International Journal of Irrigation and Agricultural Development
Agricultural Science and Development
IJIRAD 6(2) [2022] [309 – 320]
IJIRAD
ISSN: 2616-1508
https://www.ijirad.org

# Hydro-Climatic Information Needs of Smallholder Rice Farmers in Savelugu Municipality in Northern Region of Ghana

**Hajaratu Ahmed[1*], Gordana Kranjac-Berisavljevic[1], Spyros Paparrizos[2], Richard Kwame Dogbe[1], Bizoola Z. Gandaa[1], Erik Van Slobbe[2], Iwan Supit[2], Samuel Sutanto[2]**

[1]*West African Centre for Water, Irrigation and Sustainable Agriculture (WACWISA), University for Development Studies, Tamale, Ghana*
[2]*Water Systems and Global Change Group, Wageningen University & Research, The Netherlands, Lumen Building (Droevendaalsesteeg 3, 6708 PB Wageningen)*

[*]*Corresponding Author: ahmedhajaratu22@gmail.com*

## ARTICLE INFO

**Article History:**
Received: **Nov. 5, 2021**
Received in revised form: **Nov. 1, 2022**
Accepted: **Nov. 10, 2022**

**Keywords:**
Smallholder farmers,
Lowland rice,
Hydro-climatic information,
Weather forecast,
Climate change.

DOI:
https://doi.org/10.47762/2022.964x.105

## ABSTRACT

*Farmers in northern Ghana are vulnerable to climate change, partly because the region is dry and experiences uni-modal rainfall. The livelihood of these farmers is directly affected by rainfall variability and its effects on crop production. Reliable, timely and area-specific hydro-climatic information services could increase food production and security and play a significant role in poverty reduction. To achieve these results, there is the need to understand the hydro-climatic information needs of smallholder farmers and the role of such information in farmers' decision-making processes in rice production, which is the call for this paper. Savelugu Municipality in the Northern of Ghana is known for its intensive lowland rice production and vulnerability to climate change. Data were collected at three (3) independent stages namely; focus group discussions, individual farmer interviews and expert interviews with organizations offering hydro-climatic information services to smallholder farmers using separate questionnaires for understanding the farmers' needs. The results indicated that farmers adopt both scientific and local forecast methods to support the agricultural decision-making processes. Moreover, agriculture experts provide technical services, capacity building, financial support, and information on seasonal weather forecasts to farmers, however, these information are too general and not location-specific and tailored to farmers' needs. Though farmers' access information on rainfall, temperature, relative humidity, and storm occurrences, their needs are timely and area/ location specific information for accurate predictions and not the general or regional-based weather forecast information currently sourced from Agricultural Extension Agents, radios, televisions, peers and Agricultural Organizations. The study recommends the integration of local and scientific forecast knowledge to reduce the current prediction failures.*

## INTRODUCTION

Agriculture is a key sector that produces food needed to support the livelihood of people. It is vital to the economic development of most African countries. This sector contributes up to 35% and 65% to the African gross domestic product (GDP) and employment, respectively (FAO, 2019). In these countries, however, irrigation is still at its early stages, with only 5% and over 90% of arable land cultivated under irrigation and rain-fed respectively, compared with Asia which has 38% of its arable land cultivated under irrigation (Veras, 2019). Thus, the continent's agriculture is basically rain-fed and significantly dependent on weather. Farmers therefore, source weather information from both scientific and local knowledge systems. Nonetheless, the independent forecast system is challenged with intermittent prediction failures which hinder agriculture production in the African continent. The African Development Bank Group (2018), Gbangou *et al.* (2021), and Nyadzi *et al.* (2021) stated that agriculture in Africa can be better transformed by integrating local and modern scientific forecast knowledge to help improve societal resilience as well as forecast resolution to climate change.

Ghana also experiences a similar situation like the other African countries. Farmers in Ghana depend mostly on indigenous weather forecast knowledge to guide them in farming practices, especially in rice production, as well as intermittent scientific weather forecast information obtained from some experts, such as agricultural extension agents who deliver weather information from Ghana Meteorological Agency (G-Met). Using this information, farmers must make several climate-sensitive decisions months in advance in farming season (Asante and Amuakwa-Mensah, 2014).

Despite the dominant rain-fed agriculture practices under the prevailing climate change and variability, the reliability of meteorological predictions for agriculture in Ghana is generally low, and to a degree may affect crop production. For instance, climate change and variability are listed among major contributors that curb food production and availability. About 20 to 80% of inter-annual yield variation is ascribed to variation in weather, while the estimated annual agricultural losses caused by variation in weather are 5 to 10% (Oerke, 2006). Also, the intermittent predictions of local and scientific forecasts are subject to failure in forecasting the incidence of flood and drought events which are vital in rice production. Likewise, weather variables, such as humidity and temperature, are of utmost importance for rice growth. Besides the difficulty in obtaining accurate and continuous weather forecasts, climate 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 the rainy season (Ambani and Fiona, 2014).

Notwithstanding, efforts are made by some organizations, such as Ghana Meteorological Agency, Esoko, and Meteoblue, to aid farmers in making climate-sensitive decisions by producing and distributing model-based forecast information via Information and Communication Technology (ICTs) and local platforms (e.g., radio stations, web-based platform, and mobile apps). The high illiteracy rate among local farmers coupled with the unavailability of smartphones and the inability to access the web-based platform is a major limitation to the success of these efforts. Moreover, the lack of collaboration within actors, language barriers, inability to interpret forecast results, and untimely information delivery hinder the effectiveness of current hydro-climatic information in assisting farmers to make better agriculture planning and management (Feleke, 2015; Nyadzi *et al*., 2018).

The northern parts of Ghana are most vulnerable to climate variability because of limited resource availability to farmers and an erratic mono-modal rainfall pattern. Lowland rice farmers constitute a significant number of smallholders in this region and account for about half of the country's paddy rice production, with Tamale and Bolgatanga serving the key feeder markets, whereas Kumasi in the southern sector serves as the key processing market for unbranded rice (Ayeduvor, 2018). MoFA (2018) estimated about 10% of annual rice production growth between 2008 and 2019, with a sharp increase of 25% in 2019. Despite the increase in rice production, the demand for rice in Ghana far exceeds the domestic supply, which raises the percentage of imported rice to over 50% (MoFA, 2018) and creates imbalance and vulnerability to international rice price stocks. This highlights a deficit in rice production and a need to establish equilibrium demand and supply through increased rice production.

Aker (2011), and Tadesse and Bahiigwa (2015) acknowledged information as a key input for successful agricultural production. To a greater extent, on-time production, dissemination, and application of available hydro-climatic information at individual and group levels are vital to agricultural production and the adoption of mitigation measures on climate change and variability (Kumar *et al.*, 2020). Furthermore, farmers are able to draw links 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).

There is therefore, a need for service improvement since better and more reliable hydro-climatic information has the potential to improve agricultural productivity (Nyadzi *et al*., 2018). This service should be able to predict the weather and climate days and weeks in advance, especially rainfall, which is indispensable for guiding farmers in their farming practices (Logah *et al*., 2013). Moreover, Inwood and Dale (2019) stated that information needs of farmers and other agricultural actors are context-specific and, therefore, should be built based on farm location, crop type, season, market, production system, and technology access, tailored to each region of interest.

This process, however, should be preceded by understanding the farmers' hydro-climatic information needs and the role of such information in farmers' agricultural practices. The objectives of this study were: (1) to identify the available hydro-climatic information services in the study area, (2) to highlight farmers' hydro-climatic information needs, and (3) to identify threats in rice production in the study areas. The outcome of this study would be beneficial to guide the development of a "tool" that integrates scientific and traditional weather forecast knowledge.

## MATERIALS AND METHODS

### Study Area

The Savelugu Municipality of Northern Region of Ghana experiences erratic mono-modal rainfall with an estimated annual rainfall ranging from 800 to 1200 mm and maximum temperatures from 26$^{o}$C in August to 40$^{o}$C in March/April (Mdemu, 2008). A significant seasonal variation is experienced over the course of the year in Savelugu. January and October are the windiest and calmest months with an average hourly wind speed of 7.9 and 4.7 miles per hour, respectively. With reference to geographical coordinates of 9.624$^{0}$ latitude, -0.825$^{0}$ longitude, and 554 ft elevation, only modest variations in elevation are contained in topographies within 2 miles (maximum elevation change of 154 feet; and an average elevation above sea level of 519 feet), 10 miles (variations in elevation of 364 feet) and 50 miles (variations in elevation of 988 feet). The areas within these topographies are mainly covered with cropland and shrubs; within 2 miles (50% cropland and 38% shrubs), within 10 miles (47% cropland and 42% shrubs), and within 50 miles (29% cropland and 44% shrubs).

The agriculture sector is challenged by varying climate conditions such as prolonged dry season prevalent each year between November and March followed by the rainy season between April/May to September/October. Flood and drought incidences are frequently recorded in the municipality (Amikuzuno and Donkoh 2012), which pose a major threat to the predominant rain-fed agricultural activities in these areas. Majority of the farmers in the municipality are engaged in small-scale production of food crops, cash crops, and domestic animal rearing. Three (3) out of the 149 communities in the municipality were chosen for the study. The choice of the Municipality and communities is attributed to the communities' high engagement in rain-fed lowland rice production in the valleys and the frequent vulnerability of these communities to incidence of flood and drought causing serious damage to rice fields. In 2019, for instance, farmers in the Nakpazoo community were assisted to recover losses due to serious flood occurrence which caused significant loss in properties, and farm produce, particularly rice fields.

### Sampling Procedure and Instruments

The study was a mixed-method (quantitative and qualitative) research involving questionnaire administration at three (3) levels which are expert (from organizations rendering agricultural services to farmers) interviews using checklist, focus group discussions with gender segregation in two communities (Nakpanzoo and Yapalsi), and questionnaire administration to rice farmers from the three (3) communities (Nakpanzoo, Yapalsi and Diare) as presented in Table 1. The different data collection methods helped to obtain different datasets for both independent analysis and triangulation purposes.

#### *Individual Farmer Interviews*

Three (3) communities namely; Nakpanzoo, Yapalsi and Diare in the Savelugu Municipality were purposively selected for the study because of the communities' intensive engagement in lowland rice production in the valleys and their vulnerability to climate related risk such as floods and drought occurrences, and onset data variability. Amidst COVID-19 pandemic, thirty (30) rice farmers each in the Nakpanzoo and Yapalsi and fifteen (15) famers in Diare communities were randomly interviewed. A total of seventy-five (75) farmers availed themselves for the interview (Table 1). A semi-structured questionnaire with questions on currently available hydro-climatic information to rice farmers, climate/weather information needs of farmers, role of the available information in farmers agricultural decision-making processes, sources and methods of weather forecast, challenges and/or threats in rice farming among others were administered face-to-face to farmers.

### *Expert Interviews*

Several organizations provide expert services on climate to farmers in the study areas. Expert interviews were necessary for the study to develop a comprehensive understanding of the topic and to validate responses from individual rice farmers. But only nine experts providing agricultural information services to rice farmers were interviewed for the study, due to COVID-19 pandemic, the majority of organizations were working remotely.

Experts were engaged using checklist (administered face-to-face) for consistency and comparison purposes. Information on types of information services provided to farmers, the need for providing hydro-climatic information and the medium of delivery, the effects of the information on farmers' agricultural decision-making processes and challenges and/or threats which experts seek to help farmers address among others were sought. Names of experts interviewed the justification for inclusion and information provided by each expert are presented in Table 2.

### *Focus Group Discussions*

Focus group discussions (FGDs) were held in Nakpanzoo and Yapalsi communities based on equal gender bases, which are one male and one female group in each community. Participants of the FGDs were all active rice farmers who worked on rice field as family or hired laborer and/or owned rice fields and whose knowledge on weather forecast play key roles in rice production. A total of twenty-five farmers participated in FGDs. Five and seven women participated in the Nakpanzoo and Yapalsi communities' FGDs respectively; seven and six men participated in Nakpanzoo and Yapalsi communities' FGDs respectively. FGDs were important for the study as they helped to triangulate and validate individual farmer's response on hydro-climatic information needs in the study areas and to seek group voices on the subject.

**Table 1: Sample size distribution in study communities**

| Communities | Frequency | Percentage (%) |
|---|---|---|
| Diare | 15 | 20 |
| Nakpanzoo | 30 | 40 |
| Yapalsi | 30 | 40 |
| **Total** | **75** | **100** |

### Data Analysis

FGDs responses were transcribed and narratives drawn from them. Descriptive statistics were generated from the datasets and results presented in tables and graphs. Data was analyzed using Microsoft Excel version 2013.

## RESULTS AND DISCUSSION

### Demographic and Characteristics of Farmers

Table 3 shows the distribution of gender, marital status, age distribution, level of education, engagement in off-farm activities, membership of farmer-based organizations (FBOs), and access to credit, extension services, and subsidy available to respondents in the study areas. The results showed that majority of the farmers interviewed were males (74.7%) with the highest number of female rice farmers (53.3%) in the Diare community. The study revealed during FGDs that majority of the females do not own rice farms, they rather assist their husbands on rice fields. Though, those women are literally 'family or hired laborers' on rice fields, their knowledge on climate/weather forecast is vital and used/applied in all stages in rice production. A rice farmer was defined in this study as a man or woman who owns or works as a family or hired laborer on rice fields whose knowledge on climate/ weather forecast plays significant roles in all stages of rice production. Female farmers in the three communities were mostly engaged during rice sowing, harvesting, post-harvest handling, processing, and marketing. Furthermore, rice cultivation provides diverse employment opportunities and sources of income to the female farmers in the study areas. Women were paid either in cash or kind-mostly as rice paddy. The female farmers also get income through selling of cooked rice. Moreover, female farmers significantly support the livelihood of the families through income generated from rice cultivation. Hence, innovations in rice production such as the use of the Farmer Support App should not only focus on male farmers but also on female farmers.

**Table 2: Experts providing hydro-climatic information services to rice farmers**

| Name of organization | Justification for Inclusion in interview | Source (s) of Expert's Climate/ Weather Information | Type of Services Provided |
|---|---|---|---|
| Savannah Agricultural Research Institute (SARI) | -Provide services to rice farmers<br>-Installed climate/ weather station | -Within the organization<br>-Ghana Meteorological Agency (G-MET) | -Technical support services: climate information, crop variety selection, pest and disease control etc. |
| Integrated Water and Agricultural Development Ltd. (IWAD) | -Provide services to rice farmers<br>-Have established Climate/ Weather station | -Within the organization<br>-Ghana Meteorological Agency (G-MET) | -Technical support services: climate information, crop variety selection, pest and disease control, and market linkages etc.<br>-Capacity building support: trainings on rice production/ good agronomic practices |
| Catholic Relief Services (CRS) | -Provide (d) services to rice farmers | -Farmer Line<br>-Ghana Meteorological Agency (G-MET) | -Technical support services: climate/ weather information, agro-input support, market support etc.<br>-Capacity building support: trainings on rice production/ good agronomic practices |
| Association of church-based development program (ACDEP) | -Provide (d) services to rice | -Ghana Meteorological Agency (GMET)<br>-ESOKO | -Technical support services: climate information, crop variety selection, technological services, market linkages etc.<br>-Financial Support services |
| MOFA/ JICA project for sustainable development of lowland rain-fed rice production phase II | Provide services to rice farmers | -Ghana Meteorological Agency (GMET) | -Technical support services: climate/ weather information, agronomic and technical advice support etc. |
| AVNASH | Provide services to rice farmers | -Ghana Meteorological Agency (GMET) | -Technical support services: climate information, market accessibility and availability etc.<br>-Capacity building support: climate risk management training, trainings on rice production/ good agronomic practices. |
| Center for Agricultural and Rural Development (CARD) FNGO | Provide services to rice farmers | -Encourages traditional/ local weather forecast methods | -Technical support services: market linkages etc.<br>-Financial support |
| Savannah Zone Agricultural Productivity Improvement Project (SAPIP) | Provide services to rice farmers | -Ghana Irrigation Development Authority (GIDA)<br>-Ghana Meteorological Agency (GMET) | -Technical support services: irrigation support, market linkages etc.<br>-Capacity building support: training and advocacy on good agronomic practices |
| Ghana Agricultural Sector Investment Program (GASIP) | -Provide services to rice farmers<br>-Installed weather stations across Northern and Middle belts of Ghana | -Ghana Meteorological Agency (GMET)<br>-Weather stations | -Technical support services: weather/ climate information, input supports, market linkages, etc.<br>-Capacity building support: training and advocacy on good agronomic practices |

**Table 3: Characteristics of the farmers in the study communities**

| Variables | Indicators | Diare (n=15) % | Nakpanzoo (n=30) % | Yapalsi (n=30) % | Total (n=75) % |
|---|---|---|---|---|---|
| Gender | Males | 47 | 83 | 80 | 75 |
| | Females | 53 | 17 | 20 | 25 |
| Marital Status | Married | 93 | 100 | 87 | 93 |
| | Unmarried | 7.0 | 0 | 13 | 7.0 |
| Age of HH head (years) | < 25 | 0 | 0 | 7.0 | 3.0 |
| | 25-34 | 7.0 | 17 | 23 | 17 |
| | 35-44 | 40 | 27 | 20 | 27 |
| | 45-54 | 46 | 30 | 43 | 39 |
| | 55-64 | 7.0 | 13 | 7.0 | 9.0 |
| | ≥65 | 0 | 13 | 0 | 5.0 |
| Level of Education | No formal education | 74 | 64 | 74 | 69 |
| | Basic | 13 | 23 | 0 | 12 |
| | JHS | 13 | 10 | 13 | 12 |
| | SHS/ Vocational/ Technical | 0 | 3.0 | 3.0 | 3.0 |
| | Tertiary | 0 | 0 | 10 | 4.0 |
| Access to Extension Services | Yes | 67 | 87 | 47 | 67 |
| | No | 33 | 13 | 53 | 33 |
| Access to Credit | Yes | 27 | 27 | 10 | 20 |
| | No | 73 | 73 | 90 | 80 |

Rice farming in the selected communities was found to be mainly done by married farmers (93%). For example, all 30 farmers interviewed in the Nakpanzoo community are married and the same community recorded the largest household size with a mean of 18 people. The finding is in line with the statement of farmers during FGDs that "*rice production is labor-intensive and large families are at an advantage*". Martey *et al.* (2013) also stated that rice cultivation in Northern Ghana is carried out mainly by married people and heads of families.
The study categorized respondents' age into six groups. The youngest and oldest groups of rice farmers interviewed were below 25 and above 64 years old, respectively (Table 3). However, low frequencies were obtained for the youngest and oldest farmers. Notwithstanding, the majority of rice farmers (39%) have aged between 45 and 54 years old. Furthermore, that the majority of rice farmers (92%) in the three study areas were within the active working age. This implies that rice cultivation is intensive and requires energetic farmers. Nyadzi *et al.* (2019) recorded parity in the age distribution of farmers engaged in agriculture.

In terms of education, majority of farmers (69.3%) had no formal education (Table 3). Nonetheless, 10% of farmers had received tertiary education. The result is in agreement with the findings of Martey *et al.* (2013) and Nyadzi *et al.* (2019), who found that majority of rice farmers, were less educated in Northern Ghana. Only less than half of the respondents (40%) engaged in off-farm work/employment (Table 3). 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. In sum, the results indicated that quite a number of farmers (40%) had other sources of income in addition to rice farming, notwithstanding, the majority of farmers' (60%) livelihoods depended on rice cultivation. Almost half of the farmers (48%) in the three communities were members of farmer-based organizations (FBOs). Involving in strong farmer groups provides benefits to its members in different forms. This is because farmer groups have been identified as the main target for information and technology dissemination. As a result, a number of rice farmers had access to agricultural extension services (66.7%) and access to fertilizer subsidy (61.3%). Furthermore, farmers benefit from innovative ideas such as creating of rice bunds to conserve water, and cultivating intensively on relatively smaller piece of land to ensure proper field management to achieve bumper harvest. The study further revealed that the majority of the respondents (80%) did not have access to credit. The reason could be that the numbers of rice farmers engaged in off-farm work (40%) are able to partially finance their rice production activities from off-farm income, while the full-time rice farmers invest part of their profits into rice farming, as stated by some farmers in Diare community. The result is inconsistent with Martey *et al.* (2013) who identified that most rice producers have access to credit. Furthermore, rice farmers (61.3%) that have access to government-subsidized fertilizers spend less on rice production cost.

**Table 4: Descriptive statistics of the farmers in the study communities**

| | | Communities | | | |
|---|---|---|---|---|---|
| **Variables** | **Indicators** | **Yapalsi (n=30)** | **Nakpanzoo (n=30)** | **Diare (n=15)** | **Total (n=75)** |
| 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 |

Table 4 presents the minimum, mean, and maximum values of household size, years of farming experience, and farm size of respondents. The mean household size of respondents in the study areas was 16 people with maximum and minimum number of people of 50 and 5, respectively. Comparing Diare and Yapalsi communities, the former recorded the highest household size and married respondents (Table 3) whereas the opposite is true for the Yapalsi community. This could mean that married respondents have the highest household size. More so, large household size is an indication of labor availability. Both Diare and Yapalsi communities came on par with farm size (maximum = 8ha; minimum = 0.4ha).

The study documented 35 years of farming experience as the highest and 2 years as the lowest among the respondents. All four farmers aged above 65 years old living in the Nakpanzoo community (Table 3) recorded the highest years of farming experience (35 years). Similarly, the youngest farmers below 25 years of age who resided in the Yapalsi community had least years of farming experience (2 years). These results agree with a priori expectation that farming experience increases with farmers' age. The smallest and largest farm sizes for rice cultivation in the study areas were 0.4 and 8 hectares, respectively. Comparing Yapalsi and Nakpanzoo communities, Nakpanzoo has most farmers accessing extension services (86.7%) (Table 3) and the smallest farm sizes (6 ha). This confirms the findings of the focus group discussions, where farmers stated that they were advised by the agricultural extension agents to cultivate smaller farm plots intensively in other to observe good agronomic practices and have higher yields.

## Methods of Climate and Weather Forecasts

All interviewees in the three communities mentioned both scientific and indigenous/local knowledge of weather and climate forecasts as the two main methods of predicting weather and climate. Whiles the traditional forecast method involves the application of knowledge, wisdom, and practices by local people acquired over time through experience and verbally transferred from generation to generation (Gyampoh *et al.*, 2009), the scientific method of weather forecast is the application of technology and scientific knowledge to predict the atmosphere in a particular place. As presented in Table 5, local indicators that farmers use to predict rainfall occurrences in the study areas are highlighted.

**Table 5: 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 sheep and goats 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 of Information Services to Rice Farmers

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 more than one source, and experts provide information services through more than one provider. For example, farmers receive hydro-climatic information via radio stations (72%), agricultural extension agents (62.7%), face-to-face with agricultural organizations/institutions (14.7%), peers (8%), television (25.3%), mobile phones (32%), and in addition to farmers' local knowledge on weather forecast (Fig. 2). Agricultural experts also provide information either by face-to-face communication with farmers or via radio stations, television, mobile phone services, and/or through community representatives. A few farmers who did not access information via radio stated that they have economic challenges to purchase batteries, cost of radio devices, lack of mobile phones, and high cost of electricity bills. The study identified that most of the farmers who get information from agricultural extension agents are members of farmer-based organizations. Similar sources of information have been identified in different farming locations, however, the preference for one source over the others differs. For example, Nyadzi *et al.* (2019) observed that majority of farmers obtained climate information from government, non-government, and local knowledge in Northern Ghana. Furthermore, Radeny *et al.* (2019) mentioned that farmers in East Africa gained weather information from indigenous knowledge, relatives, friends, neighbors, observations, media (radio), village and clan meetings, and service providers such as NGOs, extension agents, and researchers. Other sources include mobile phones, leaflets, brochures, television, and the internet (Kumar *et al.*, 2020).

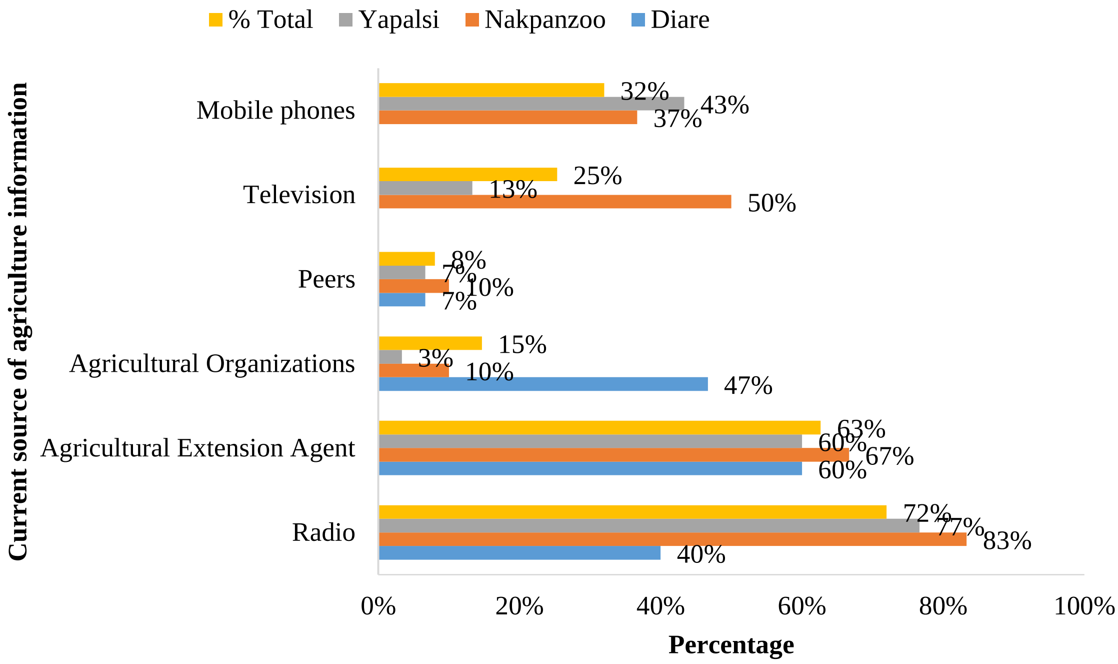


**Figure 2: Source of currently available information services to farmers in the study communities**
*Note that farmers can receive information from more than one source*

## Hydro-climatic Information in the Study Communities

Farmers received a bundle of agricultural services from experts. The study grouped these services into three, namely; technical, financial, and capacity building support services. Technical support services comprise information on water availability, seasonal weather forecast (rainfall, relative humidity, storms, and atmospheric temperature). The study revealed that 80% of the respondents received information on the seasonal weather forecasts, representing the highest information services received. All experts interviewed stated that they provide information on the seasonal weather forecasts (technical support services) to farmers. A nexus can be established between farmers and agricultural experts in northern Ghana concerning the provision of technical support services. Farmers obtained technical support services more often because of the immersed dependency on rain-fed agriculture and their increased vulnerability to climate change and variability. Despite the importance of hydro-climatic information/ seasonal weather forecast in agricultural production, not all farmers are reported to have access to such information. For instance, farmers in the Central Tongu district were reported to lack access to information on climate and weather (Anaglo *et al.*, 2014). On the contrary, in Bangladesh, farmers receive both technical and capacity building information services (Kumar *et al*., 2020).

## Hydro-climatic Information Needs of Rice Farmers in the Study Communities

The farmers in the study areas stated that four (4) weather parameters are mostly needed. These parameters are rainfall, relative humidity, temperature, and prediction of storm occurrence. Although farmers currently access information on these four parameters, both farmers and experts stressed on the need for location-specific weather forecasts, but not general information received from the aforementioned sources. Information on rainfall is of utmost importance to farmers (99%), followed by temperature (72%) and relative humidity (61%) as the second and third most needed information for farmers, respectively (Figure 3). The respondents further stated that every activity in rice production depends on seasonal weather forecasts. Therefore, access to area-specific seasonal weather information greatly influences their agricultural decision-making and adaptation measures to respond to climate change. Similar findings have been reported in India and Bangladesh where farmers prioritize rainfall information in addition to others. In India, farmers mostly prioritize information on rainfall (Mittal *et al.*, 2010). Lizumi and Ramankutty (2015) highlighted rainfall and temperature as the most needed information by farmers. Furthermore, the information needed by farmers in Bangladesh from the most to least importance were rainfall, storm surge, hailstorm, temperature, fog, and relative humidity (Kumar *et al.*, 2020).

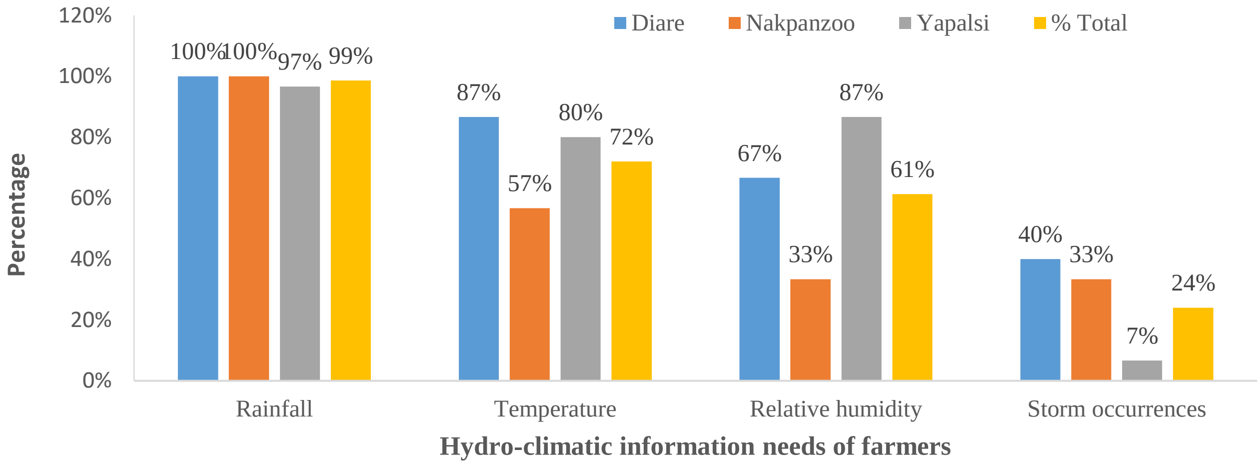


**Figure 3: Hydro-climatic information needs of farmers in Diare, Nakpanzoo and Yapalsi communities**

**Influence of the Available Information on Farmers' Agricultural Decision-making Process**

Rice farmers reported that in addition to scientific weather forecast information received from experts, farmers' agricultural decision-making processes are influenced by the indicators presented in Table 6. Farmers' decision to prepare the field for cultivation is influenced by the fruiting of two most important trees; the shea tree and *lannea acida/Sinsaba spp*, as fruiting of these trees signifies the beginning of the farming and rainy season. Following land preparation, farmers decide to either sow directly or transplant rice seedlings and apply fertilizer when the soil has adequate moisture. To test for soil moisture content, small holder farmers form bolus of soil in the palms. Balls are easy formed from a moist soil which lives the palms moist. Similarly, the level of water available in the soil is determined using cutlass. Smallholder farmers dig soils with cutlass, and the depth of wetness on the cutlass indicates the level of water available in the soil. By observing the field, any crop/ plant other than rice is considered weed and farmers base that to control weeds, whiles abnormal growth in rice field such as stunted growth; leave coloring indicates pest and disease infestation and/ or nutrient deficiency. Dryness of paddy and bending of dried paddy indicates the readiness for harvesting of rice.

**Table 6: Observable indicators and their influence on agricultural activities**

| Indicators | Types of activities |
|---|---|
| Fruiting of *Lannea acida/ Sinsaba spp.* | Land preparation |
| Fruiting of shea trees | |
| Adequate soil moisture | Sowing |
| | Fertilizer Application |
| Appearance of weeds | Weed Control |
| Abnormal rice growth | Pests and Diseases Control |
| Dryness of rice paddy | Harvesting |
| Bending of dried paddy | |

### Threats and the Adopted Mitigation Strategies in Rice Production

Several threats were identified in the study areas (Figure 4). Among them were natural disasters, such as floods, drought, and bushfires. Inadequate access to agricultural information, financial constraints, lack of labor, and challenges associated with accessing agro-inputs for rice production were also mentioned. Again, the major threat mentioned is the inability to predict the incidence of floods and droughts.

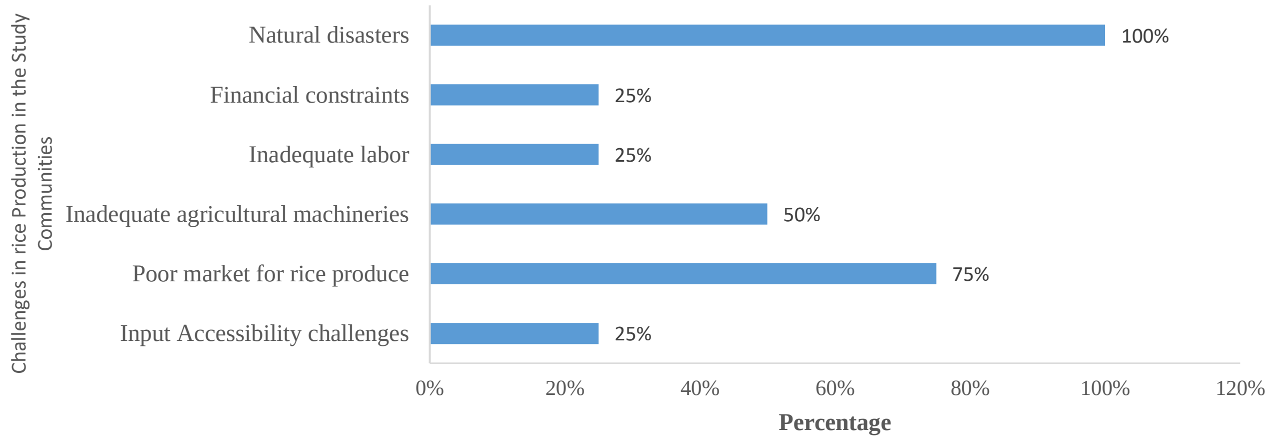


**Figure 4: Challenges in rice production in the study communities**

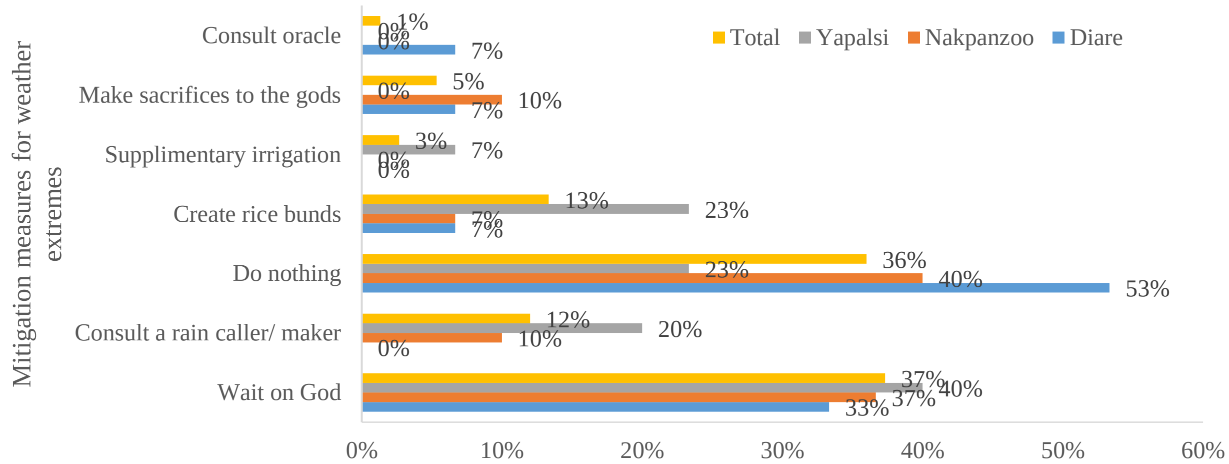


**Figure 5: Mitigation measures for weather stresses on the rice fields**

Predictions of weather in the cropping season influence farmers' decisions on crop varieties and sowing timing. 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 are the creation of bunds (13%), rain makers consultation (12%) to call/ make rains, practice supplementary irrigation (3%), and timely crop harvest (Fig. 5). Although farmers stated during the FGD that opening of rice bunds in one farm may cause severe flooding in an adjacent farm, it is the best mitigation measure according to farmers. Farmers who wait on God (37%) as well as farmers who do nothing (36%) were the majority. According to those farmers, incidence of floods and draughts are natural phenomena controlled only by God and no human being can do anything about it. Therefore, farmers put their trust in God and hope for God's mercy to resolve the situation when they prevail.

## CONCLUSION

This study has provided an understanding of hydro-climatic information needs for lowland rice farmers in Savelugu Municipality in the Northern Region of Ghana. Weather-related information is crucial for farming communities. The study sought for farmers at individual and FGD levels as well as experts' views on suitable ways to address farmers' information needs. Farmers have access to technical, capacity building, and financial support services, with weather support (seasonal weather forecast-rainfall, relative humidity, storms, and atmospheric temperature) being the most important information. Although information on rainfall, relative humidity, storms, and atmospheric temperature are available and accessible to farmers, lowland rice farmers in the valleys are in need of location-specific hydro-climatic information that is available and accessible for them. The available hydro-climatic information is insufficient to address the local needs due to occasional prediction failures. Incidence of flood and drought are the major threats rice farmers face in the study areas. Nonetheless, farmers adopt mitigation measures such as creation of rice bunds, supplementary irrigation, consult rain makers to call rains whiles the majority of farmers do nothing and wait on God to intervene.

There is a high potential for rain-fed rice production in the valleys of Savelugu Municipal and this could be sustained through an accurate, timely, and area-specific weather/rainfall forecast system. Integration of local and scientific weather forecasting knowledge is the key to achieving this potential. All three groups of respondents proposed a blend/an integration of scientific and traditional forecast methods as a suitable solution to address intermittent prediction failures in their regions. Therefore, we recommend a development of integrated weather forecast tool or modification of such tools 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 interest.

## CONFLICT OF INTEREST

There is no conflict of interest regarding the publication of this paper.

## ACKNOWLEDGEMENT

This publication was made possible through support provided by the West African Centre for Water, Irrigation, and Sustainable Agriculture (WACWISA), University for Development Studies, Ghana, with funding support from the Government of Ghana and World Bank through the African Centers of Excellence for Development Impact (ACE Impact) initiative, and WAGRINNOVA which funded field activities.

## REFERENCES

Aker, J. C. 2011. Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries. Agricultural economics, 42(6), 631-647.

Ambani, M., and Fiona, P. 2014. Facing uncertainty: the value of climate information for adaptation, risk reduction and resilience in Africa. Amikuzino, J., & Donkoh, S. A. (2012). Climate variability and yields of major staple food crops in Northern Ghana. *African Crop Science Journal*, *20*, 349-360.

Anaglo, J. N., Boateng, S. D., and Boateng, C. A. 2014. Preferred Agricultural Information Sources Among Crop Farmers in The Central Tongu District. *Research Journal of Sociology*, *2*(3), 2347-8241.

Asante, F. A., and Amuakwa-Mensah, F. 2014. Climate change and variability in Ghana: Stocktaking. *Climate*, *3*(1), 78-101.

Ayeduvor, S. 2018. Assessing quality attributes that drive preference and consumption of local rice in Ghana (Vol. 48). *Intl Food Policy Res Inst.*

Carr, E. R., Goble, R., Rosko, H. M., Vaughan, C., and Hansen, J. 2020. Identifying climate information services users and their needs in Sub-Saharan Africa: a review and learning agenda. *Climate and Development*, *12*(1), 23-41.

Feleke, H. G. 2015. Assessing weather forecasting needs of smallholder farmers for climate change adaptation in the Central Rift Valley of Ethiopia. *Journal of Earth Science and Climate Change*, *6*(10), 1-8.

Food and Agriculture Organization of the United Nations, FAO. 2019. Handbook on climate information for farming communities: what farmers need and what is available Rome. Italy.

Gbangou, T., Ludwig, F., van Slobbe, E., Hoang, L., Kranjac-Berisavljevic, G. 2019. Seasonal variability and predictability of agro-meteorological indices: tailoring onset of rainy season estimation to meet farmers' needs in Ghana. *Climate Services*, *14*, 19-30.

Gyampoh, B. A., Amisah, S., Idinoba, M., and Nkem, J. 2009. Using traditional knowledge to cope with climate change in rural Ghana. *Unasylva*, *60*(281/232), 70-74.

Inwood, S. E. E., & Dale, V. H. 2019. State of apps targeting management for sustainability of agricultural landscapes. A review. *Agronomy for sustainable development*, *39*(1), 8.

Kumar, U., Werners, S., Paparrizos, S., Datta, D. K., and Ludwig, F. 2020. Hydroclimatic information needs of smallholder farmers in the lower Bengal delta, Bangladesh. *Atmosphere*, *11*(9), 1009.

Kumar, U., Werners, S., Roy, S., Ashraf, S., Hoang, L. P., Kumar Datta, D., and Ludwig, F. 2020. Role of Information in Farmers' Response to Weather and Water Related Stresses in the Lower Bengal Delta, Bangladesh. *Sustainability*, *12*(16), 6598.

Lizumi, T., and Ramankutty, N. 2015. How do weather and climate influence cropping area and intensity? *Global food security*, *4*, 46-50.

Logah, V., Ewusi-Mensah, N., Tetteh, E. N., Quansah, C., and Danso, I. 2013. Seasonal variations of soil microbial biomass under different nutrient management and cropping systems on a Ferric Acrisol in Ghana.

Martey, E., Wiredu, A. N., Asante, B. O., Annin, K., Dogbe, W., Attoh, C., and Al-Hassan, R. M. 2013. Factors influencing participation in rice development projects: the case of smallholder rice farmers in Northern Ghana. *International Journal of Development and Economic Sustainability*, *1*(2), 13-27.

Mdemu, M. V. 2008: Water productivity in medium and small reservoirs in the Upper East Region (UER) of Ghana. Doctoral dissertation, Rheinischen Friedrich-WilhelmsUniversität, 159 pp.

Mittal, S., and Mehar, M. 2016. Socio-economic factors affecting adoption of modern information and communication technology by farmers in India: Analysis using multivariate probit model. *The Journal of Agric. Edu and Exten*, *22*(2), 199-212.

MoFA 2018. Agricultural sector annual progress report, Accra MoFA. (https://www.mofep.gov.gh/sites/default/files/pbb-estimates/2018/2018-PBB-MoFA.pdf) (11/ 01/2021)

Nyadzi, E. 2016. Climate variability since 1970 and farmers' observations in Northern Ghana. *Sustainable Agriculture Research*, *5*(526-2016-37880).

Nyadzi, E., Werners, E. S., Biesbroek, R., Long, P. H., Franssen, W., and Ludwig, F. 2019. Verification of seasonal climate forecast toward hydroclimatic information needs of rice farmers in Northern Ghana. *Weather, Climate, and Society*, *11*(1), 127-142.

Oerke, E. C. 2006. Crop losses to pests. *The Journal of Agricultural Science*, *144*(1), 31-43.

Radeny, M., Desalegn, A., Mubiru, D., Kyazze, F., Mahoo, H., Recha, J., and Solomon, D. 2019. Indigenous knowledge for seasonal weather and climate forecasting across East Africa. *Climatic Change*, *156*(4), 509-526

Tadesse, D. 2008. Access and utilization of agricultural information by resettler farming households:Tthe case of Metema Woreda, North Gondar, Ethiopia (Doctoral dissertation, Haramaya University).