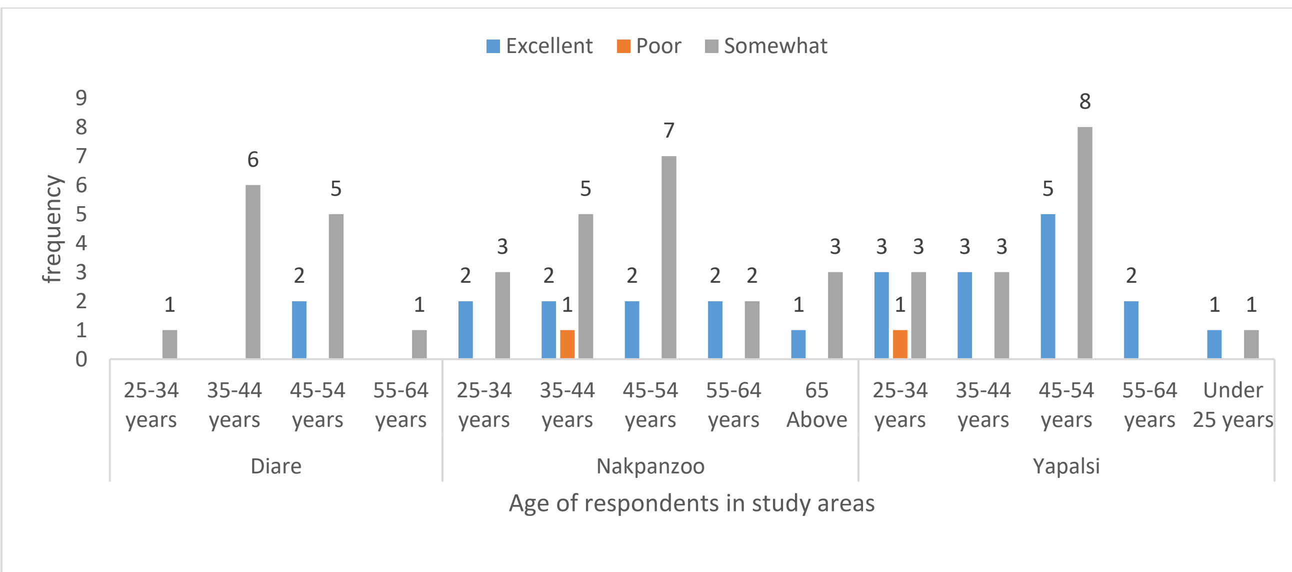

Figure 13: Relationship between farmers' knowledge on local weather forecast and age of farmers.

(Source: 2020 Field data)

4.3.2. Local weather and climatic forecast methods

Rice farmers in the valleys revealed numerous ways of forecasting weather and climate traditionally. These are presented in Table 6.

Table 6: Local signs used for weather forecast

Indicator	Meaning
Black ants moving their eggs from one place to another	Rains
Strong winds blowing from East to West	Rains
Reddish appearance of the moon with clouds at one side	Rains
A very warm weather	Rains
Some birds' craw in the bush	Rains
Presence of ruminants in the house at unusual times	Rains
Unusual sounds of frogs in the afternoon	Rains
Extreme scorching sun	Rains
Jalenjahe/duck (Anas platyrhynchos) faces East when swimming	Rains
The return of flock of birds to their nest in the evening after leaving the nest in the morning	Enough rains that season
Formation of clouds coupled with little wind	Heavy rains
Presence of army worm pupa	Drought
Snails remaining/hiding in their shells	Drought
Jalenjahe/duck (Anas platyrhynchos) faces West when swimming	Drought
Absence of strong wind at the onset of rains	Normal season

(Source: 2020 Field Survey)

Some local indicators used in Mozambique include incidence of clear moon, a clearly visible sun with no clouds around, occasions of numerous stars in the sky; blowing of wind in one direction without response from the opposite direction and a very hot temperature throughout the year are indications of drought (Salite, 2019). Similarly, in Northern Ghana, indicators such as formation of dark clouds coupled with strong winds, gathering of clouds at north-east direction, the rapid flapping and stretching of the wings of ducks, the burrowing of caterpillars into the soil among other signs as indication of rains (Nyadzi et al., 2020).

4.3.3 Hydro-climatic information needs of rice farmers in the study areas

The findings of the study revealed that four kinds of weather parameters are most needed by rice farmers in the study areas. These are: rainfall, relative humidity, temperature and prediction of storm occurrence. The farmers stressed the need for location-specific weather/rainfall forecast, but not general information received from the aforementioned sources. Information on temperature and relative humidity were the second and third most needed information for farmers, respectively. The farmers expressed their grievance on occasions when rain falls shortly after applying chemical fertilizers, weedicides or pesticides. According to the farmers all the chemicals are washed away by the rains and this contributes to high production cost and low rice yields. The respondents further stated that information on relative humidity, temperature and storm direction are significant to farmers decision making on activities such as time for fertilizer/chemical application, sowing, rice variety selection among others. Most importantly, according to respondents, access to area specific weather information will influence their agricultural decisions and adaptation of measures to respond to climate change. Similar findings have been reported where farmers prioritize rainfall information in addition to other needs. For example, in India, farmers most prioritized information needs were on weather (specifically on rainfall), and others were diseases and pest control, pesticides, market prices and information on seeds (Mittal et al., 2010). Lizumi & Ramankutty (2015) highlighted rainfall and temperature as the most needed information by farmers. Furthermore, key information needs of farmers in Bangladesh in order of priorities were rainfall, storm surge, hailstorm, temperature, fog and relative humidity (Kumar et al., 2020). Figure 14 below shows that all the respondents need information on rainfall.

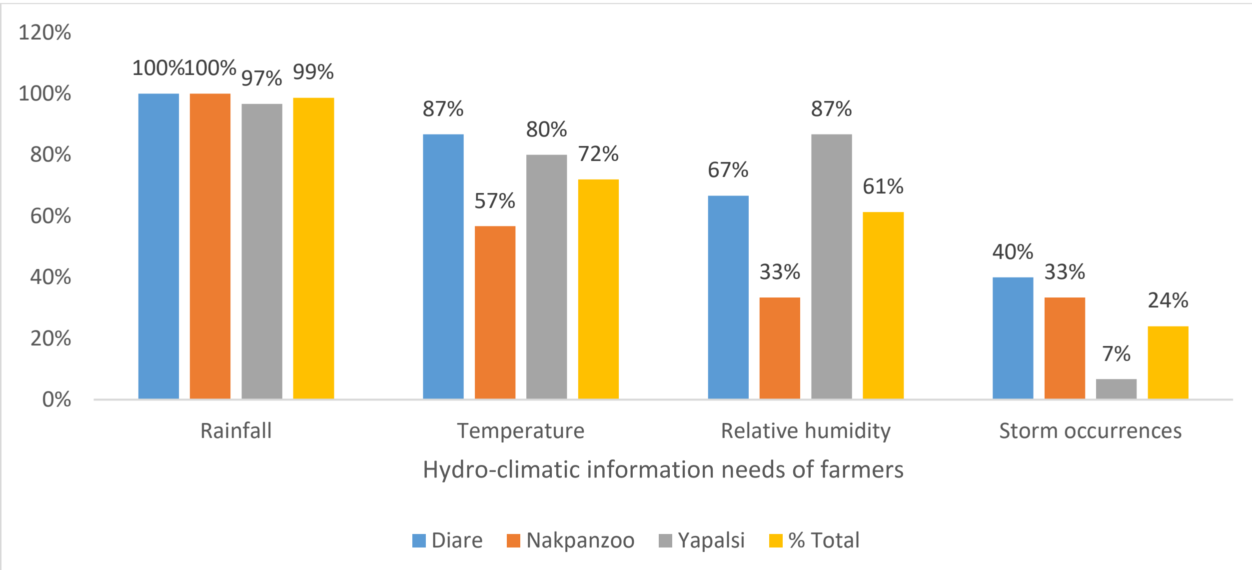

Figure 14: Hydro-climatic information needs of farmers in Diare, Nakpanzoo and Yapalsi communities

(Source: 2020 Field survey)

4.3.4 Advance time for weather forecast required by rice farmers in the study areas

The study revealed that twenty-eight (37.3%), seventeen (22.7%) and thirteen (17.3%) respondents need weather forecast information one month, two weeks and one week, respectively ahead of time to inform their agricultural decision-making process. Only three (4%) out of the seventy-five respondents suggested the need for weather forecast information three months in advance. The decisions include planting and harvesting dates, crop types and variety selection, time of fertilizer application, etc. Farmers in Bangladesh prefer to be informed on weather forecast in a descending order of preference at least two to one week, in real times, on seasonal bases, one month, 2/3 days and the least a day ahead of time (Kumar et al., 2020).

The results are shown in Figure 15 below.

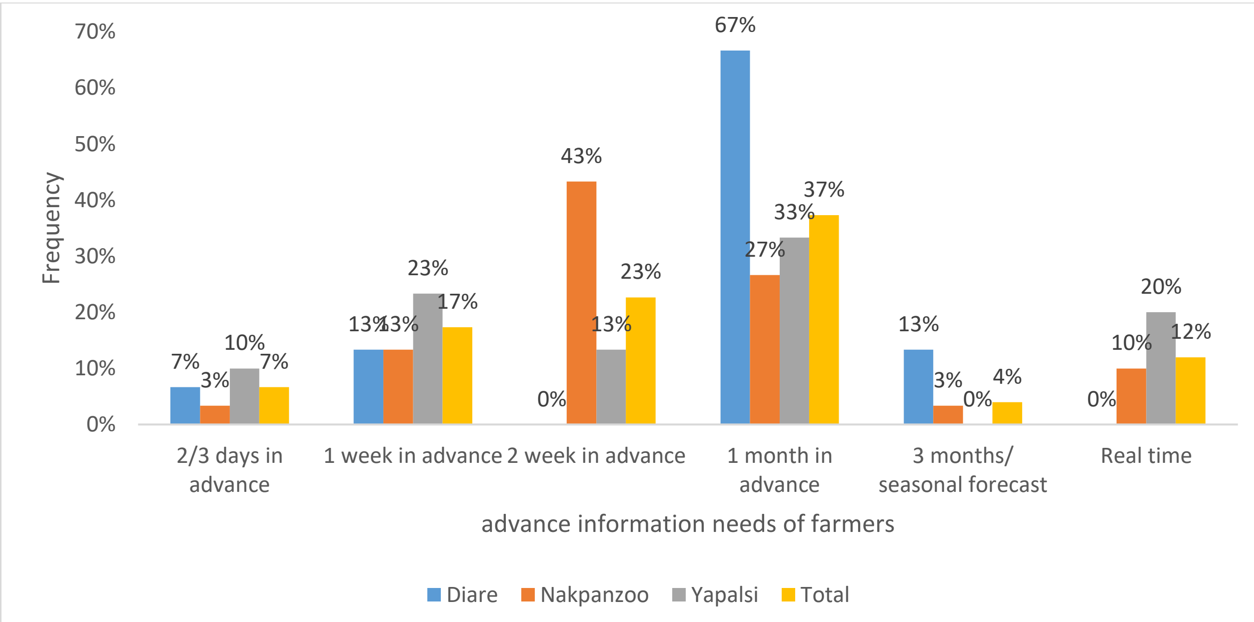

Figure 15: Advance information needs of rice farmers in the study areas

(Source: 2020 Field survey)

4.3.4.1 Nexus between how often weather information is accessed and advance needs of farmers

Focus group discussions revealed that rice farmers access weather information on three occasions; weekly (on radios), at the beginning of the farming season (from agricultural extension agents) and as and when farmers are in need of the information (from agricultural extension agents). However, interactions with individual farmers showed that majority of farmers (37.3%) prefer to access weather information one month in advance, while very few farmers (4%) prefer to be informed three months in advance. The results are presented in Figure 16 below.

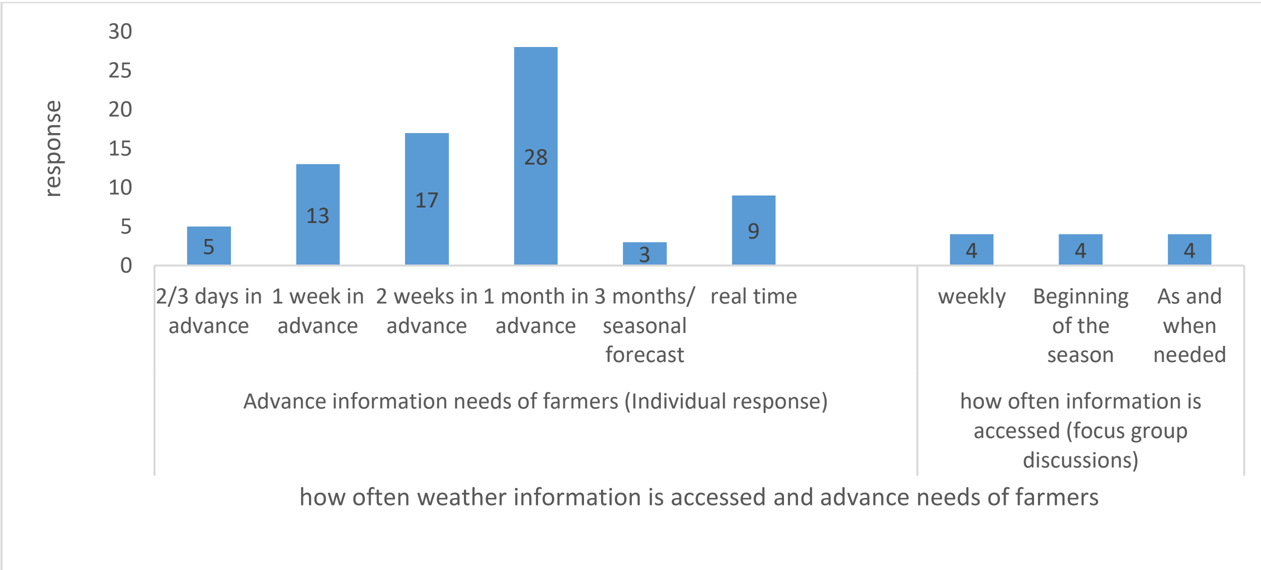

Figure 16: How often weather information is accessed and advance needs of farmers in the study areas

(Source: 2020 Field survey)

4.3.5 Preferred communication channel

Twenty-eight (37.3%) of the respondents prefer to access weather/rainfall information via mobile phones and radio, whereas only three farmers prefer to receive weather/rainfall information from their peers. The farmers suggested weather/rainfall information via mobile phones should either be in pictorial mode, or through phone calls in local language (Dagbani), text/SMS or combination of all. Furthermore, weather/climate information via radio stations should be delivered solely in the local language. Twenty-six rice farmers (34.7%) prefer face-to-face weather information delivery by Agricultural extension Agents or Agricultural Organizations. Also, three farmers prefer to source weather/climate information from their colleague farmers since they are familiar with their peers. From Figure 17 below, seventeen farmers in Yapalsi prefer to receive weather information via mobile phones although the community recorded the highest number of farmers without access to formal education.

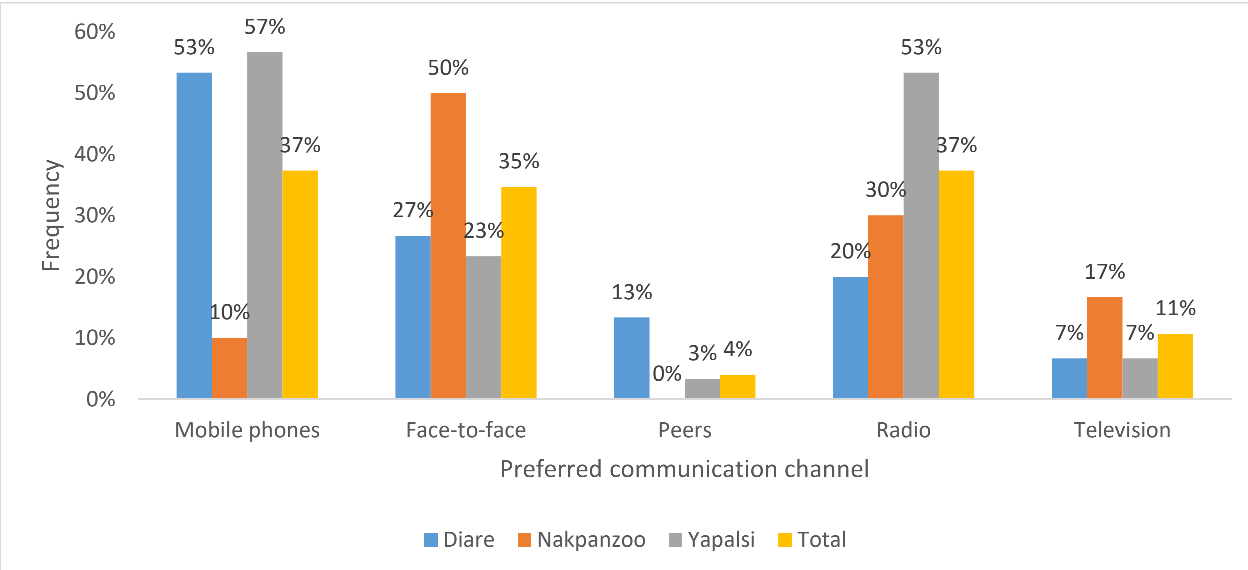

Figure 17: Preferred communication channel: Note; farmers preferred multiple channels of communication

(Source: 2020 Field survey)

4.3.5.1 Comparison among expert delivery channels, farmers source of weather/climate information and farmers' preferred information communication channel

Figure 18 below shows that rice farmers in the study areas currently receive weather/climate information through the preferred information channels from experts. Although experts' channels of information delivery tallies with farmers preference, more experts need to adopt mobile phones as an information delivery tool, since farmers prefer to source information via mobile phones.

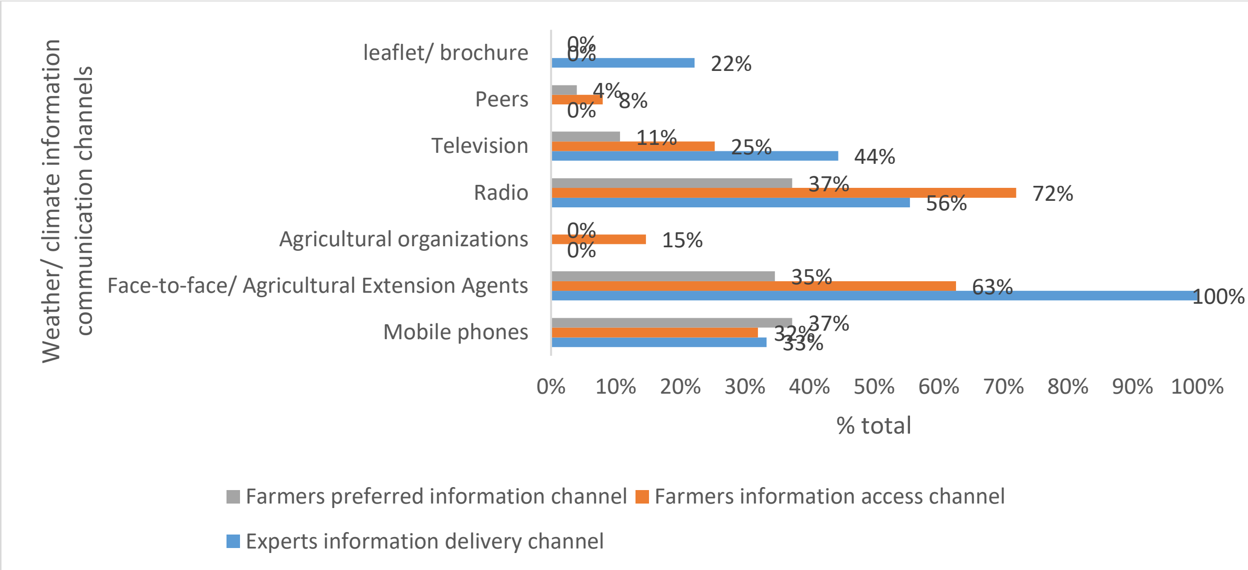

Figure 18: Weather/climate information delivery, sources and preferred channels

(Source: 2020 Field survey)

4.4 Objective three: To evaluate farmers' perception on the quality of the available information

The study sought to evaluate farmers' perception on the quality of the available information identified in objective one. The quality/reliability of available weather/rainfall information was determined on a five-point response where scale 1=very good, 2= good, 3= acceptable 4= poor and 5= very poor). The data was subjected to descriptive statistics.

Rice farmers' perception on quality/reliability of available information services

The study sought to evaluate farmers' perception on the quality of both hydro-climatic information services (water availability and seasonal weather forecast) and other agricultural information services (input prices and availability, crop variety selection, agricultural education and training as well as market prices and availability) available to farmers in the study areas. The availability of hydro-climatic information services greatly influences farmers' agricultural decision-making processes. For example, type of inputs (crop varieties, fertilizers and chemicals) to select and agronomic practices to employ are dependent on the weather/rainfall forecast for each cropping season.

Table 7 below presents frequencies and percentages related to quality/reliability attributes of various information services. More than half (62.7%) of the total number of respondents perceived quality/reliability of information on crop variety selection as very good. Twelve and one farmer perceived the reliability of information on crop variety selection to be good and acceptable, respectively. None of the farmers rated the quality of information on crop variety selection as poor and very poor. The farmers response indicates that on average, information on crop variety selection is of very good quality and reliable. According to the farmers, information services play a significant role in rice production. Weather information is very important here for selection of rice variety. For example, farmers' decision on rice variety for planting is based on information on onset of rains, duration and intensity of rainfall. The farmers emphasized that they prefer rice varieties such as AGRA, Jasmin and Mandii because these varieties are high yielding, easy to cultivate, drought and flood tolerant and are less labour intensive.

Similarly, water availability and seasonal weather forecast were rated as very good quality/reliable information services received by forty-four (58.7%) farmers. Eleven (14.7%) and one of the rice farmers rated the quality of information on water availability as good and acceptable, respectively, whereas one farmer also rated the quality of information on water availability as poor. On the other hand, twelve (16%), four (5.3%) and one of the farmers stated that the quality/reliability of information on seasonal weather forecast were good, acceptable and poor, respectively. A contradictory result was reported in Bangladesh where majority of farmers perceived the quality of the available hydro-climatic information to be very poor, whereas few accepted the information and very few perceived the available information to be very good (Kumar et al., 2020).

According to the farmers, vital to information on rainfall/weather forecast is the availability of soil moisture for plant use. The farmers' reasons for rating information on water availability and seasonal weather forecast as very good and good is due to the severe flood occurrence in 2018/2019 cropping season. According to the farmers, rice bunds were created and crops harvested in time as measures to mitigate the forecasted incidence of floods in that cropping season. On the contrary, some farmers were affected by the floods on the rice fields because of rainfall/weather forecast failures. These farmers stated a contradictory information from some experts and traditional weather forecast. Farmers who blended local and scientific weather/rainfall forecast knowledge harvested on time, whereas those farmers who solely depended on scientific weather forecast had their rice fields flooded. The study revealed during focus group discussions that the best way to reduce weather/rainfall forecast failures is by blending knowledge from the two sources, according to all the four interviewed groups. In addition, eight out of nine experts providing agricultural information services to farmers stated that rice farmers combine both scientific and local knowledge to forecast rainfall/weather.

The information service that recorded the highest frequency for 'poor' (six farmers) was market prices and availability, even though 14 (18.7%), 5 (6.7%) and 10 (13.3%) farmers rated the service as very good, good and acceptable, respectively. It was discovered during the interview that the least number of farmers (35 or 46.6%) had access to market prices and availability. The farmers further stated that prices for harvested rice was not encouraging *vis-a-vis* the efforts/resource engaged in rice cultivation. In addition, inadequate rice milling machines in the areas of study, long distances to rice mills, poor road network, consumer preference for polished rice, among others, compel farmers to sell the raw/ unprocessed rice at low prices to few rice buyers interested in the product.

Rice farmers gave positive response to input availability and prices by rating the quality/reliability as very good (35 or 46.7%) and good (12 or 16%), although one farmer stated that the quality of inputs was poor. The farmers explained that information received on input availability and prices plays a key role in planning farming activities such as the farm sizes to cultivate given the available resources and prices and availability of inputs. Similarly, rice farmers perceived the quality of agricultural education and training as very good (31- 41.3%), good (12- 16%) and acceptable (3- 4%) with no records for poor and very poor.

Table 7: Rice farmers' perception on the types of information services received

Water availability				
	Communities			
Quality attributes	Diare (n=15) %	Nakpanzoo (n=30) %	Yapalsi (n=30) %	Total(n=75)
Very good	53.3	60	60	58.7
Good	13.3	6.7	23.3	14.7
Acceptable	0	3.3	0	1.3
Poor	0	3.3	0	1.3
Very poor	0	0	0	0
Seasonal weather forecast				
Very good	40	66.7	60	58.7
Good	20	6.7	23.3	16
Acceptable	6.7	10	0	5.3
Poor	6.7	0	0	1.3
Very poor	0	0	0	0
Inputs prices and availability				
Very good	13.3	53.3	56.7	46.7
Good	20	3.3	26.7	16
Acceptable	0	0	0	0
Poor	6.7	0	0	1.3
Very poor	0	0	0	0

Crop variety selection				
Very good	26.7	83.3	60	62.7
Good	20	6.7	23.3	16
Acceptable	6.7	0	0	1.3
Poor	0	0	0	0
Very poor	0	0	0	0
Agricultural education and training				
Very good	13.3	40	56.7	41.3
Good	13.3	33.3	20	24
Acceptable	6.7	0	6.7	4
Poor	0	0	0	0
Very poor	0	0	0	0
Market prices and availability				
Very good	6.7	10	33.3	18.7
Good	0	10	6.7	6.7
Acceptable	13.3	13.3	13.3	13.3
Poor	6.7	6.7	10	8
Very poor	0	0	0	0

(Source: 2020 Field survey)

(Scale: Very Good = 1; Good = 2; Acceptable = 3; Poor = 4; Very Poor = 5)

4.4.1 Rice farmers' perception on the quality/reliability of weather/rainfall information sources

The quality/reliability of sources of weather/rainfall information services for farmers were highlighted in the study. A mismatch between frequencies for weather/rainfall information sources (number of farmers who sourced information from radio, agricultural extension agents, television, peer farmers and mobile phones) and that for quality/reliability rating (number of farmers who perceived quality/reliability of information sources) was observed.

For example, the study recorded a total number of fifty-four (72%) farmers who access information via radio stations. Only thirty-one (41.3%) farmers out of the seventy-five respondents rated the quality/reliability of information sourced via radio station as very good, good (5 or 6.7%) and acceptable (1 or 1.3%). Information sourced via radio stations is sometimes reliable, although there are intermittent failures, rice farmers reported.

Apart from Diare community, where the number of farmers (6 or 40%) with access to information via radio stations tallied with those farmers who rated the quality of weather/rainfall information sourced via radio station, there was a mismatch in farmers response to access to information via radio stations and the quality rating of the information sourced from radio stations in Nakpanzoo (25 farmers sourced information via radio compared with 12 farmers who rated the quality of information sourced via radio station) and Yapalsi (23 farmers sourced weather/rainfall information via radio as against 19 farmers who rated the quality of weather/rainfall information sourced via radio station) communities. The reasons for the contradiction in farmers response could be that some farmers did not actually source information via the stated sources, or some farmers who did source weather/rainfall information via the identified information channels were indifferent about the quality/reliability of weather/rainfall information they received, or the combination of several information sources posed challenges to the farmers to specifically rate the quality/reliability of a particular information source.

Apart from information sourced from peer farmers (very good = 50.7%, good = 2.7%, acceptable = 2.7% and poor = 1.3%), none of the quality/reliability of information sources identified were perceived by farmers as being poor. A greater number of farmers stated that information sourced from their peers (either the peer farmers own knowledge on weather forecast or from other information channels) are on the average accurate and reliable, despite occasional failures. The respondents stated their satisfaction with weather/rainfall information sourced from agricultural extension agents (very good = 38.7%, good = 10.7% and acceptable = 2.7%), television (very good = 33.3% and good = 5.3%) and mobile phones (very good = 41.3%, good = 6.7% and acceptable = 1.3%). Similarly, Kumar et al., (2020) reported farmers highly valued their own knowledge and knowledge sourced from input dealers. In addition, information sourced from peer farmers and Agricultural Extension Agents were also valued by farmers but information sourced via mobile phones was perceived to be of poor quality. In summary, all the identified information sources to farmers relatively provided reliable weather/rainfall information which positively influence farmers' agricultural decision-making process in spite of the occasional failures. The results are presented in Table 8 below.

Table 8: Rice farmers' perception on the quality/ reliability of information sources

	Communities			
Farmers' perception	**Diare (n=15) %**	**Nakpanzoo (n=30) %**	**Yapalsi (n=30) %**	**Total (n=75) %**
		Radio station		
Very good	26.7	36.7	53.3	41.3
Good	6.7	3.3	10.0	6.7
Acceptable	6.7	0.0	0.0	1.3
Poor	0.0	0.0	0.0	0.0
Very poor	0.0	0.0	0.0	0.0
		Agricultural Extension Agents		
Very good	20	43.3	43.3	38.7
Good	0	16.7	10.0	10.7
Acceptable	0	0.0	6.7	2.7
Poor	0	0.0	0.0	0.0
Very poor	0	0.0	0.0	0.0
		Peer farmers		
Very good	13.3	60.0	60.0	50.7
Good	0.0	3.3	3.3	2.7
Acceptable	0.0	0.0	6.7	2.7
Poor	0.0	3.3	0.0	1.3
Very poor	0.0	0.0	0.0	0.0

Television				
Very good	33.3	56.7	10.0	33.3
Good	6.7	6.7	3.3	5.3
Acceptable	0.0	0.0	0.0	0.0
Poor	0.0	0.0	0.0	0.0
Very poor	0.0	0.0	0.0	0.0
Mobile phones				
Very good	26.7	36.7	53.3	41.3
Good	6.7	3.3	10.0	6.7
Acceptable	6.7	0.0	0.0	1.3
Poor	0.0	0.0	0.0	0.0
Very poor	0.0	0.0	0.0	0.0

(Source: 2020 Field survey)

(Scale: very good=1, Good=2, Acceptable=3, Poor=4, Very poor=5)

4.4.2 Rice farmers' perception on format of mobile phone communication delivery

In objective one, rice farmers in the study areas stated the format through which they sourced information: via calls from agricultural extension agents, SMS, internet, mobile Apps and calls from peer farmers. Again, the study observed difference in responses in Nakpanzoo community regarding the frequency of farmers who received calls from agricultural extension agents (6) and those who rated the quality/reliability of calls from agricultural extension agents (5). The same community further recorded mismatch in frequency of farmers who received SMS (9) and those who rated the quality/reliability of SMS (1). The reason for the difference in response could be that some farmers did not own mobile phones hence received no information, or some farmers were indifferent of the reliability of information they received, or some farmers were reluctant in answering the questions.

The study revealed that rice farmers in the study areas rely on all the formats of mobile phone communication although information was not always accurate. Only one farmer perceived weather/rainfall information via SMS as poor. The results are presented in Table 9 below.

Table 9: Farmers' perception on information delivery format

		Communities		
Farmers' perception	**Diare (n=15) %**	**Nakpanzoo (n=30) %**	**Yapalsi (n=30) %**	**Total (n=75) %**
		Calls from Agricultural Extension Agents		
Very good	33.3	16.7	20.0	21.3
Good	0.0	0.0	23.3	9.3
Acceptable	0.0	0.0	10.0	4.0
Poor	0.0	0.0	0.0	0.0
Very poor	0.0	0.0	0.0	0.0
		SMS		
Very good	6.7	10.0	23.3	14.7
Good	0	16.7	3.3	8.0
Acceptable	0	0.0	3.3	1.3
Poor	0	0.0	3.3	1.3

Very poor	0	0.0	0.0	0.0
Internet				
Very good	0.0	0.0	3.3	1.3
Good	0.0	0.0	0.0	0.0
Acceptable	0.0	0.0	0.0	0.0
Poor	0.0	0.0	0.0	0.0
Very poor	0.0	0.0	0.0	0.0
Mobile Application				
Very good	0.0	0.0	3.3	1.3
Good	0.0	0.0	3.3	1.3
Acceptable	0.0	0.0	0.0	0.0
Poor	0.0	0.0	0.0	0.0
Very poor	0.0	0.0	0.0	0.0
Peer Farmers				
Very good	0.0	3.3	0.0	1.3
Good	0.0	0.0	0.0	0.0
Acceptable	0.0	0.0	0.0	0.0
Poor	0.0	0.0	0.0	0.0
Very poor	0.0	0.0	0.0	0.0

(Source: 2020 Field survey)

(Scale: Very good=1, Good=2, Acceptable=3, Poor=4, Very poor=5)

Findings from the study showed that the currently available hydro-climatic information services to rice farmers play a significant role in farmers' agricultural decision-making process in terms of planning the seasonal activities such as rice variety selection and time to carry out activities including land preparation, sowing, fertilizer application and harvesting. The farmers further stated that there is significant increase in yields of rice in seasons of less weather prediction failures emerging from both scientific and local weather forecast. Therefore, there is the need for accurate and reliable weather forecast to achieve the expected yields of rice, holding all other factors of production constant.

4.5 Objective four: To analyze the influence of the available information on farmers' agricultural decision-making process.

The study sought to highlight the influence of the available hydro-climatic information services on farmers' agricultural decision-making processes. According to the rice farmers, the currently available hydro-climatic information services from both local and scientific sources influence their agricultural decision-making process on when and how to carry out various agricultural activities such as time to prepare the land, sow, apply fertilizer, crop variety selection and when to harvest; and mitigation measures to adopt to combat challenges forecasted for that cropping season. The study further revealed that rice farmers in the study areas relate the effects of currently available hydro-climatic information (weather/rainfall forecast) services with the ability to accurately predict drought and flood occurrences to inform farmers decision on adaptation measures/strategies to employ against those challenges. This implies that the currently available hydro-climatic information services influence the planning and execution of rice cultivation activities in the study areas and affects every aspects of farmers' agricultural decision-making process.

4.5.1 Usefulness of services to farmers' decision making

From the experts view point, farmers' decisions/activities are categorized as follows: cropping activities (eg. adoption of good agronomic practices), input selection (fertilizer, rice varieties), climate/weather decisions (eg. rainfall events) and market decisions or services (who to sell to and at what price). All nine experts stated that their services are useful in farmers' decision on cropping activities and input selection, while seven out of the total number of interviewees attributed farmers' decision on climate and market selection to the usefulness of their services.

Table 10: Usefulness of services to farmers' decision-making

Farmers' decisions/ activities		
	Frequency (n=9)	**%**
Cropping activities	9	100
Input selection	9	100
Climate decision	7	77.8
Market decision	7	77.8

(Source: 2020 Field survey)

4.5.2 Indicators to carry out various farm activities

This section discusses results from focus group discussion showing traditional indicators farmers' use for carrying out various farm activities. Discussions with all the four groups revealed that rice farmers apply local knowledge in predicting weather and especially, rainfall events. Elders of the farming communities visit soothsayers in the communities at the beginning of the season to inquire about the outcome of that season. When the season depicts any calamity such as drought, the soothsayer advises the leaders to make sacrifices (to offer either red or black goats or hen, milk and a local food made from corn, called "masa") to either an Eastern or Western shrine located within the communities. The choice of shrine is dictated by the gods through the soothsayer. No sacrifices are made when the season has adequate rains. Farmers also decide current season's activities such as land preparation and planting based on experience from previous seasons. For example, they delay time of land preparation and planting when they experienced floods in the previous season. All the four groups considered fruiting of Shea (*Vitellaria paradoxa*) and Sinsaba (*Lannea spp*) trees as indicators to prepare the rice fields. Adequate soil moisture content is an important factor in sowing and fertilizer application according to the four groups. Weed and pests and diseases control are done by field observation and following the growth of rice plants, respectively. Indicators for harvesting paddy are dryness and bending of grains, and reduced volume of water on the field.

4.5.3 Water and weather-related stresses in rice cultivation

The ability to predict occurrences of water and weather-related stresses by the available hydro-climatic information services significantly inform farmers' agricultural decision-making process. Therefore, the study sought to reveal the various types of water and weather stresses, the degree of occurrences, types of mitigation measures employed and the effects on farmers' agricultural decision-making process.

4.5.4. Water stress

The majority of respondents stated that the major water stress sometimes (41 response or 54.7%– Figure 19 below faced in the rice valleys was occurrence of drought (52 or 69.3%) and flood (47 response or 62.7%). Climate change and variability have aggravated the incidence of drought and flood and resulted in impacts on crop production, including reduced yields, increased crop pest and disease infestation. However, eleven (14.7%) of the respondents stated that they do not face any challenge related to water stress in the rice valleys. The response could be attributed to lack of knowledge on water stress and its impacts on crop production. Similar hydro-climatic stresses experienced by farmers in Bangladesh were incidence of flood, erratic rainfall, irrigation water scarcity or drought, abnormalities in weather, occasions of storm, pest outbreak, and temperature stresses (Kumar et al., 2020). Similarly, Mondal et al., (2013) recorded incidence of flood, salinity and cyclones as the main hydro-climatic stresses faced by farmers in south-west coastal Bangladesh. Globally, the occurrences of drought and flood is reported to be more frequent and severe, and undergo alternation which subject agricultural production to more threats (Ding et al., 2018; Wu et al., 2018). In Figure 19, 55% of the respondents stated that weather stresses are sometimes observed in the study areas, whereas 24% and 9% of farmers respectively mentioned that they often and most often experience weather extremes. Whiles 3% of farmers rarely mentioned that rarely does weather extremes happen, 9% of farmers think weather extremes never happens in the study areas. Farmers' response to the frequency of occurrences of water stresses indicates how differently they are affected or experience water stresses. In Figure 20, about 55%, 24%, 9% and 3% of respondents stated that they sometimes, often, almost often and rarely experience water stress in their rice farms. Notwithstanding, 9% of farmers stated that they had never experience water stress in their rice farmers.

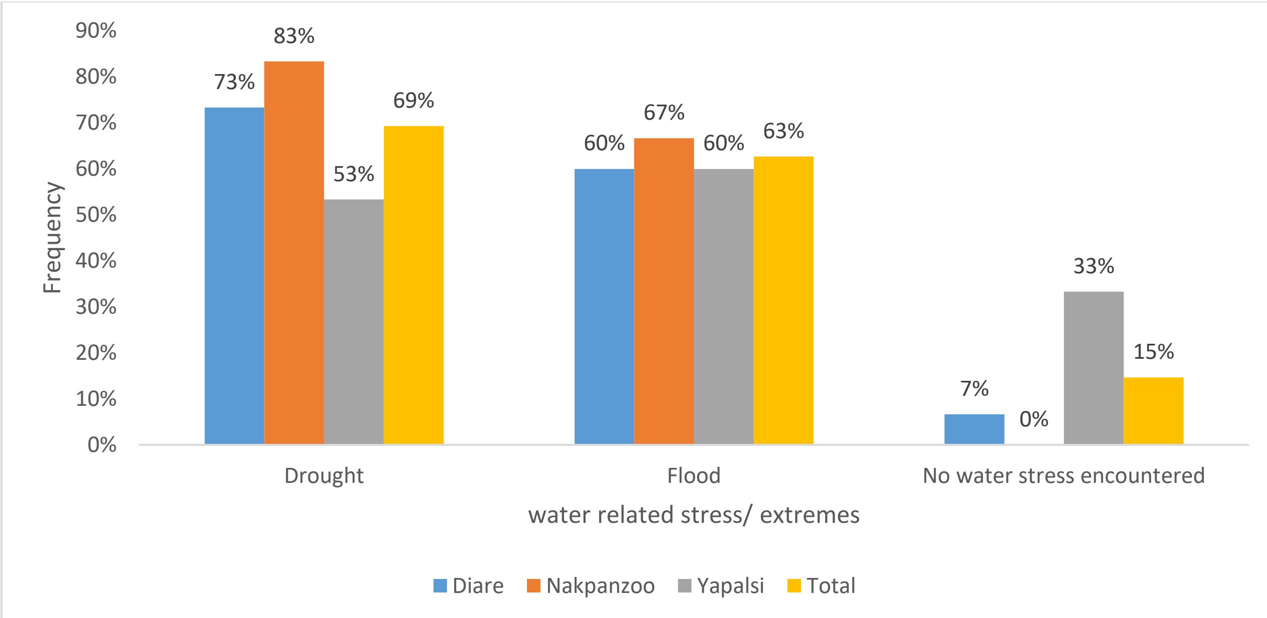

Figure 19: Water related stresses on rice fields

(Source: 2020 Field survey)

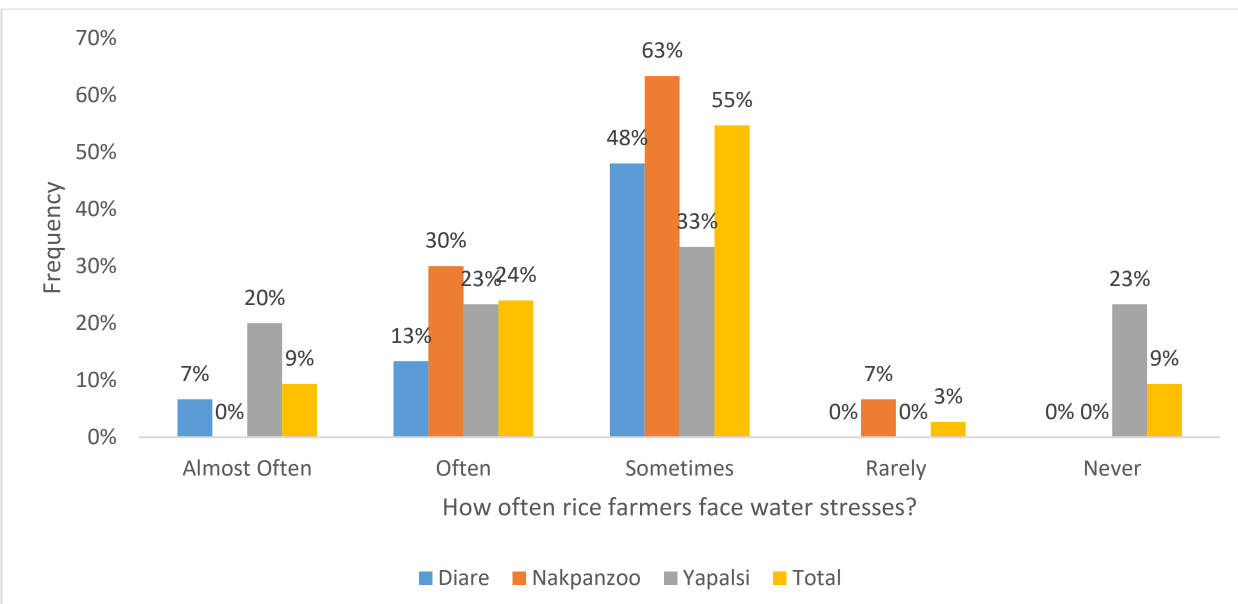

Figure 20:How often rice farmers face water stresses?

(Source: 2020 Field survey)

The study revealed that only ten (13.3%) out of the seventy-five respondents created bunds on the farms to allow excess water run off or to conserve water when faced with floods and droughts, respectively. It was highlighted during focus group discussions that the opening of bunds in a farm (upstream) during flooding results in severe flooding/damage in another farm (downstream), hence, creating of rice bunds was not an appropriate mitigation measure for rice farmers in the study areas. Similarly, only two farmers in Yapalsi engaged in supplementary irrigation during drought periods. This is because of scarcity of irrigation water in the communities. Therefore, respondents (37.3%) pray at the start and in the course of the rainy season, as the last resort. The farmers further stated that their prayers were sometimes answered because of the strong faith and belief attached to the prayers. Alternatively, twenty-seven (36%) out of the total respondents mentioned that they do nothing when faced with water stress. *'Incidence of droughts and floods are beyond human control'*, was these farmers' response. Therefore, farmers are open to whatever the season entails. Nine (12%) farmers mentioned that they consulted rain makers/callers to initiate rains in times of drought whereas, four farmers offered animal (fowls or ruminants) sacrifices to appease the gods for rains or to save the farms from flooding. One farmer in Diare community mentioned that he consults the oracle on the type of sacrifice to offer in order to protect his farm from water stress. The result is shown in Figure 21 below. Previous studies have reported that climate change mitigation measures adopted by farmers range from farmers taking no mitigation/adaptation initiative to climate/weather changes or stresses to land area expansion and farm enterprises (Morton et al., 2017), farmers practicing and increasing supplementary irrigation, early application of pesticides, on-time or adjusting to appropriate harvesting and planting times in response to weather/climate forecast which influences farmers decisions (Kumar et al., 2020). Furthermore, farmers in Savelugu Municipal of Northern Ghana adopt early planting, creating fire belts, changing of planting dates to suite prevailing weather/ climatic condition, improved seed variety selection and use of fertilizer as mitigation measures against the prevailing climate change and variability (Ibrahim et al., 2019). These measures were recorded for both water and weather-related stresses.

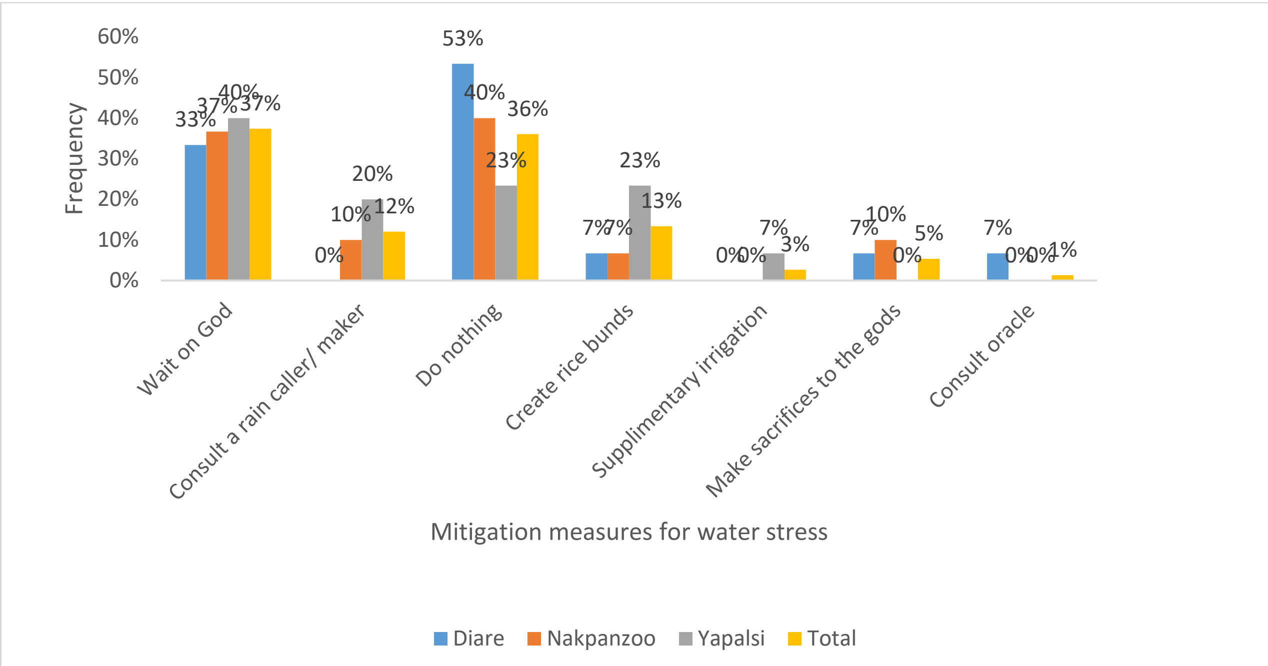

Figure 21: Mitigation measures for water stresses on rice fields

(Source: 2020 Field survey); Note: farmers adopt more than one mitigation measure

4.5.2.2 Weather extremes

Figure 22 below shows droughts (69.3% or 52 responses) and flood (53.3% or 40 responses) occurrences, followed by occassional wild fire (9.3% or 7 response) and lastly high temperature (6.7% or 5 responses) in the study area.

According to the majority of respondents (70.7% or 53 responses), represented in Figure 23 below, drought and flood sometimes occur in rice valleys due to human activities such as deforestation and starting bush fires. The effects of weather stresses in rice production are reduced yields, increased cost of production, increase of crop pests and disease infestation.

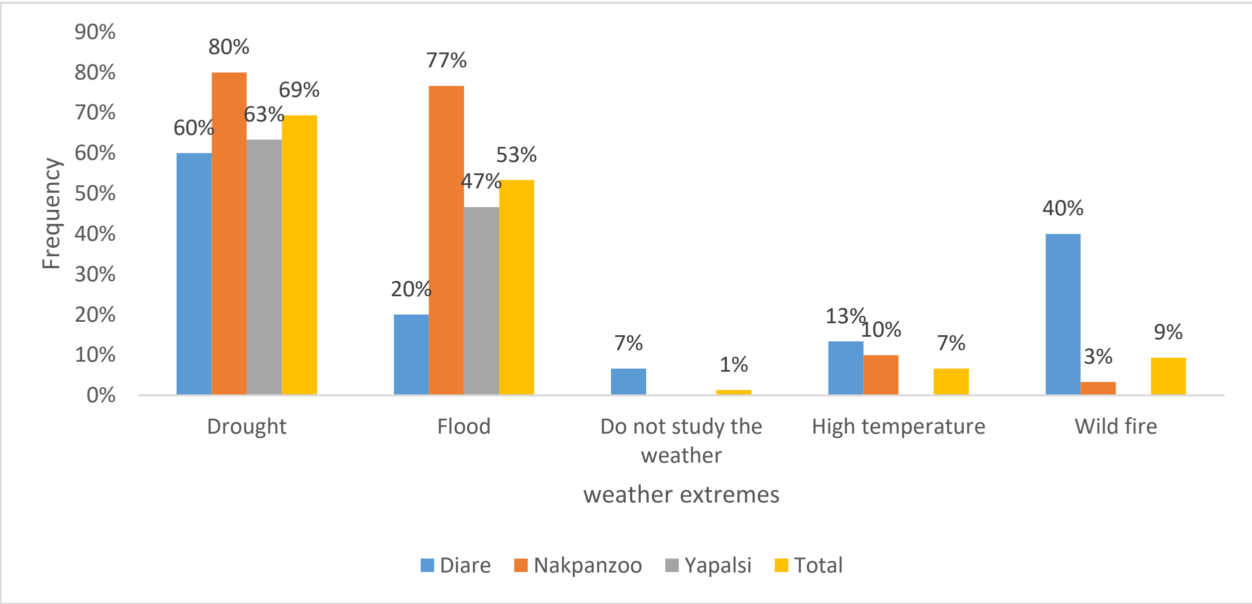

Figure 22: Weather extremes on rice fields

(Source: 2020 Field survey)

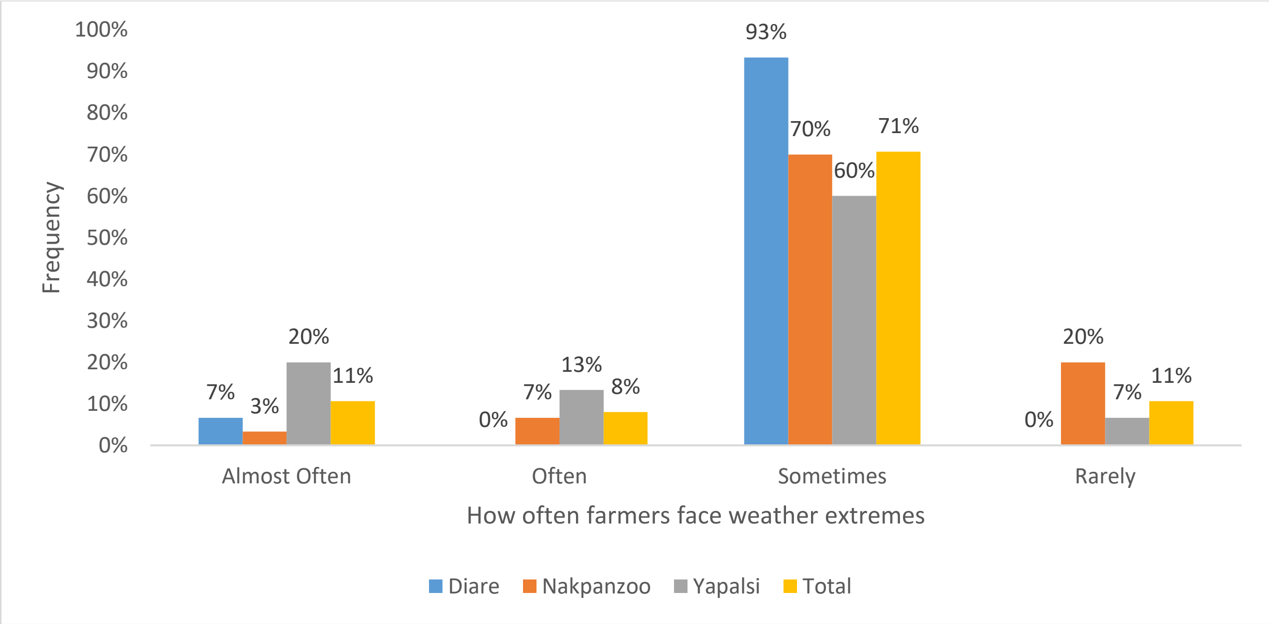

Figure 23: How often rice farmers face weather extremes on the field

(Source: 2020 Field survey)

Predictions of weather stressess for a cropping season influence farmers decision on crop varieties to select and time of planting. According to five farmers (6.7%), AGRA rice variety, for example, is high yeilding and drought tolerant, hence, the farmers grow AGRA rice variety in seasons of anticipated drought occurrence. Furthermore, the respondents stated that the choice of early or late maturing rice varieties depended on either late or early onset of rains respectively. Other mitigation measures adopted by rice farmers were creation of bunds (34.7% or 26 response), rain makers consultation (17.3% or 13 response), practise supplimentary irrigation (2.7% or 2 response) and timely crop harvest. Although farmers stated during FGD that the opening of rice bunds in one farm may cause severe flooding in an adjacent farm, there were instances where the best mitigation measure at the time was to open rice bunds. Farmers' decision to open rice bunds leads to severe flooding within the communities. For example in 2019, 'there was severe flooding in Nakpanzoo community because farmers opened rice bunds which caused runoff from the farms into the communities', rice farmers' reported during FGDs. Figure 24 represents the results.

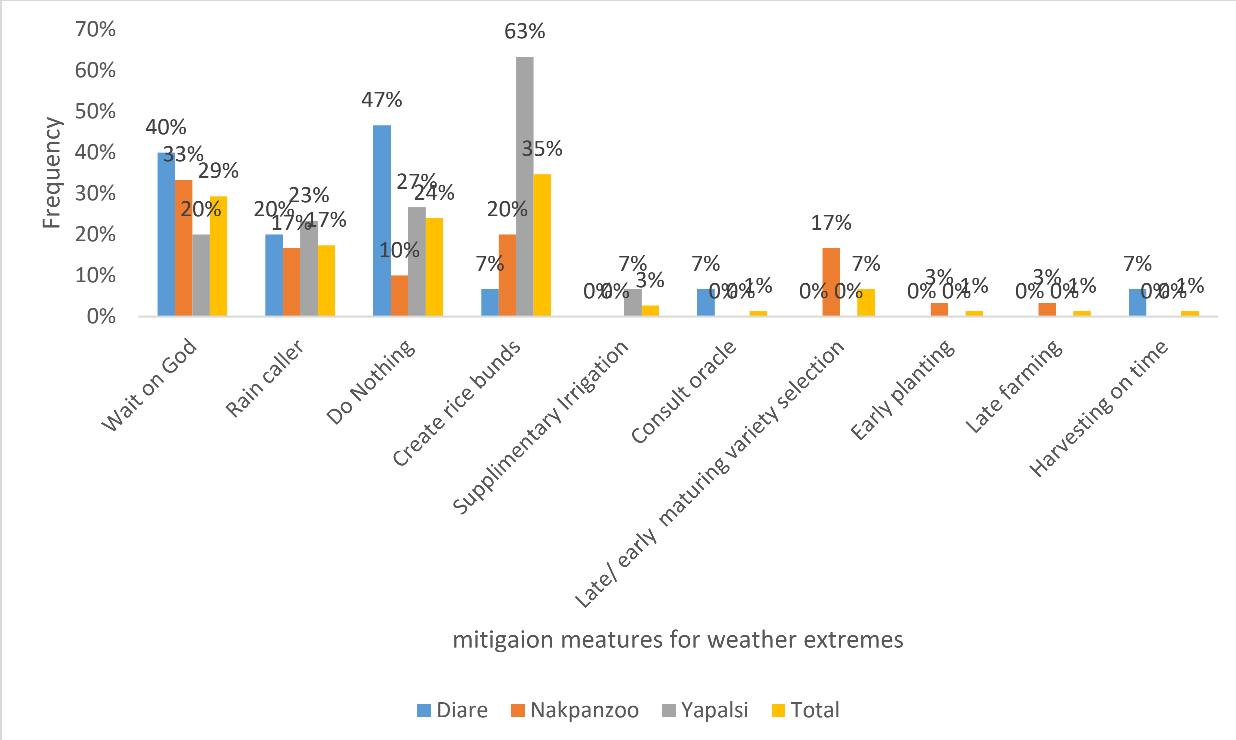

Figure 24: Mitigation measures for weather stresses on the rice fields

(Source: 2020 Field survey); Note: rice farmers adopt more than one mitigation measure

The results revealed that the currently available hydro-climatic information has great influence on farmers' agricultural decision making processes in the planning and excution of farming activities.

4.5.3 Influence of available information on farmers' agricultural decision-making process; the perspective of Individual farmers, Focus Group Discussions and Expert Interviews

Both expert interviews and focus group discussions with farmers highlighted that natural disasters such as droughts, floods and bushfires are the major threats to the livelihood of lowland rice farmers among others. The respondents further explained that these natural disasters cause drastic reduction in yields of rice. Four (44.4%) each and seven (77.8%) out of nine experts interviewed stated that incidence of drought, bushfires and floods respectively, were the major threats to farmers livelihood in the study areas. In other countries, the livelihood of rice farmers in Madacasca are threatened by frequent diseases and pest outbreak, cyclone, severe flooding and drought, market access and price volatility (Harvey et al., 2014); incidences of flood, drought, high temperature and variation in rainfall pattern are major threats to Ghanaian rural poor (Akudugu & Alhassan, 2012, misah et al., 2009). Response from the two interviews indicated that weather forecast from the available hydro-climatic information services influence farmers discussions to put in place suitable/appropriate measures before and during the season to help reduce threats to their livelihoods. Similarly, individual farmer interviews also confirmed the two main weather/ water stresses faced on the rice fields as drought and floods. The results show that rice farmers in the study areas affirm their responses both individually and in groups and information service providers (experts) understand their clients' situations. Figure 25 below shows the response.

The above factors are considered natural phenomena, but some measures such as rice field bunding, selection of early or late maturing rice varieties for cultivation etc., are helpful to mitigate these factors, according to experts and group discussion responses. Others include alternative livelihood activities such as engagement in off-farm activities (trading, food vending, livestock production) (Yamba et al., 2017), migration of people from rural areas to urban cities to look for greener pasture (Harvey et al., 2014).

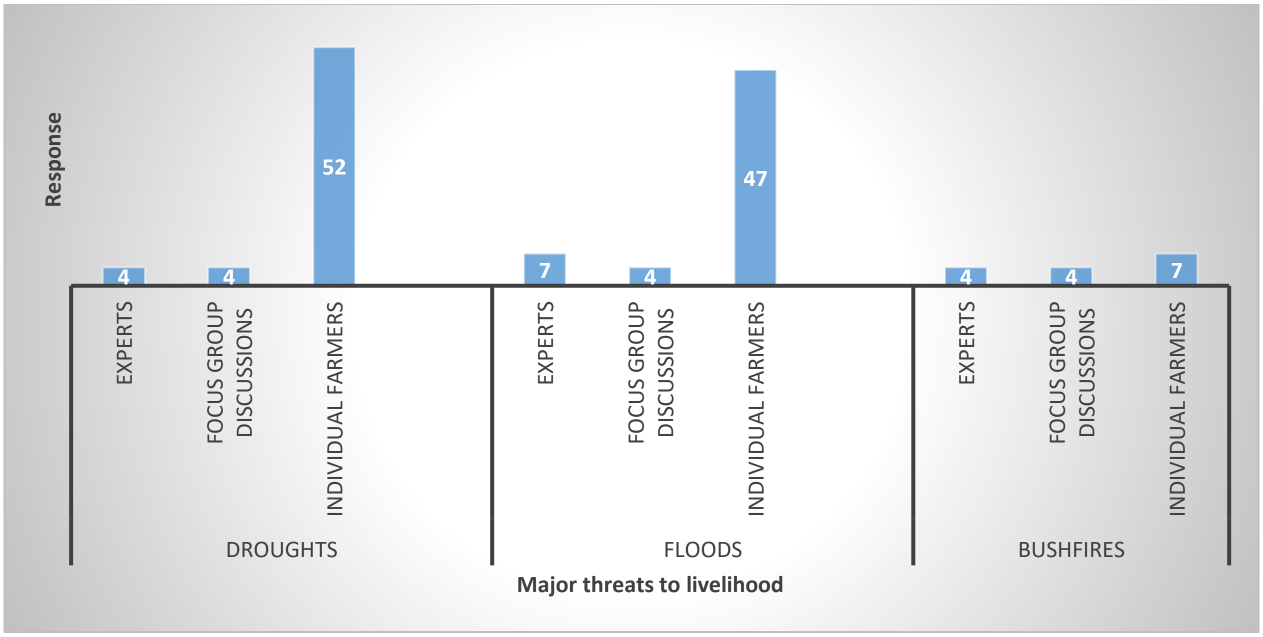

Figure 25: Major threats to livelihood of rice farmers

(Source: 2020 Field data)

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of key findings

The research was carried out with the aim of understanding the hydro-climatic information needs of rice farmers in Northern Ghana. The study was a mixed-method approach comprising of both qualitative and quantitative research approach which employed descriptive statistics and Likert type scale methods for analysis using Microsoft EXCEL software versions 2013. Below are the key findings:

1. The information services available to farmers in the study areas currently are technical, financial and institutional. Rice farmers have access to information on seasonal weather forecast and water availability in addition to farmers own knowledge on weather/rainfall forecast. These information are disseminated via mobile phones, face-to-face, radio and television by agricultural extension agents, both government and non-government agricultural organizations and from peer farmers
2. Rice farmers in the study areas highlighted their need for information on area specific rainfall, temperature, relative humidity and storm occurrences.
3. Averagely, farmers perceive the hydro-climatic information to be of good quality and reliable despite occasional failures.
4. The available hydro-climatic information services play significant role in farmers' agricultural decisions in areas of input selection, planting and harvesting times, time to carry out certain farming activities among others.

5. The respondents concluded that the available hydro-climatic information significantly influence their agricultural decision-making.

5.2 CONCLUSIONS

All the three levels of interviewed participants indicated the relevance of information services to farmers' agricultural decision-making process. The study highlighted in both focus group discussion and individual farmer interviews that the activities of experts such as type of information provided and mode of information transfer, are in line with farmers expectations and farmers base their agricultural decision making such as inputs selection, time of planting and harvesting, size of farmland, agronomic practices to adopt among others on information received, although not all farmers information needs are met.

On average, farmers perceived the available agricultural information services as of good quality and reliable despite intermittent failures. Likewise, the mode of accessing information. All respondents suggested the need to blend scientific and local knowledge sources, specifically on weather and climate as a great tool for improvement of rice production and yields in the valleys. According to all the respondents, if immediate solutions are deployed to address the highlighted livelihood threats of farmers, they could increase and sustain rice production in the valleys.

5.3 RECOMMENDATION

There is a high potential for rain-fed rice production in the valleys and this could be sustained through accurate, timely and area specific weather/ rainfall forecast system. An integration of local and scientific weather forecasting knowledge is the key to achieving this potential. Therefore, the researchers recommend a modification of the farmer-support App to include all the identified local indicators for weather predictions in pictorial form and in farmers own language as the case for voice SMS, calls and audios. Training sessions should be held for farmers on the use of mobile phones since respondents, especially women showed interests.

5.4 DEVELOPMENT IMPACT OF THIS STUDY

The findings from this study is aimed to assist researchers to modify/adjust a developed 'Farmer-Support App' to suit Northern Ghana's climate and to address the hydro-climatic information needs of farmers, and ultimately, to boost rain-fed rice production. Furthermore, this research will help in the achievements of the following Sustainable Development Goals (SDGs);

1. **Goal 1: No poverty:** the research will help provide farmers in Northern Ghana with resources and services for accurate weather forecast and consequently reduce climate-related disasters including floods and drought prevailing in those communities.
2. **Goal 2: Zero hunger:** the findings from this research will help support farmers adapt to climate change to boost and sustain agricultural production and will result to minimizing if not eradicate hunger and malnutrition in Northern Ghana.
3. **Goal 13: Climate action:** through this research, vulnerable areas prone to floods and droughts in Northern Ghana will be able to adopt disaster risk measures to meet the agricultural needs.

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APPENDIX

Questionnaires used to carry out this research work. These are grouped into three appendices. Appendix 1, 2 and 3 were questionnaires used for Focus Group Discussion, Expert Interviews and Individual farmer interviews, respectively.

Appendix 1: Questionnaire for focus group discussion

A. General information	**Responses/comments**
Date	
Location	
Consent of participation	
GPS location	
Field Facilitators	
Participants	
B. Cropping practices	
1. Who is landholder and who is the decision maker?	
2. Discuss farming practices of the rainfed rice production	
C. Access to weather information in communities in the valley	
1. Discuss importance of information and existing information services for agricultural practices	

2. At present how do farmers in the valley get access to rainfall and other weather-related information services? • Where they get information? • How often? • What is the lead time?	
3.. How and who communicate that information to farmers?	
4. How effective is the communication of information to farmers? Is it to individual or group?	
5. What are the major limitations of currently available rainfall and weather information service in the village?	
6. What factors influence agricultural information transfer? • Traditional (eg. Believes, norms, values)	

• Social (eg. Access to land, ceremonies) • Economic (eg. cost of information, information medium) • Environmental (eg. flood, draught, bush fire)	
D. Traditional knowledgebase of rainfed rice farmers	
1. What are local farmers' knowledge on weather and climatic forecast? What capacity do they need to better understand their forecast and information	
2. Do they currently use/apply traditional knowledge for agricultural decision? 3. If yes, types of traditional/local knowledge indicators used/applied for agricultural decisions-making in;	

• Land preparation • Transplanting/ sowing • Fertilizer application • Weed control • Pests and diseases control • Harvesting • Others specify	
4. Discuss usefulness of traditional information forecast and compare preferences with scientific forecast in the areas of • Land preparation • Transplanting/ sowing	

• Fertilizer application • Weed control • Pests and diseases control • Harvesting • Others specify	
5. Who act on that information? How they act on that information made by traditional knowledge system? • Land preparation • Transplanting/ sowing • Fertilizer application • Weed control • Pests and diseases control	

• Harvesting • Others specify	
6. What is the major limitations of traditional knowledge/ forecast system for taking agricultural decision on; • Land preparation • Transplanting/ sowing • Fertilizer application • Weed control • Pests and diseases control • Harvesting • Others specify	

7. How scientific forecast knowledgebase could be improved with local observation on • Land preparation • Transplanting/ sowing • Fertilizer application • Weed control • Pests and diseases control • Harvesting • Others specify	
8. How local knowledgebase could be improved based on scientific forecast information on?	

• Land preparation • Transplanting/ sowing • Fertilizer application • Weed control • Pests and diseases control • Harvesting • Others specify	
E. Adaption currently to flood/ draught occurrences	
1. Discuss how farmers in the valley adapt to: • weather variability • climate change	

• floods • Draught • land use change • changes in socio-economic aspects of their livelihoods in rural context?	
2. How diversified and adaptive are the local incomes and livelihood opportunities of the farmers in the valley? Answers should be based on rice value chain eg. Owning a commercial tractor, combine harvester	
3. Identify and discourse the major threats of livelihood of the community in particular and lowland rainfed rice farmers?	
4. How do farmers see their future in lowland rice production activities in the valley?	

Appendix 2: Expert Interview Form

Interviewers: Hajaratu Ahmed and Richard Dogbe (MPhil Students, Ghana).

Date: ....../....../2020 Time:.........

Issue/Discussion points	**Responses/comments**
Introduction with the Expert As part of modifying our Farmer Support App, developed by the integration of scientific and indigenous weather forecast methods to ease farmers agricultural decision-making processes, we aim to take your valuable responses and opinion for the research entitled "Understanding the hydro-climatic information needs of farmers in Northern Ghana". Kindly be assured that every information you provide on the services you provide to farmers will be used solely for this research. Thank you.	
Name of the Expert/Interviewee	
Email ID/Mobile	
Designation/Responsibilities	
Name of the Organization	
Interview Method	
1. Who are the primary users/customers of your services?	
2. What services do you provide to the farmers?	
3. Do you provide information services to the farmers?	

4. Which media/technology do you use for interacting with farmers?	
5. What are sources of the information that you provide to the farmers?	
6. How advance/lead time information do you provide to the farmers and other groups, if any?	
7. Do farmers take decision for crops based on your information services? 7a. how do you know that? (any M&E?)	
8. How effective/useful that information for crop related activities/decision-making to the farmers? 8a. For example: which types of decision-making?	
9. What factors influence uptake of your information services?	
10. What factors limit uptake of your information services?	
11. Did you involve users in the design phase of your service?	

12. Is there any feedback mechanism from the users? For example: from end-users/ intermediaries	
13. Did you assess needs before design your services? 13a. What are the processes?	
14. How do you notice importance of water related information for agricultural decision-making?	
15. How farmers depend on water related information at present situation?	
16. Currently how often farmers access to information services from you? 16a. How advance?	
17. What capacity do you need to improve information services to the farmers?	
18. What capacity do farmers need to better uptake of your information services?	
19. Could you discuss usefulness and limitations of traditional information sources and compare preferences with scientific forecast information?	
20. What are major challenges for developing information services for farmers?	

21. Discourse major threats that impact on livelihood of the peri-urban farmers	
22. How do you see farming future/crop production activities in peri-urban areas?	
23. Do you have any other comments on information services for farmers?	

Appendix 3: Baseline Questionnaire/ Farmer survey questions

SECTION 1 (S1): DEMOGRAPHIC INFORMATION OF FARMER

Community: …………………………… Date of interview: …… /……../…….

Enumerators name………………………….. . Number…………………

Farmer name…………………………………… Number………………………………

S1Q1. Age: [0] under 25 [1] 25-34 [2] 35-44 [3] 45-54 [4] 55-64 [5] above 65

S1Q2. Gender: [0] Female [1] Male

S1Q3. Marital status: [0] Single [1] Married [2] Divorced [3] Widowed

S1Q4. What is your household size? ……

S1Q 5. How many people are engaged in the farming activities? ....

S1Q6. Educational background: [0] No formal education [1] Basic [2] JHS [3] SHS/ technical /vocational [4] Tertiary.

S1Q7. Are you the land owner? [0] No [1] Yes

S1Q8. Are you into animal production? [0] No [1] Yes

S1Q9. Are you engaged in any non-farm employment (off-farm work)? [0] No [1] Yes

S1Q10. Number of years in farming...................

S1Q11. Number of years in rice farming...................

S1Q12. Are you a member of any farmer organization/association? [0] No [1] Yes

S1Q13. If yes, please state………………………………………………………..

S1Q14. Do you receive any visit from extension agents on your rice production? [0] No [1] Yes.

If yes, how many times? ....

S1Q15. Do you have access to credit to engage in your rice farming? [0] No [1] Yes

If yes, in what form? [0] In cash…………. [1] In kind (specify)……………….

S1Q16. If yes, from which organization?..

S1Q17. Do you have access to subsidized fertilizer for your rice cultivation? [0] No [1] Yes

S1Q18. How many acres/ha of rice are you cultivating?......................

SECTION 2: S2: SOIL INFORMATION (please all questions are related to rice production)

S2Q1. Are you aware of the concept of soil moisture? [0]No [1] Yes

S2Q2. Do you have an alternative name for soil moisture in your area?

....

....

S2Q3. Do you use soil moisture information as an indicator for agricultural decision-making? [0]No [1] Yes

S2Q4.In which decisions of the following do you take soil moisture into account?

Variable	**0** **Not significant**	**1** **significant**	**2** **Very significant**	**3** **Extremely significant**	**4** **Don't know**
Land preparation					

Sowing					
Fertilizer application					
Weed control					
Pest control					
Harvesting					
Which other decisions do you consider soil moisture					

S2Q5. If you had information regarding soil moisture, how will you use it?

....

....

S2Q6. What makes you decide if the soil is OK to start sowing?

....

....

S2Q7. How do you decide if there's enough rain/water on the ground to start sowing?

....

....

S2Q8. When you think about the onset (beginning) of the rain, do you consider also the date in your decision to start sowing?

....

....

S2Q9. Do you consider other factor(s) to inform your decision to start sowing?

[0] no [1] yes

If yes, specify

………………………………………………………………………………………..

S2Q10. Do you visit your fields before you decide on sowing? [0] No [1] Yes

S2Q11. Do you examine soil moisture by hand feeling? [0] No [1] Yes

S2Q12. How do you examine your soil moisture content at the various stages in rice production?

Activity	**Ways of examining soil moisture**
Land preparation	
Sowing	
Fertilizer application	
Weed control	

Pest control	
Harvesting	
Other activities (specify)	

S2Q13. Is the soil color important to you? [0] No [1] Yes

S2Q14. How do you categorize the condition of soil in terms of water content?

[0] Soft when there's rain? [1] Hard when there's no rain? [2] Do you have/use specific categorization?

....

....

....

S2Q15. Do you decide to harvest your rice based on the end of the rainy season?

[0] No [1] Yes

S2Q16. If YES, how do you decide when to harvest?

....

....

....

SECTION 3 (S3): WATER AND WEATHER STRESSES

S3Q1. What are some of the water challenges you face on your rice crop?

…………………………………………………………………………………………………

S3Q2. How often does water stress challenges affect your crop?

[0] Almost always [1] Often [2] Sometimes [3] Rarely [4] Never

S3Q3. How often do you face problems in the rice production due to water scarcity?

[0] frequently (every year) [1] Occasionally (in some years)

[2] Rarely (very rare amongst years) [3] Never

S3Q4. What do you think is the main cause of water scarcity on rice fields?

....

S3Q5. What do you do when (if) you face water scarcity on your rice fields?

…………………………………………………………………………………………………

S3Q6. How often do you face problems in rice production due to flooding?

[0] frequently (every year) [1] Occasionally (in some years)

[2] Rarely (very rare amongst years) [3] Never

S3Q7. What do you think is the main cause of flooding in your rice field (s)?

....

S3Q8. What do you do when (if) you face flooding in your rice field (s)?

....

S3Q9. What are the major weather challenges for your rice crops?

....S3

Q10. How often does draught affect your rice production, if any?

[0] Almost always [1] Often [2] Sometimes [3] Rarely [4] Never

....

S3Q11. What do you do when (if) you face draught in your rice field (s)?

....

S3Q12. What measures do you put in place to save your rice from draught should in case it happens?

....

SECTION 4: (S4): AGRICULTURAL INFORMATION

S4Q1. Do you have access to any agricultural information that play a role in your farming decision making? [0] No [1] Yes

S4Q2. If yes, from where? Please list (multiple answers)

……………………………………………………………………………………….

S4Q3. How often do you receive these information? (0) not often (1) often (2) most often (3) very often

S4Q4. If no, why and how?...

S4Q5. What kind of information do you receive?

(0) water availability (1) seasonal weather forecasts (2) input prices and availability (3) crop/variety selection (4) disease control (5) market prices (6) others (specify)…………………………………………………………………………………… ……………………………

S4Q6. How would you rate the quality of information you receive in each case?

	Quality rated					
Information type	**Excellent**	**Very good**	**Good**	**Acceptable**	**Poor**	**Very poor**
water availability						
seasonal weather forecasts						
input prices and availability						
Crop/variety selection						
Diseases control						
market prices						
Specified information						

S4Q7. Does the information provided meet your needs? [0] No [1] Yes [2] not really

S4Q8.What other information do you need?..

S4Q9.How much do you depend on water information for agricultural decision-making?

[0] Almost always [1] Often [2] Sometimes [3] Rarely [4] Never

S4Q10. How much do you depend on weather information for agricultural decision-making?

[0] Almost always [1] Often [2] Sometimes [3] Rarely [4] Never

S4Q11. How do you access rainfall information now?

[0] TV [1] Radio [2] Newspaper [3] Mobile (sms, voice call, app: ....)

[4] Peer farmers [5] Extension officers

[6] Other (specify:..)

S4Q12. How would you rate the quality/ reliability of the information sources in each case?

	Quality rated					
Information sources	**Excellent**	**Very good**	**Good**	**Acceptable**	**Poor**	**Very poor**
TV						
Radio						
Newspaper						
Mobile (sms, voice call, app:						
Peer farmers						
Extension officers						
Specified						

S4Q13. What is the quality of the available weather information services now?

[0] Very good [1] Good [3] Acceptable [4] Poor [5] Very poor

SECTION 5 (S5): INFORMATION NEEDS

S5Q1. How would you rate your understanding of local weather?

[0] Excellent [1] Somewhat [2] Poor

S5Q2. Do you think that weather information are important to make agricultural decisions?

[0] Strongly agree [1] Agree [2] Undecided [3] Disagree [4] Strongly disagree

S5Q3. What kind of information do you need to make agricultural decisions? (multiple answers could be provided)

[0] Rainfall [1] Temperature [2] Humidity [3] Storm [4] Other (specify:..)

S5Q4. How advanced information should be for rice crop related decision-making?

[0] Real-time [1] 1-day in advance [2] 2/3 days in advance

[3] 1-week in advance [4] 2-weeks in advance [5] 1-Month in advance

[6]3-Months / seasonal forecast

SECTION 6 (S6): WEATHER FORECAST METHODS

S6Q1. Which weather forecasting method do you use?

[0] local [1] scientific [2] both

S6Q2. If local method or both methods;

Which local indicators do you use to predict the weather?

……………………………………………………………………………….

S6Q3. How do you use these local indicators to predict the weather?

…………………………………………………………………………………….

S6Q4. How did you come about these indigenous/local weather forecasting indicators?

…………………………………………………………………………………………

S6Q5. How accurate is this method?..

S6Q6. If scientific or both methods;

Which scientific indicators do you use to predict the weather?

……………………………………………………………………………….

S6Q7. What makes you think it is scientific?...

S6Q8. How do you use these scientific indicators to predict the weather?

…………………………………………………………………………………….

S6Q9. How did you come about this scientific weather forecasting knowledge?

…………………………………………………………………………………………

S6Q10. How accurate is this method?..

S6Q12. How do you combine these two methods?..

S6Q13. Do you have any additional comments on any/ all the weather forecasting methods?

....

S6Q14. Which is the best way(s) weather information should be communicated to you?

....

SECTION 7. USE OF MOBILE PHONE AND APPs

S7Q1. Do you have a mobile phone? [0] No [1] YES

S7Q2. Do you use mobile phone for agricultural information? [0] No [1] YES

S7Q3. If S7Q2 YES, how do you get agricultural information by mobile phone?

[0] Agricultural extension officers call [1] SMS [2] Internet / website

[3] Mobile APPs [4] I don't take information through mobile phone

[5] Other (specify:..)

S7Q4. How would you rate the quality/ reliability of the mobile information received in each case?

	Quality rated					
Information sources	**Excellent**	**Very good**	**Good**	**Acceptable**	**Poor**	**Very poor**
Internet/ website						
Mobile App						
SMS						

Extension officers call						
Specified						

S7Q5. If S7Q2 YES, what type of information is received by mobile phone?

[0] Weather information

[1] Fertilizer or pesticide application

[2] Crop disease and control advice

[3] Price of input (fertilizer, pesticide, seed, etc.)

[4] Market price of crop

[5] I don't take information through mobile phone

[6] Other (specify:..)

S7Q6. How would you rate the quality/ reliability of the information received in each case?

	Quality rated					
Information type	**Excellent**	**Very good**	**Good**	**Acceptable**	**Poor**	**Very poor**
Weather information						
Crop disease and control advice						
Market price of crop						
Fertilizer or pesticide application						
Price of input (fertilizer, pesticide, seed, etc.)						
others						

S7Q7. Do you have a smartphone in the family? [0] No [1] YES [2] I don't take information through mobile phone

S7Q8. Do you use smartphone for agricultural information? [0] No [1] YES

S7Q9. If S7Q8 YES, which type of smartphone APPs do you use?

[0] Weather / climate APPs [1] Farm management APPs

[2] Agriculture news APPs [3] Disease and pest APPs

[4] Market data APPs

[5] Other (specify:...)

- I don't use mobile APPs

S7Q10. If you use smartphone and mobile APPs, how easy is to find specific agricultural information through these APPs?

[0] Very easy [1] Easy [2] Neutral

[3] Difficult [4] Very difficult

[5] I don't use APPs for agricultural information

[6] I don't know APPs that offer agricultural information

Do you have any challenge using the smartphone regularly? (0) No (1) Yes

S7Q11. If yes, what are the factors that limit you from using them regularly?

[0] Economic reasons [1] Unsuitable [2] Incompatible design

[3] Personal lack of ICT knowledge [4] Internet and unavailability

[5] I don’t know

[6] Other (specify:...)

S7Q12. Would you be interested in using mobile APPs, if we help you?

[0] No [1] YES

S7Q13. If YES, which format do you prefer?

[0] Text format [1] Photograph/Image/Diagram [2] Audio / Video

[3] Other (specify:...)

S7Q13. How frequently?

....

SECTION 8 (S8). CROP TYPES CULTIVATED

S8Q1. Apart from rice, which other crops do you grow?

Crop types	**Land size (acre/ha)**

SECTION 9 (S9). Information on rice farming

S9Q1. Where do you obtain your rice seeds for planting?

0) market 1) from storage 2) specify 3) MoFA

others:……………………………………

S9Q2. Do you buy the rice seeds?

[0] No [1] YES

If yes, at what price?...........................

S9Q3. If you obtain your rice seeds from storage in question 1, how long have you being recycling (replanting) the rice seeds?

0) first time 1) two years 2) three years 3) more than three years.

S9Q4. **Please fill in the following information (specialization) in rice production**

2. Use of Seeds (a) Traditional varieties [Name:_____________________]	3. Which variety do you prefer? (a) Improved Varieties
(b) Improved Varieties [Name:_____________________]	(b) Traditional Variety

S9Q5. Why do you prefer the chosen variety in question 4 above?

S9Q6. Is your rice farm on one piece of land or on separate pieces of land?

[0] one field [1] separate fields

S9Q7. How many acres of land is your rice farm?..................................

S9Q8. If the rice field is on one/separate fields, how many man-days does it take to carry out each activity (with regard to rice production)?

Activity	**Plot 1**			**Plot 2**			**Plot 3**		
	family labor	**hired labor**	**No. of days**	**Family labor**	**hired labor**	**No. of days**	**Family labor**	**hired labor**	**No. of days**
Land Preparation	No. of males……. No. of females:.......	No. of males… No. of females:.....	No. of males … No. of females:.......	No. of males … No. of females:...........	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...

Nursing (if any)	No. of males… No. of females:...	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...
Transplanting/ sowing	No. of males… No. of females:...	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...
1st Weeding 2nd Weeding	No. of males…	No. of	No. of males …	No. of males …	No. of	No. of males …	No. of males …	No. of males …	No. of males…

	No. of females:...	males… No. of females:...	No. of females:...	No. of females:...	males… No. of females:...	No. of females:...	No. of females:...	No. of females:...	No. of females:...
Fertilizer application	No. of males… No. of females:...	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...
Spraying pesticides and herbicides	No. of males… No. of females:...	No. of males…	No. of males …	No. of males …	No. of males…	No. of males …	No. of males …	No. of males …	No. of males… No. of females:...

		No. of females:...	No. of females:...	No. of females:...	No. of females:...	No. of females:...	No. of females:...	No. of females:...	
Harvesting	No. of males… No. of females:...	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...
Processing of harvested grains	No. of males… No. of females:...	No. of males… No. of fema	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of fema	No. of males … No. of females:...	No. of males … No. of females:...	No. of males … No. of females:...	No. of males… No. of females:...

		les:...			les:...				
TOTAL MAN-DAYS									
Average cost of labor per day (GH¢)									

SECTION 10 (S10). INPUT DATA (for rice production)

Item	**Plot 1**		**Plot 2**		**Plot 3**	
	Qty	**Unit price (GH¢)**	**Qty**	**Unit price (GH¢)**	**Qty**	**Unit price(GH¢)**
Total man-days (labor)						
Tractor services (GH¢) Bullock labor (Animal days, GH¢)						

Pesticides/Insecticides (litres) Herbicides (litres)						
Transport of crops (GH¢)						
Spraying cost during storage						
Seeds (in bags) Local Variety Modern variety						
Inorganic fertilizers (in bags)						
Herbicides (if applicable)						
Harvesting cost						
Total cost of production						

SECTION 11 (S11): RETURNS ON RICE

S11Q1. **Please indicate the total number of bags of rice output per acre and the price of each bag.**

Plot (acre)	Total output (bags)	Price per bag (Ghana Cedis)
1		
2		
3		

S11Q2. How do you store the harvested grains?

………………….

S11Q3. What do you do with the harvested grains?

[0] consume [1] sell [2] both

S11Q4. If you happen to sell your grains,

What quantity do you sell?

S11Q5. Where do you sell your grains?.................................

S11Q6. Whom do you sell to?..

S11Q7. How do you measure the grains for sale?

[0] in kurga-bowls [1] in cups [2] others (specify) ………………

S11Q8. What do you use the sales money for? eg. Invest in children education

……………………………………………………………………….

SECTION 12 (S12): Farmers observations over the past years (climate indices)

S12Q1. What are your observations about the patterns of the following climate indices the past 20-30 years?

Rainfall amount	□ Increased □ Decreased □ Same □ Different every year □ Don't know
Temperature	□ Increased □ Decreased □ Same □ Different every year □ Don't know
Onset of rainfall	□ Early onset □ Late onset □ Normal □ Don't know
Cessation of rainfall	□ Early □ Late □ Normal □ Don't know

Frequency of prolonged dry spells	□ Increased □ Decreased □ Normal □ Don't know
Length of the growing season	□ Increased □ Decreased □ Same □ Don't know

S8Q3a. Major farming decisions and timescale per each crop? (Mention up to 3 major crops) – 1st major crop

Crop: .... Calendar / Seasonal agricultural activities	LAST YEAR Onset: □ Early □ Late Cessation: □ Early □ Late Rainfall: □ Regular □ Frequent dry spells	NORMAL (AVERAGE) YEAR Onset: □ Early □ Late Cessation: □ Early □ Late Rainfall: □ Regular

	☐ Heavy rainfall ☐ Non-heavy rainfall ☐ Sort rain rainy season ☐ Long rain rainy season	☐ Frequent dry spells ☐ Heavy rainfall ☐ Non-heavy rainfall ☐ Sort rain rainy season ☐ Long rain rainy season
Action		
Pre-season Buying seeds Seed variety Land size and allocation Labour size	☐ JAN ☐ FEB ☐ MAR ☐ APR ☐ MAY ☐ JUN ☐ JUL ☐ AUG ☐ SEP ☐ OCT ☐ NOV ☐ DEC	☐ JAN ☐ FEB ☐ MAR ☐ APR ☐ MAY ☐ JUN ☐ JUL ☐ AUG ☐ SEP ☐ OCT ☐ NOV ☐ DEC
Land preparation When to clear land When to plow When to harrow	☐ JAN ☐ FEB ☐ MAR ☐ APR ☐ MAY ☐ JUN ☐ JUL ☐ AUG ☐ SEP ☐ OCT ☐ NOV ☐ DEC	☐ JAN ☐ FEB ☐ MAR ☐ APR ☐ MAY ☐ JUN ☐ JUL ☐ AUG ☐ SEP ☐ OCT ☐ NOV ☐ DEC
Planting When to nurse seeds When to transplant When to do direct seeding	☐ JAN ☐ FEB ☐ MAR ☐ APR ☐ MAY ☐ JUN ☐ JUL ☐ AUG ☐ SEP ☐ OCT ☐ NOV ☐ DEC	☐ JAN ☐ FEB ☐ MAR ☐ APR ☐ MAY ☐ JUN ☐ JUL ☐ AUG ☐ SEP ☐ OCT ☐ NOV ☐ DEC

Sowing method (e.g. broadcast by hand or machine)		
Fertilizer application The kind of fertilizer to buy When to carry out 1st fertilizer application When to carry out 2nd fertilizer application	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Weed control	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Pest control	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Harvesting	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC

S8Q3b. Major farming decisions and timescale per each crop? (Mention up to 3 major crops) – 2nd major crop

Crop: .... Calendar / Seasonal agricultural activities	<u>LAST YEAR</u> <u>Onset</u>: □ Early □ Late <u>Cessation</u>: □ Early □ Late <u>Rainfall</u>: □ Regular □ Frequent dry spells □ Heavy rainfall □ Non-heavy rainfall □ Sort rain rainy season □ Long rain rainy season	<u>NORMAL (AVERAGE) YEAR</u> <u>Onset</u>: □ Early □ Late <u>Cessation</u>: □ Early □ Late <u>Rainfall</u>: □ Regular □ Frequent dry spells □ Heavy rainfall □ Non-heavy rainfall □ Sort rain rainy season □ Long rain rainy season
Action		
Pre-season Buying seeds Seed variety Land size and allocation Labour size	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Land preparation When to clear land	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN

When to plow When to harrow	□ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Planting When to nurse seeds When to transplant When to do direct seeding Sowing method (e.g. broadcast by hand or machine)	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Fertilizer application The kind of fertilizer to buy When to carry out 1st fertilizer application When to carry out 2nd fertilizer application	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Weed control	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Pest control	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN

	□ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Harvesting	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC

S8Q3c. Major farming decisions and timescale per each crop? (Mention up to 3 major crops) – 3rd major crop

Crop:	LAST YEAR	NORMAL (AVERAGE) YEAR
Calendar / Seasonal agricultural activities	Onset: □ Early □ Late Cessation: □ Early □ Late Rainfall: □ Regular □ Frequent dry spells □ Heavy rainfall □ Non-heavy rainfall □ Sort rain rainy season □ Long rain rainy season	Onset: □ Early □ Late Cessation: □ Early □ Late Rainfall: □ Regular □ Frequent dry spells □ Heavy rainfall □ Non-heavy rainfall □ Sort rain rainy season □ Long rain rainy season
Action		

Pre-season Buying seeds Seed variety Land size and allocation Labour size	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Land preparation When to clear land When to plow When to harrow	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Planting When to nurse seeds When to transplant When to do direct seeding Sowing method (e.g. broadcast by hand or machine)	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Fertilizer application The kind of fertilizer to buy	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC

When to carry out 1st fertilizer application When to carry out 2nd fertilizer application		
Weed control	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Pest control	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC
Harvesting	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC	□ JAN □ FEB □ MAR □ APR □ MAY □ JUN □ JUL □ AUG □ SEP □ OCT □ NOV □ DEC