UNIVERSITE JOSEPH KI-ZERBO

ECOLE DOCTORALE INFORMATIQUE ET CHANGEMENTS CLIMATIQUES

BURKINA FASO

Unité-Progrès-Justice

MASTER RESEARCH PROGRAM

SPECIALITY: INFORMATICS FOR CLIMATE CHANGE (ICC)

MASTER THESIS

Subject:

Evaluate the effectiveness of local rainfall forecast application for farmers making decision

Presented the July 19, 2021 and by:

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Academic year 2020-2021

SUMMARY

In Niger rainfall forecasts are provided at large scale and by administrative region which does not support farmer for strategic decisions on crop management and risk reduction strategies. This study evaluate effectiveness of two local rainfall forecasts Application (Accuweather and Weather channel) for agricultural decision making in the regions of Zinder and Tahoua in Niger. The applications were installed in the smartphone of 10 fields technicians based in 10 communes, respectively. Results showed that the best forecast effectiveness was 67% with Accuweather against 73% for weather channel and with rainfall occurrence above 91% and 81%, respectively. For both applications, the higher is forecast, and the greater is the rainfall occurrence. We infer that forecast percentage threshold is important for users for decision making. For example, with a forecast above 70% indicates high rainfall occurrence. In this context, farmers can trust forecasts and schedule their agricultural activities. However, there was a maximum number of forecasts within 21-30% interval with an effectiveness below 25%. Here, it needs not trust the forecasts of these two applications for making agricultural decisions.

In this study, many farmers were interested in using these applications. At this stage, it is highly recommended to repeat the experimentation while focusing on acceptance threshold, which could better serve farmers in their decision making.

Key words: Rainfall; Forecast; Accuweather; Weather channel; Niger

RESUME

Au Niger, les prévisions pluviométriques sont fournies à grande échelle et par région administrative, ce qui ne permet pas aux agriculteurs de prendre des décisions stratégiques sur la gestion des cultures et les stratégies de réduction des risques. Cette étude a évalué l'efficacité de deux applications de prévisions pluviométriques locales (Accuweather et Weather channel) pour la prise de décision agricole dans les régions de Zinder et Tahoua au Niger. Les applications ont été installées dans le smartphone de 10 techniciens agricoles basés dans 10 communes, respectivement. Les résultats montrent que la meilleure efficacité de la prévision était de 67% avec Accuweather contre 73% pour la chaîne météo et avec une occurrence des précipitations supérieure à 91% et 81%, respectivement. Pour les deux applications, plus la prévision est élevée, plus l'occurrence des précipitations est importante. Nous en déduisons que le seuil du pourcentage de prévision est important pour les utilisateurs lors de la prise de décision. Par exemple, une prévision supérieure à 70 % indique une forte occurrence des précipitations. Dans ce contexte, les agriculteurs peuvent se fier aux prévisions et programmer leurs activités agricoles. Cependant, il y avait un nombre maximum de prévisions dans l'intervalle 21-30% avec une efficacité inférieure à 25%. Ici, il n'est pas nécessaire de faire confiance aux prévisions de ces deux applications pour prendre des décisions agricoles.

Dans cette étude, de nombreux agriculteurs étaient intéressés par l'utilisation de ces applications. À ce stade, il est fortement recommandé de répéter l'expérimentation en se concentrant sur le seuil d'acceptation, ce qui pourrait mieux servir les agriculteurs dans leur prise de décision.

Mots clés : Pluie ; Prévision ; Accuweather ; Weather channel ; Niger

- **DEDICATION**

I dedicate this work to my late father ELH Maman Garba

ACKNOWLEDGEMENTS

All the praises and thanks be to Allah, the almighty for giving me health, patience, time and strength to finish this work. Firstly, I would like to express my sincere gratitude to

- Pr Tanga Pierre ZOUNGRANA Director of “Ecole doctorale Informatique et Changement Climatique” (ED-ICC)
- Dr Ousmane COULIBALY Deputy Director of “Ecole doctorale Informatique et Changement Climatique” (ED-ICC)
- My Major Supervisor Dr YAMEOGO Lassane Department of Geography at Joseph KI-ZERBO university of Ouagadougou
- My Co-supervisor and my Director of internship Bouba TRAORE, PhD Agriculture and Climate change, ICRISAT-Niger
- I thank everyone who has contributed to this study. Spiffily Mrs. Ibrahima Abdoussalam, Illiasso Aboubacar, Mss Ressi and Dr Mariama Diallo for their supports and contributions.
- All the staff of the MRP Climate change and informatics for their implications in the successfulness of this program. I would like to thank the German federal Ministry of Education for financing this program. Special thanks go to all my Family and colleagues of MRP- ICC. I thank you for your friendship and your patience.

ACRONYMS AND ABBREVIATIONS

ICRISAT: International Institute for Crops of Semi-Arid Tropical
PMH: Weekly Maximum Forecast
PMJ: Daily Maximum forecast
WAM: West African Monsoon
MCSs: Mesoscale Convective Systems
GCMs: General Circulation Models
IPCC: The Intergovernmental Panel on Climate Change
IPCC AR5: The Intergovernmental Panel on Climate Change Fifth Assessment Reports
CSA: Climate-smart agriculture
DMN: National agro-meteorological services
CGIAR: Consultative Group for International Agricultural Research
ICT: Information and communication technology
ACMAD: African Center of Meteorological Applications for Development
AGRHYMET: Agriculture, Hydrology, Meteorology research center
ABN: Niger Basin Authority
PRESAO: Seasonal Forecast in West Africa
JAS: July, August and September
PRESASS: Seasonal Forecast in Sudano-Sahelian Africa
CILSS: Permanent Interstate Committee for Drought Control in the Sahel
UV: Ultraviolet
PAIBO: Access to rainfall amount from Neighbour
PAIRL: Access to rainfall amount through local radio broadcasting
DRLP: Constraint for reading rainfall information
SLP: Capacity for reading rainfall information

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CHAPTER 1: INTRODUCTION

1.1 Background

In Sahel rainfall is connected with the variability of the atmospheric circulation which are governed by global-scale constraints. Seasonal accumulation of rainfall across the Sahel is the aggregate of weather features that are, in comparison short-lived (a few hours) and small scale (Biasutti et al., 2018). In West African region, 70–90% of the annual rainfall is produced by Mesoscale Convective Systems (MCSs): fast moving squall lines and larger Mesoscale Convective Complexes (Fink et al., 2006; Mathon et al., 2002). The dynamics of Sahel rainfall variability are connected with the dynamics of the West African Monsoon (WAM) which variability and change can have a devastating impact on the local population, especially since the region lacks sufficient irrigation infrastructure (Boko et al., 2007). WAM involves the interaction of multi-scale processes ranging from planetary to cumulus scales making it challenging for General Circulation Models to simulate accurately (Raj et al., 2019). Accurate simulation, and projection of the WAM are of utmost importance for improving the adaptability of the region. However, according to IPCC AR5, there is "low to medium confidence" in the robustness of projected rainfall change over West Africa due to the considerable inter-model variations in both the magnitude and the sign of change. This disparity can be partially attributed to the inability of conventional general circulation models (GCMs) to resolve the convective rainfall (Stocker, 2014). However simulations of WAM using GCMs often suffer from shortcomings associated with their spatial resolution (Sylla et al., 2010) and this limitation is partly due to the poorly resolved effects of vegetation, orography, and coastlines, which are important controls on the regional precipitation pattern.

Regarding the weather service, about 80–90% of the rainfall in the Sahel comes from storms that are especially well organized. They are larger than 80–100,000 km2 and live longer than 6 hour in spite of those storms being just 11% of the total Mesoscale Convective Systems. Seasonal rainfall variability, thus, likely depends on the controls upon the number and intensity of such organized storms (Mathon et al., 2002). Climate models vary widely in their ability to capture rainfall anomalies. However, understanding the physical mechanisms that modulate Sahel rainfall patterns is key for gaining further confidence in future predictions.

Seasonal forecasts of rainfall have become operational in the last ten years or so (Hulme, 1992) because the modern era of meteorology set the limits to the successful forecasting of future states of the atmosphere to about six days. Recently, a revolution from deterministic to probabilistic forecast schemes, has extended predictability of climate to several months ahead for large parts of the globe. With droughts record, high interannual variability of rainfall and its largely agricultural economy, Africa is a prime potential benefactor of seasonal forecasting.

Forecasts made by meteorologists based on ‘climatology’ and ‘persistence’ and empirical knowledge about evolution of weather systems are known as synoptic forecasts. Before the advent of computers, this was the only method of weather forecasting. Up to 12 hours or 24 hours in advance, the meteorologists can actually make very good forecasts based on this technique. But beyond that this type of forecast is not useful (Rauch et al., 2019).

1.2 Problem Statement

In Niger, climate change and variability are a major concern for sustainable development affecting agriculture and other key sectors with direct implications on food security of rural populations. Drought occurred in 1973–1974 and 1984 pointed out effect of rainfall variability on agricultural activities and this is projected to intensify with future climate change (Mortimore, 2010). Most of the population lives in rural areas and their main livelihood is rainfed agriculture, are particularly vulnerable to climate risks. The combination of rainfall variability and lack of means of rural communities to a chronic vulnerability to food insecurity (Zakari et al., 2014). In recent years, climate-smart agriculture (CSA) technologies has been by extension workers in order to increase agricultural productivity and build up resilience of agricultural systems face to climate change (FAO, 2010). Among CSA technologies, weather and climate services indicated principal entry point to reduce farmers’ vulnerability in Africa (Ouédraogo et al., 2018). There is evidence that agro-meteorological information tailored to farmers can improve agricultural productivity and increase their income thereby reducing the impacts of climate change and minimizing the risk of food insecurity (Vaughan et al., 2019). However, at the farm level, agro-meteorological services are often not really relevant, adapted, and usable for decision making in crop management. Indeed, national agro-meteorological services (DMN) is not well-equipped to farmers’ needs especially for forecasting expertise and dissemination channels. DMN in Niger usually concentrate their forecasting efforts on short term and seasonal (http://www.meteo-niger.org/content.phpmodule=meteo&action=12). However these forecasts are provided for large scale and by administrative region which are not sufficient to take some strategic decisions on crop management planning and risk

reduction strategies. The skill of such forecasts is often considered too low by met services and they do not often produce them.
Framers’ perceptions on use of forecasts for agricultural decision making highlighted that they seek contextual and location-specific forecasts to aid decision making and “would like access to forecasts at the correct time to facilitate decisions and predict impacts. The time-gap between issuing of the forecast and its reception by farmers has long been a critical challenge for agro-meteorological warning systems, particularly in the poor countries, such as Niger, where information dissemination networks are weak, distances are large, and the extension service has suffered a chronic lack of financial resources for many years. The large diffusion of mobile phone technology throughout sub-Saharan Africa offers the potential to reduce the time-gap and costs associated with the dissemination of forecasts to farmers (Traore, B., Ouédraogo, M., Birhanu, Z.B., Zougmoré, 2018). Digital technology could allow communities to provide timely feedback on information received and its performance, thereby improving their engagement in the whole agro-meteorological monitoring system (B. Traore et al., 2017).

In this study, we used two mobiles rainfall forecasting applications and evaluated their efficiency for providing guidance for farming system in Niger.

1.3 General Objective

Evaluate the effectiveness of two rainfall forecasts tools for agricultural decision making in the regions of Zinder.

1.3.1 Specific objectives

- ❖ Evaluate the effectiveness of rainfall forecasts provided by Accuweather application;
- ❖ Evaluate the effectiveness of rainfall forecasts provided by Weather Channel applications;
- ❖ Evaluate farmer perception of rainfall forecasting tool and rainfall distribution

1.3.2 Research Questions

- ❖ What is the effectiveness of rainfall forecasts by Accuweather application?
- ❖ What is the effectiveness of rainfall forecasts by Weather Channel application?
- ❖ What are Farmer’s perceptions on rainfall forecast application?

1.3.3 Research hypothesis

- ❖ Daily and weekly rainfall forecast by Accuweather and Weather Channel are closely related to the observe rainfall.
  - ❖ Daily and weekly rainfall forecast support farmers for agricultural decision making.

CHAPTER 2: HOST STRUCTURE

2.1 Host Structure Presentation

Founded in 1972, the International Institute for Crops of Semi-Arid Tropical Zones (ICRISAT) is an international non-profit and apolitical organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners from throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, and 644 million of these are the poorest of the poor. ICRISAT is one of fifteen centers funded by the Consultative Group for International Agricultural Research (CGIAR) whose primary responsibility is to preserve and disseminate the plant genetic resources that form the basis of global food security. ICRISAT's mission is to help the poor of the semi-arid tropics through human-face science and development research, with a view to increasing agricultural productivity and food security. This is why the work of ICRISAT is oriented towards semi-arid tropics whose main environmental constraints to agriculture are low rainfall and soil degradation. ICRISAT works on five mandate crops that are of particular importance to feeding the poor: millet, sorghum, groundnuts, chickpeas and pigeon peas. ICRISAT is represented in West Africa (Niamey and Bamako), East and South Africa (Nairobi, Bulawayo, Lilongwe, Maputo) and India (Patancheru) where the headquarters are located (Figure 1).

ICRISAT has dramatically changed its scope. The emergence of global markets, biotechnology, and information and communication technology (ICT) has influenced its strategic direction. Thus, following recent recommendations, ICRISAT's research programs focus on three global research themes:

- Policy and Market Impact;
- Biotechnology for the poor;
- Improvement and management of crops for food security;

To adapt to the current changes and constraints, discussions are underway for a new reorganizing research structure across all regions with effect from July 01, 2021. The new research structure shall consist of:

i. Three Global Research Programs working across Asia, Eastern and Southern Africa, and West and Central Africa to be led by three global research program directors

ii. Three Regional Directors – one each for Asia, Eastern and Southern Africa, and West and Central Africa

iii. Director, Business Development to lead resource generation, working closely with research team of all three global research programs and regions.

iv. Head, Science Quality and Strategy to monitor quality of science at the Institute and coordination in development of different research strategies.

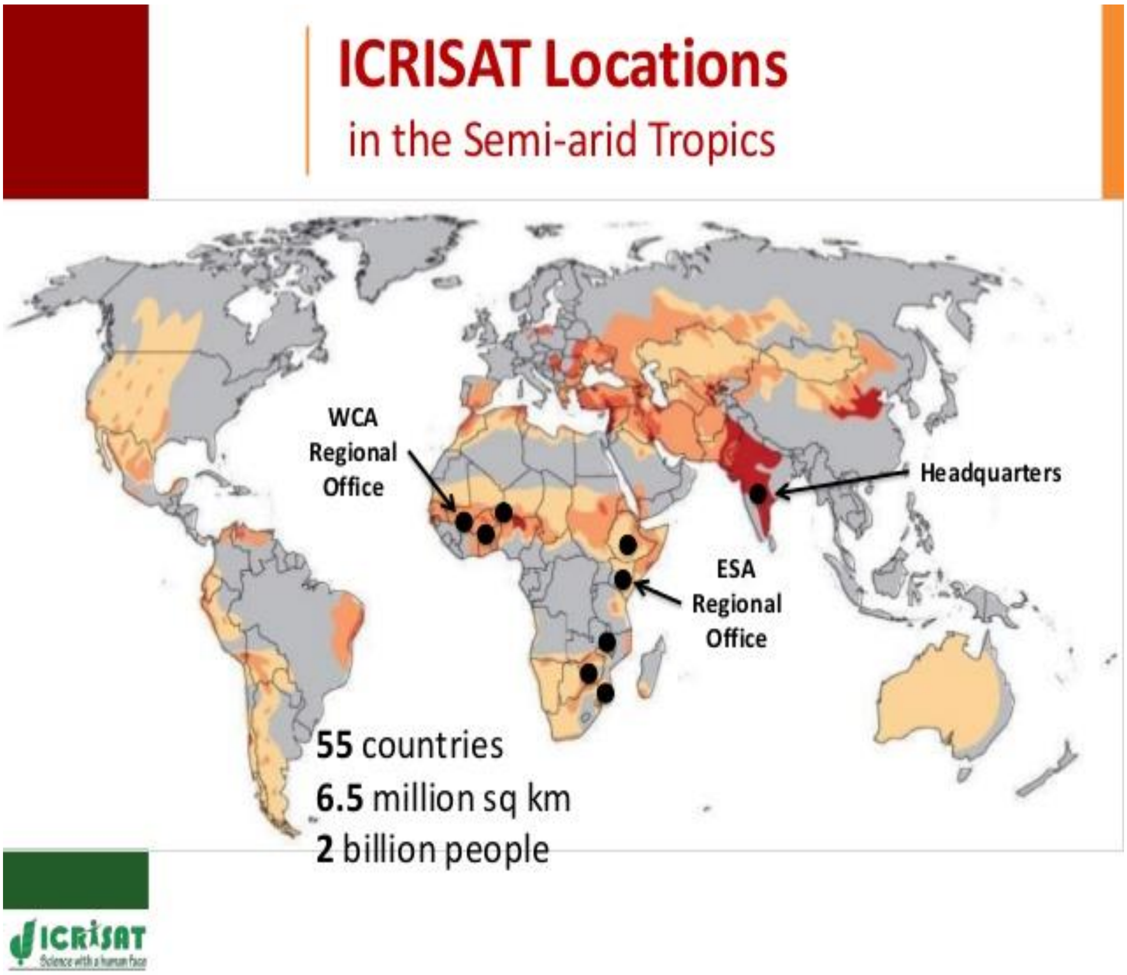


Figure 1: ICRISAT working countries

The overall objective of this new structure is to recognize that ICRISAT's research and development activities continue to focus on global problems and implement solutions at regional and local levels and aligned to country strategies in an effective manner.

The three global research programs consist of:

- Global Research Program on "Accelerated crop improvement of highly nutritious legumes and cereals food in the Semi-Arid Tropics by enhancing the genetic gains" (Short title: Accelerated Crop Improvement);
- Global Research Program on "Towards inclusive and resilient farm and food systems for nutrition in the Semi-Arid Tropics" (Short title: Resilient Farm and Food Systems); and
- Global Research Program on "Enabling Transformations through improving policies, facilitating institutional innovations, markets, and scaling impacts and capacity development to support sustained reduction in poverty and malnutrition in the Semi-Arid Tropics" (Short title: Enabling Systems Transformation).

The three global research programs shall consist of 18 research clusters working globally in the three regions – Asia, Eastern and Southern Africa, and West and Central Africa.

Figure 2: Global research programs of ICRISAT effective from 1st of July 2021

2.2 Role and locations

- Global Research Program Directors

Located in any of the three regions, the Global Research Program Directors devote 80% of their time to research management across regions including resource mobilization, research supervision, administration, staff supervision, and 20% of their time to scientific research mostly through supervision of scholars or association with one of the research clusters as scientist and any other duty assigned by ICRISAT. Global Research Program Directors can be program coordinators for larger projects that may span across programs and/or across research clusters within a program.

- Regional Directors

Located in each of the three regions, Regional Directors devote 60% of their time to resource mobilization including development of innovative funding strategies, developing and strengthening relationships in the regions and countries, 20% to support project implementation in the regions and countries, 10% to provide administrative support to staff in the region, and 10% to manage and support ICRISAT's Integrated Support Center in the region and any other duty assigned by ICRISAT.

- Director, Business Development

The Director, Business Development leads the formulation of innovative business development opportunities, gather donor intelligence and identify new donors and/or potential funding opportunities, develop and present innovation funding pitches to current and new donors, and coordinate multi-disciplinary teams to develop proposals and follow-through for successful funding.

- Head, Science Quality and Strategy

The Head, Science Quality and Strategy is responsible for maintaining ICRISAT's high quality of science in different scientific areas including delivery of high-quality outputs, projects and publication of high-quality manuscripts. The Head leads the unit to develop, refine, implement and monitor the institutes principles of conducting high quality scientific research, developing high quality reproducible reliable data, avoiding data fraud, assuring database controls for data management and maintaining ethics in science. Monitoring and evaluating manuscripts, outputs, projects and reports before submission/publication is part of the function of the Head, Science Quality and Strategy.

- Research Cluster Leaders

Research Cluster Leaders is based across regions and their roles is on rotational basis, with the duration of role depending upon the performance of the incumbent and availability of expertise in the research cluster group, so as to provide opportunities to a larger group of scientists in an endeavor to build leadership skills for the future. Research Cluster Leaders shall devote 20% of their time in management of staff in a research cluster across the regions and 80% of their time on research. Research Cluster Leaders work closely with both Global Research Program Directors and Regional Directors and their reporting relationship will be split 60% and 40% respectively. Research Cluster Leaders can be principal investigators for projects implemented across regions.

- Country Representatives

Located in their respective countries, Country Representatives will devote 60% of their time to resource mobilization, relationship development, administrative support and any other duty assigned by ICRISAT and 40% of their time to research. Country Representatives, as part of their research duties, can be principal investigators in country-specific projects. Country Representatives works closely with both Global Research Program Directors and Regional Directors and the reporting relationship will be split 40% and 60% respectively.

- Research Scientists

Research scientists located across regions shall devote 15% of their time to management of staff within the region and 85% of their time on research and resource mobilization for research. Individual scientists is responsible for management of their research team, output delivery and aligning research with other teams. Research scientists can be principal investigators for region-specific projects.

CHAPTER 3: LITERATURE REVIEW

3.1 Weather forecast Definition

Weather forecasting is the application of science and technology to predict the conditions of the atmosphere for a given location and time. People have attempted to predict the weather informally for millennia and formally since the 19th century (Kombi, 2019).

The history of weather forecasting dates back to time immemorial with oracles and diviners, but modern science really dates from the late 19th century and early 20th century. However, it has gained ground since World War II as technical means such as radar and modern communications made access to data faster and more abundant. Still, even though the resolution of our data has increased exponentially, forecasting remains as much an art as it is a science. Indeed, the state of the atmosphere can be understood in chaos theory and can never be fully defined, leaving room for the human factor in forecasting (Prévision météorologique — Wikipédia (wikipedia.org)). The forecast assessment study sets out to answer the question "Will it rain tomorrow or not?". Whatever rainfall forecast, it is necessary for its verification. The user does not always clearly know the predictand, due to the often too imprecise formulation of the forecast. A rainfall forecast should refer to a specific space domain and time interval. Thus, "rain tomorrow in Zinder" should not be checked in the same way depending on whether it means that rain will be recorded by the rain gauge. Between 0 hours and 24 hours (this predictand is easily observable by the meteorological service) or that there will be a period of rain anywhere between 8 a.m. and 8 p.m. (this predictand is different, both by the time interval and by the domain concerned). The verification of the second predictand requires a more detailed analysis, based both on occasional observations of rain gauges and on weather radar images, which may show that it will have rained in one part of the area, but not in another. This very simple example shows the need for a precise definition of the predictand in order to understand the forecast itself and be able to verify it. We will assume subsequently that the rainfall forecast occurrence will have been the subject of a precise definition allowing it to be compared with an actual observation (Rousseau, 2001). Weather forecasting is a complex and often challenging skill that involves observing and processing vast amounts of data. Weather systems can range from small, short lived thunderstorms only a few miles in diameter that last a couple hours to large scale rain and snow storms up to a thousand miles in diameter and lasting for days.(Bloomer, Mark, n.d.). Forecasting is a necessary part of any activity strategy, since no preventive or protective measure can be fully effective.

Forecasting remains helpful as a foundation to create any action or policy before facing any events. As an example, in the tropics region which several countries only had two seasons in a year (dry season and rainy season), many countries especially country which agriculture relies on rainfall will need weather forecast to decide the best time to start planting their products and maximizing their harvest (Bouzaïane, 2008). Providing reliable rainfall forecasts for the coming rainy season is therefore crucial for many national weather services in the tropics and subtropics.

3.2 Different types of rainfall forecast

3.2.1 Seasonal forecasts

Seasonal forecasting is defined as a technique of forecasting meteorological parameters on a time scale of a few months to come. An average or an anomaly of temperature and precipitation is forecast for each month or season (Kombi, 2019). Seasonal forecasting in general consists in looking for statistical links between certain indicators of the rainy season and parameters characterizing the state of the atmosphere and / or the oceans (Point, n.d.). To cover the period of the growing season in the Sahelian countries of West Africa, the forecast extends over a period of six months starting in June. It generally relates to: (i) forecasts of total rainfall depending on whether they are in excess or in deficit; (ii) the start and end dates of the season and (iii) the dry sequences or pockets of drought during the campaign. These forecasts indicate the most likely scenario among the three predefined scenarios: below, near or above average (Agrhymet, 2021). The seasonal rainfall forecast for a place represents the quality of the rainy season in relation to a known situation, taken as a reference (for example the average rainfall accumulated over a period of thirty years commonly called "normal rainfall" and this according to a probability If the forecast is above average, the season is said to be “wet” or “excess” and “normal” when the forecast is near average. When the forecast is below average, we say that the season will be “dry” or “deficit.” This type of forecast gives general rainfall trends without being able to give any indication of its distribution (Agrhymet, 2021).

- ❖ Access to seasonal rainfall forecast

In West Africa and Niger in particular, seasonal forecasts started in 1998 with the support of the ACMAD-AGRHYMET-ABN-ICRISAT consortium following the establishment of the process, which was then named seasonal forecast in West Africa (PRESAO). This process provides forecasts of average climate conditions, namely: precipitation for the period from July to September (JAS), corresponding to the rainiest months in the Sahelian zone and stream flows during the high-water period. The PRESAO process works in its area of intervention to reduce vulnerability to climate variability. The information provided will make it possible to take the necessary measures for a better management of water resources.

The seasonal forecasts are designed by these structures on the basis of different methods:

- Statistical methods (statistical model);
- Statistical-dynamic methods (statistical-dynamic model);
- Dynamic method (dynamic models). (Kombi, 2019)

Each year, before the start of the rainy season, an expert forum called PRESASS (Seasonal agro-hydro-climatic forecasts in Sudano-Sahelian Africa) is organized by the AGRHYMET Regional Center of CILSS, ACMAD and the National Meteorological Agencies. In collaboration with experts from West and Central African countries to develop seasonal forecasts for Africa south of the Sahara. Following this regional forum, each national meteorological agency prepares the country's seasonal forecast at the start of each agricultural season (April-May) in order to allow users, particularly in the rural development sector, to better plan their agricultural activities. National forecasts have the advantage of being disaggregated at the country level and compiled on the basis of local historical data (Traore, B., Ouédraogo, M., Birhanu, Z.B., Zougmoré, 2018).

3.2.2 Example of seasonal climate forecast for the 2021 in Niger

- Rainfall forecast for the 2021 season

The results of seasonal rainfall climate forecasts are the subject of a consensus around the products of forecasting models, observations on the state of the oceans and current knowledge on the climate of the sub-region. This forecast is a qualitative assessment of the amounts of cumulative rainfall expected during the months of July, August and September (JAS) 2021. It does not take into account the temporal distribution of precipitation (this distribution concern is taken into account in the second part (II) of this bulletin through the forecasts of agro-climatic parameters essential for the appreciation of the profile of the seasons). Specifically, over the period July-August-September 2021, a humid or excess rainy season with a normal trend is expected on the agro-pastoral belt of the country (green color) with overall rainfall amounts greater than the cumulative amount (DMN, 2021a).

The upper number indicates the probability that the rainfall is higher than normal (Figure

3). The middle number indicates the probability that the rainfall will be equal to normal. The lower number indicates the probability that the rainfall will be lower than normal.(DMN, 2021a)

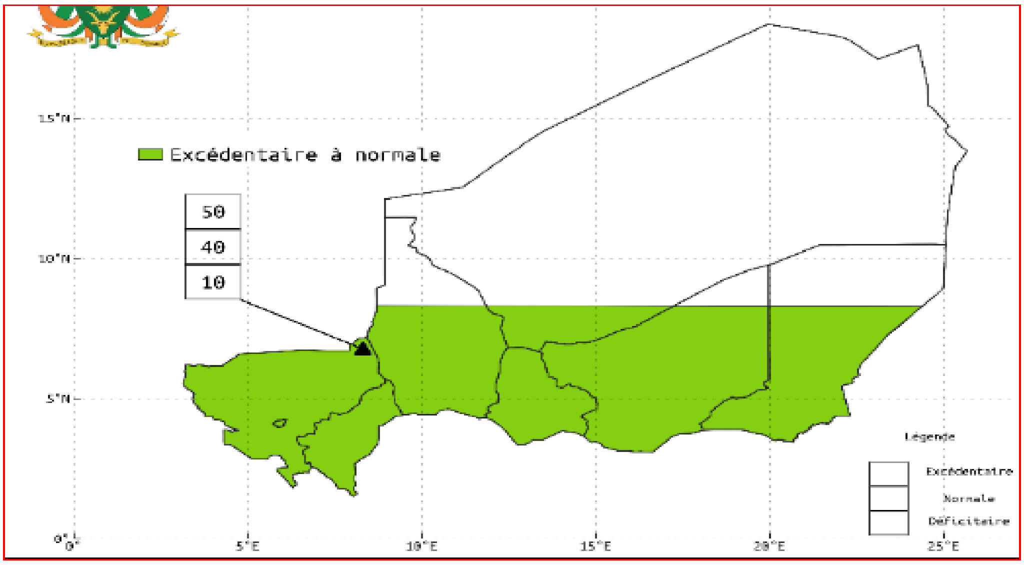
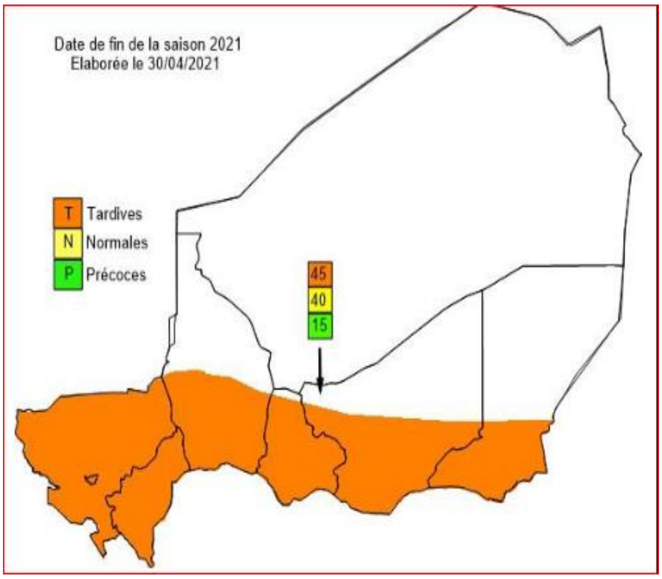


Figure 3:Niger Rainfall Forecast 2021

❖ Forecast of agro-climatic parameters for the 2021 wintering season

Even if rainfall distributions within the season are not predicted, key agro-climatic parameters such as season start dates, season end dates, dry sequences (rainfall breaks) expected at the start of the season, the dry stretches towards the end of the season are planned and make it possible to sufficiently appreciate the expected profile of the coming season for better planning of the agro-pastoral campaign.



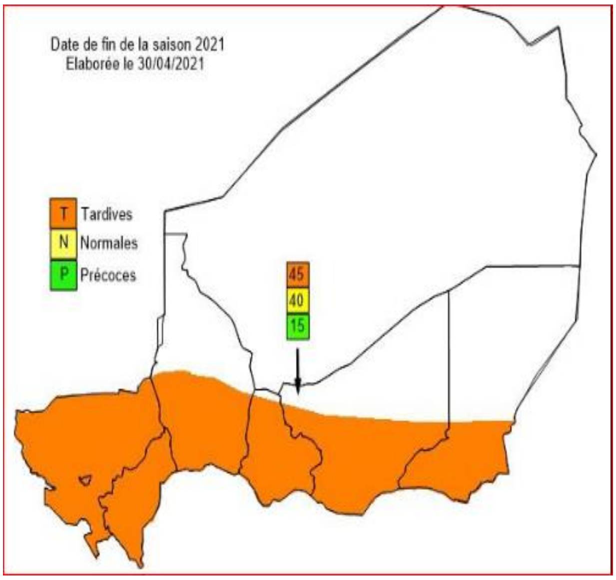


Figure 4:Forecast for the start and the end of rainy season in Niger in 2021

For rainy season start dates, normal start dates are expected over the north of the Tillabéri region and the south of the Diffa region. In the rest of the agricultural zone, normal start of the season dates with an early trend are expected. End dates of the 2021 rainy season late to normal end of season dates are expected over most of the agricultural zone of Niger.

- ❖ Dry stretches at the start and end of the season

Dry stretches of long to medium duration are expected at the start of the season throughout the agricultural zone with the exception of the regions of the river where they are expected to be normal. Dry stretches of normal length are expected across the country at the end of the season

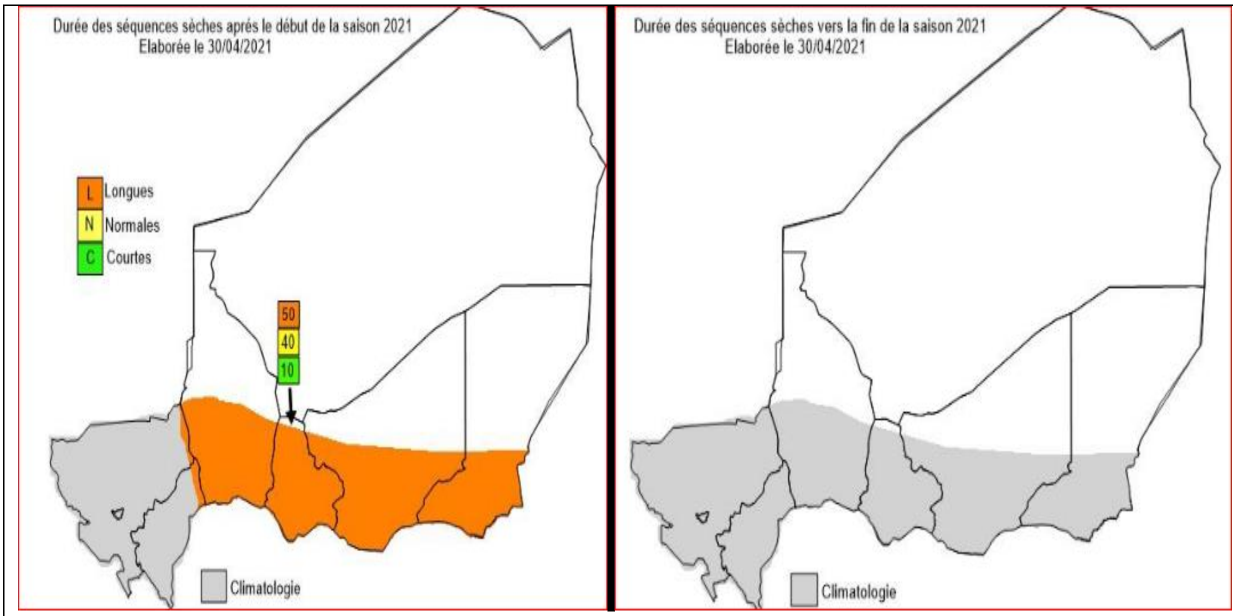


Figure 5:Niger's Dry stretches at the start and end of the season

- Advice and advice to agricultural stakeholders

In view of the cumulative rainfall that is generally higher than the average expected in the Sahelian strip, the durations of long to average dry spells, and excess stream flows, the risk of flooding is high. To mitigate these risks to people, animals, crops and material goods, it is recommended to:

Closely monitor the alert thresholds in the various sites at high risk of flooding; Strengthen the communication of seasonal forecasts and sensitization of vulnerable communities, by involving state actors and the various disaster risk reduction platforms in the communication and crisis management chain,

Prevent the anarchic occupation of flood-prone areas, especially in urban areas, ensure regular cleaning of the drainage channels, Maintain and enhance the dikes, Maintain homes to make them less vulnerable to heavy rains in order to avoid collapses that could lead to loss of human life. Despite the generally humid character expected for the 2021 rainy season, it is likely to observe in places (in a localized manner) water deficits but also delays in the establishment of fodder biomass and planting failures and affect plant growth. These water deficits could also favor the development of insect pests of crops. To prevent risks, it is recommended to:

Diversify agricultural practices to reduce the risk of lower production in exposed areas, the use of improved seeds (drought resistant varieties, short cycle varieties); Promote the use of fertilizers (organic manure and mineral fertilizer); Strengthen the agro-hydro-meteorological supervision and assistance mechanisms for producers.

To reduce the risk of water-related diseases (cholera, malaria, dengue, bilharzia, diarrhea, etc.) in wet or flooded areas, it is strongly recommended to: Raise awareness on climate-sensitive diseases, in collaboration with meteorology, hydrology and health services, Vaccinate populations and animals, encourage the use of mosquito nets, set up stocks of antimalarial drugs, Provide stocks of medicines in hard-to-reach areas following the floods(DMN, 2021a)

- ❖ Weekly weather forecast

A weekly weather forecast is a statement saying what the weather will be like the next day or for the next few days. Weekly forecasts or commonly called weekly weather reports correspond to forecasts which are produced for a period of 7 consecutive days. These bulletins generally cover parameters such as rainfall, temperature (average, minimum, maximum), wind, evapotranspiration, humidity, etc. Unlike seasonal forecasts, weekly bulletins have the advantage of being more precise and more responsive to the needs of communities (Traore, B., Ouédraogo, M., Birhanu, Z.B., Zougmoré, 2018). For instance for the next six days the weather situation will be characterized mainly by good penetration of the monsoon over the country limiting the intertropical front on an axis

North Agadez and North Bilma; thus promoting weak to moderate or even strong rain-storming activities in places especially on the southern strip of the country and on the Air(La & Nationale, 2015).

- ❖ Daily weather

Daily rainfall forecasting is the application of all techniques of science and technology to predict atmospheric conditions for a given location and on a day's scale. It is done by collecting quantitative data on the current state of the atmosphere at a given location and using scientific understanding of atmospheric processes to project the evolution of the atmosphere. It is also based on computer models that take into account many atmospheric factors. However, the forecast becomes less accurate as the difference between the current time and the time of the forecast (the scope of the forecast) increases. This inaccuracy in predictions may be due to the chaotic nature of the atmosphere, the massive computing power required to solve the equations that describe the atmosphere, the error involved in measuring initial conditions, and an incomplete understanding of atmospheric processes (Traore, B., Ouédraogo, M., Birhanu, Z.B., Zougmoré, 2018). A daily weather forecast involves the work of thousands of observers and the work of thousands of observers and meteorologists all over the world. Modern computers make forecasts more accurate than ever, and weather satellites orbiting the earth take photographs of clouds from space. Forecasters use the observations from ground and space, along with formulas and rules based on experience of what has happened in the past, and then make their forecast (Agumagu, 2016)

3.2.4 Forecast importance

Weather forecasting is used in many situations like severe weather alerts and advisories, predicting the behavior of the cloud for air transport, prediction of waterways in a sea, agricultural development and avoiding forest fire.

- ❖ Severe weather alerts and advisories

A major part of modern weather forecasting is the severe weather alerts and advisories which are the national weather service's issue in anticipation of severe or hazardous weather are expected. This is done to protect life and property. Some of the most commonly known of severe weather advisories are the severe thunderstorm and tornado warning, as well as the severe thunderstorm and tornado watch. Other forms of these advisories include winter weather, high wind, flood, tropical cyclone, and fog. Severe weather advisories and alerts are broadcast through the media, including radio, using emergency systems as the Emergency Alert System which breaks into regular programming.

- ❖ Agricultural development

Weather plays an important role in agricultural production. It has a profound influence on the growth, development and yields of a crop, incidence of pests and diseases, water needs and fertilizer requirements in terms of differences in nutrient mobilization due to water stresses and timeliness and effectiveness of prophylactic and cultural operations on crops. Weather aberrations may cause (i) physical damage to crops and (ii) soil erosion. The quality of the crop produced during movement from field to storage and transport to market depends on weather. Bad weather may affect the quality of the produce during transport and viability and vigor of seeds and planting material during storage.

- ❖ Avoiding Forest fire

Weather forecasting of wind, precipitations and humidity is essential for preventing and controlling wildfires. Different indices, like the Forest fire weather index and the Haines Index, have been developed to predict the areas more at risk to experience fire from natural or human causes. Conditions for the development of harmful insects can also be predicted by weather forecasting.

- Military applications

Military weather forecasters present weather conditions to the war fighter community. Military weather forecasters provide pre-flight and in-flight weather briefs to pilots and provide real time resource protection services for military installations. Naval forecasters cover the waters and ship weather forecasts. The Navy provides a special service to both themselves and the rest of the federal government by issuing forecasts for tropical cyclone across the Pacific and Indian Oceans through their Joint Typhoon Warning Center.

- Air Force Air

Air Force Weather provides weather forecasting for the Air Force and the Army. Air Force forecasters cover air operations in both wartime and peacetime operations and provide Army support. Military and civilian forecasters actively cooperate in analyzing and creating weather forecast products (Agumagu, 2016).

CHAPTER 4: METHOD AND MATERIAL

4.1 Materials

4.1.1 Study area

The department of Magaria is located in the south of Niger in the Zinder region (Figure 5). It covers an area of 8,434 km² and its capital is Magaria. Following the administrative reform in Niger in 2011, the department of Magaria was divided into two departments including the department of Magaria and Dungass. The department of Magaria covers henceforth the rural communes of Bandé, Dantchiao, Kwaya, Sassoumbroum, Wacha, Yékoua and has a population of around 718,440 inhabitants in 2016. The new department of Dungass covers the rural communes of Gouchi, Mallawa, Dungass and Dogo Dogo and a population estimated in 2016 at 440,044 inhabitants which gives a density of about 83 people per square kilometer. The two departments are limited to the north by the departments from Matamèye and Mirriah, to the east by the department of Gouré, to the south by Nigeria and to the west by the department of Tessaoua.(Ozer et al., 2009).

The natural vegetation consists of scattered trees, shrubs and grasses. The terroir is generally flat in this zone of savannah where the dominant trees are thorny and non-thorny species. The annual rainfall is between 400 and 500 mm and the rainfall is spread over a single rainy season from June to October. The rest of the year is divided into two dry seasons namely a cold period from November to February with an average temperature between 8 to 12 ° C and a hot period from March to the end of May with an average temperature between 38-40 ° C. The main activities in this locality are agriculture, small-scale animal husbandry and petty trading.

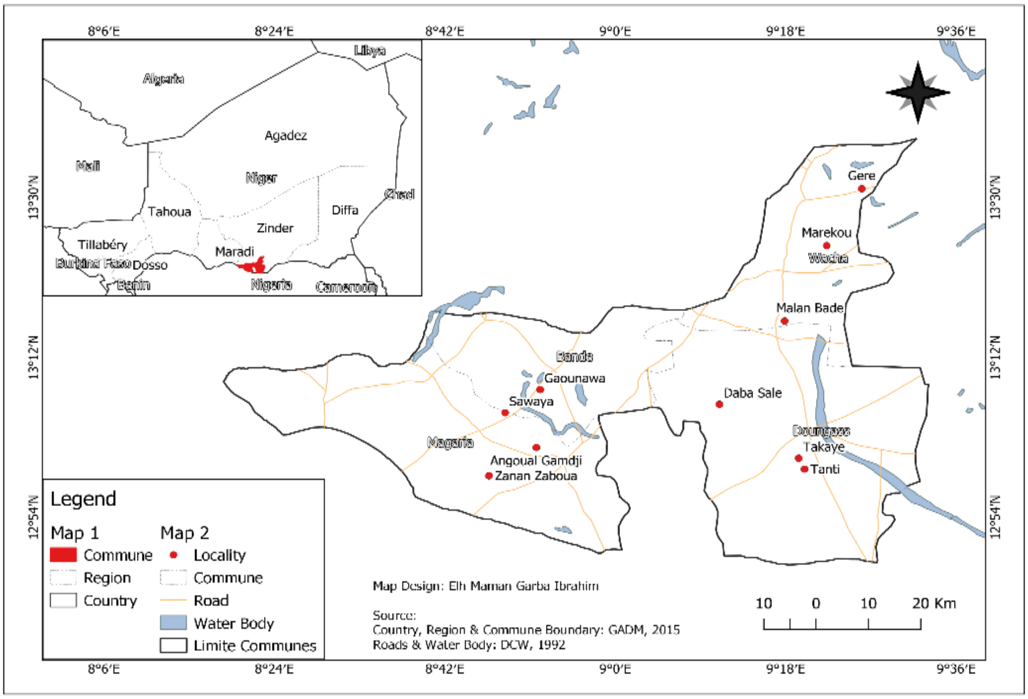


Figure 6: Study site

Agriculture is practiced on the sandy soil, although clay is found in parts of the area. Although this area has some moderate agricultural potential, it is not self-sufficient in terms of food security, even during a year of good harvests. The main food crops are millet and sorghum. It should be noted that the production of sorghum has decreased in recent years due to the gradual degradation of the soils and rainfall deficits which prevent crops from completing their normal cultivation cycle. However, cowpeas, peanuts and sesame are the main cash crops in this area. In fact, sesame is in the process of taking the place of peanuts following the strong demand for this product in the markets, especially in Nigeria. Yet this area was once the first groundnut production area in Niger which led to the creation of a groundnut processing factory.

Agricultural practice is still traditional with archaic tools such as hoe, daba, hilaire, sheep traction etc. The fields are prepared by hand, although on the other hand the well-to-do have in recent years been using modern means such as tractors which are most often rented from Nigeria or at the Magaria agriculture service level. Since 2014, each rural commune has been provided with at least one tractor thanks to the 3N initiative program (Les Nigériens Nourrissent les Nigériens). The agricultural workforce is made up of daily men and women who are members of poorer households to be remunerated in cash or in kind.

Agriculture in this area faces enormous difficulties, mainly related to flower-growing insects and grasshoppers. Flowering insects are harmful to all crops, while grasshoppers mainly attack millet and sorghum. Some insects such as aphids and caterpillars mainly attack cowpeas and peanuts. To protect crops, farmers generally resort to the most accessible and less expensive treatments, often ineffective. Thus, phytosanitary products are generally purchased in local markets and in Nigeria, however the agricultural service and non-governmental organizations provide provide support to populations especially during years of crisis. In the event of a large-scale invasion, the state organizes a large-scale phyto-sanitary treatment free of charge. Despite the depletion of cultivated soils, and the physical accessibility of fertilizer especially the proximity to Nigeria, farmers rarely use chemical fertilizers for land fertilization. The amendments made are mainly based on organic materials produced mainly by better-off households (Ozer et al., 2009).

Livestock is the second sector of economic activity in this zone. Even if the practice of breeding is sedentary, this activity remains and remains a great source of income, especially for the wealthiest households. The types of animals kept are mainly large ruminants (cattle), small ruminants (sheep, goats) and poultry house breeding (pigeon, guinea fowl and hen). The practice of fattening is highly developed in this area and practitioners take advantage of the good prices that the Nigerian markets offer them even if, moreover, with the economic crisis that Nigeria is going through, the price of animals has recently experienced a drop. Only a few wealthy households have cows, given its requirements in terms of grazing areas but also veterinary care. The breeding of small ruminants (goats and sheep) is more widespread due to their rapid multiplication capacity and their tolerance for extensive breeding (less demanding compared to other species). The main sources of water supply for livestock are wells, public fountains and ponds during the rainy season.

The study area borders with Nigeria, this neighborhood has allowed the development of other economic sectors in addition to agriculture and livestock. Depending on one's abilities, economic activities such as trade, peanut oil extraction for women especially are developed. The sale of firewood remains the preserve of very poor and poor households in the area.

4.1.2 Forecast Application

- ❖ Accuweather

AccuWeather is a free weather forecast app that provides the best, most relevant, and precise weather forecast for locations across the globe. Also, it hosts special weather features that differ depending on the location. With its proven digital competence and innovation with leadership in weather category, it is considered as the most trusted and most accurate weather app available to users. It is amazingly designed that provides a superior user experience.

The AccuWeather app provides upgraded location management. It also boasts an enhanced performance on effective radar and satellite animation. It also gives an amazing experience for breaking weather and trending video content. Also, it showcases its signature feature, the Minute Cast, that gives minute-by-minute precipitation type and intensity forecasts for the next two hours. Moreover, its new design for the AccuWeather's "follow-me" widget gives easy access to different weather information on the go. Furthermore, it also gives map view and different information such as humidity, UV percentage, wind direction and speed, and cloud cover. This app helps users whether to decide to bring or not an umbrella or coat. It can be downloaded from Google play store. Downloading and installing AccuWeather for Android is quite easy, even for the beginner. An interface opens immediately and prompts the user to begin the configuration process. This process only takes a few minutes and is easy. A one-touch option allows the user to automatically detect the current location. There is also an option to manually enter the name of a city. Once this option is set, other locations can be entered into the app and saved to a favorites list. The user interface includes an intuitive swipe function that allows the user to scroll through a large amount of information with one hand. Forecasts can be viewed by hourly or daily slots, and information is updated regularly. A temperature indicator has also been added to the notification bar, which can be extended to show the daily forecast. https://www.accuweather.com/en/ne/niamey/254119/daily-weather-

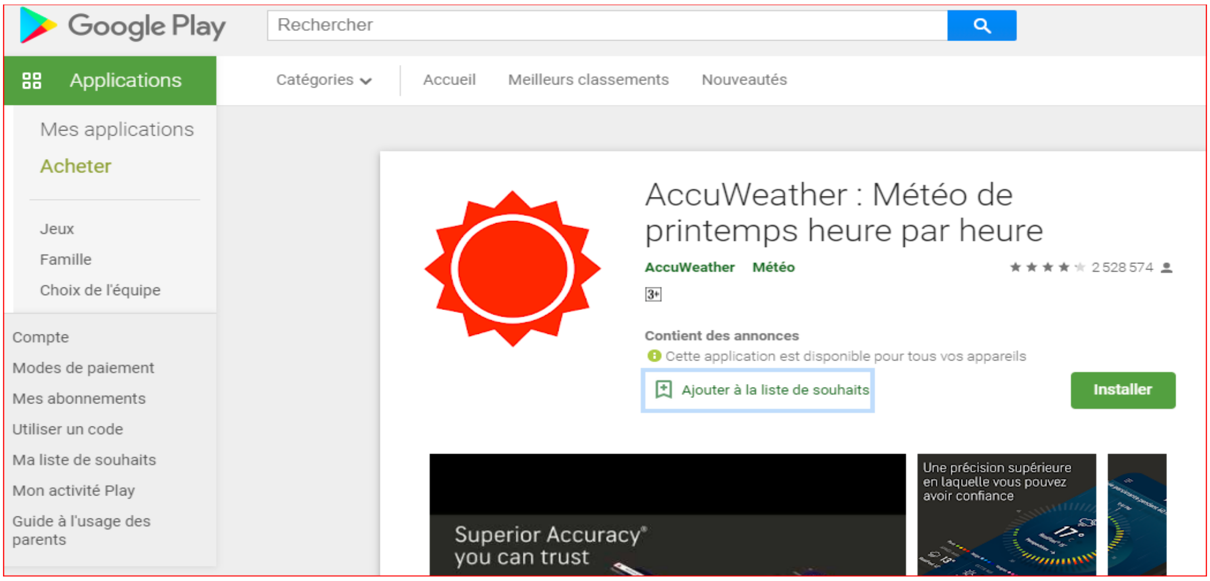


Figure 7: Accuweather Application

AccuWeather, provides a portfolio of products and services through the airwaves, via the Internet, in print, and behind the scenes that benefit hundreds of millions of people worldwide. AccuWeather services 18,000 paying customers in media, business, government and institutions, and millions more through AccuWeather.com.

❖ Weather Channel

One of the best weather apps for Android, the Weather Channel app offers localized, daily and weekly forecasts, as well as a "Felt" feature so you know what to prepare for when you leave home. The app also offers real-time rain alerts with radar and the ability to track seasonal allergies. The application be downloaded for free from https://play.google.com/store/apps/details?id=com.weather.Weather.

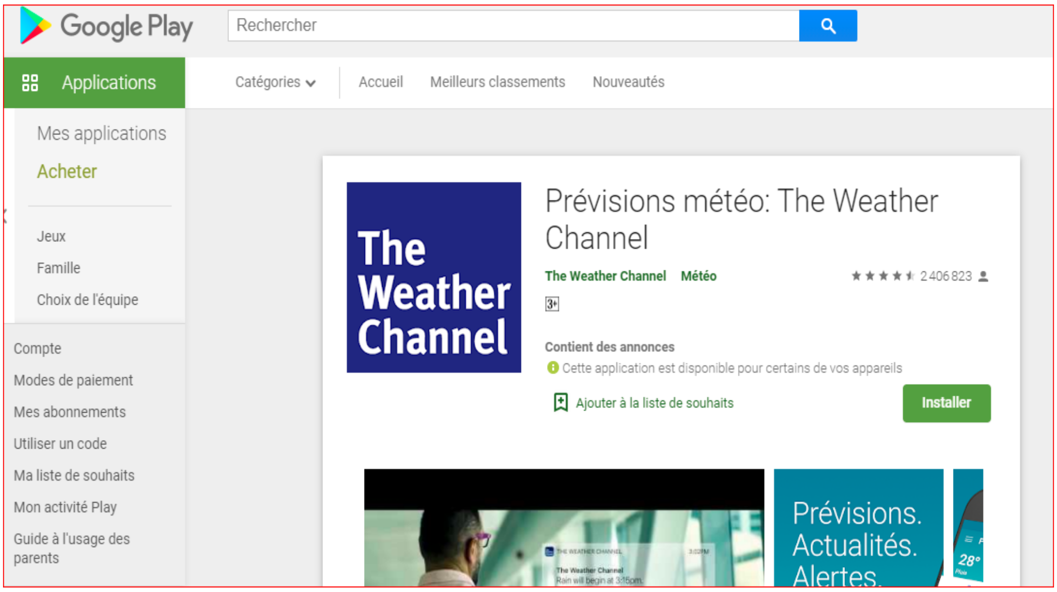


Figure 8: Weather channel's Window's

4.1.3 The farmer Rain gauge

In Niger, the most well-known and distributed rain gauge is the "Farmer rain gauge" with direct reading. The farmer rain gauge is made up of: a plastic bucket graduated by fields; hatched in millimeters of rain; a receiving ring of 100 cm2 of surface at the top end of the bucket; a metal support with two smooth iron rings; welded on the upper edges to hold the bucket; vertical and stable.

Figure 9:Farmer rain gauge (Above picture indicates distance between rain gauge and house; below picture indicates farmers reading rainfall amount).

- Farmer Rain Gauge Installation

In the Sahel region rainfall is accompanied by winds; it follows that the raindrops do not fall vertically, they are inclined. To collect exactly the amounts of rainfall, rain gauge must be installed in marge space and separate with a distance of at least four 4 times the height of any obstacle nearly located.

For example, if the height of the trees is 5 m, the rain gauge must be at least 20 m away of these trees. Be perfectly vertical and well-sealed in the ground; her receiving surface must be 1.50 meters from the ground.

- Maintenance of the farmer rain gauge

The rain gauge should be kept carefully, well maintained. For this, we must: surround the rain gauge with an enclosure to protect it against animals and children; constantly clean the bucket and the test tube, and replace if broken. Keep the bucket in a safe place after the rainy season.

- Rain measurement by farmer Rain Gauge

Every day, in the morning 6 a.m. we measured total rainfall for the last 24hours. The rain gauge must be emptied after each measurement. With the farmer rain gauge, the process is simple: we read the height of the water in the bucket graduated in millimeters and we write its value on the reading sheet in millimeters and tenth. Thus, we repeat this operation several times, but in writing the partial values on a scrap paper. We do the sum of these partial values after measuring everything the contents of the bucket.

4.1.4 Python

ABC programming language led to the design and development of programming language called Python. In the early 1980s, Van Rossum used to work at CWI (Centrum voor Wiskunde en Informatica) as an implementer of the programming language called ABC. Later at CWI in the late 1980s, while working on a new distributed operating system called AMOEBA, Van Rossum started looking for a scripting language with a syntax like ABC but with the access to the Amoeba system calls. So Van Rossum himself started designing a new simple scripting language that could overcome the flaws of ABC. Van Rossum started developing the new script in the late 1980s and finally introduced the first version of that programming language in 1991. This initial release has module system of Modula-

Later on, this programming language was named ‘Python’ (http://www.trytoprogram.com/python-programming/history-of-python/).

Before using Python, we need to be sure that it is not installed in the computer because nowadays many Linux and UNIX distributions (and even some windows computers) include a recent Python. A simple test can be run by entering python in a command line window a response from a Python interpreter. For this study we will use Python 3.x. to https://www.python.org/downloads/

Anaconda (https://www.anaconda.com/products/individual), is an open-source distribution for programming languages, including Python, R, Ruby, Lua, Scala, Java, JavaScript, C/ C++, FORTRAN. Anaconda is an open source package management system and environment management system that runs on Windows, macOS and Linux. download python and install.

A virtual environment is an isolated copy of Python that maintains its own files, directories, and paths. This allows you to work with specific versions of Python and libraries without affecting other projects. For the creation and activation of environments use following terminal commands: conda create --name myenv. Examples: conda create --name eagles-python In order to activate your conda environment use: conda activate eagles-python

Jupyter Notebook (IPython): Jupyter Notebook is open-source web application which makes it easy to create and share documents.With jupyter notebook you can nicely combine live code, equations, visualizations and narrative text. You can install jupyter notebook using following command: conda install -c anaconda jupyter Other IDE´s If you want to use another IDE (Integrated Development Environment) than IPython you can use one of the various other Python IDE´s, which offer you an easy way to write your code and visualize your data: Common IDE´s:

Rodeo http://rodeo.yhat.com/

Spyder https://github.com/spyder-ide

PyCharm https://www.jetbrains.com/pycharm/

4.2 Methodology

4.2.1 Forecast data collecting with Accuweather and Weather channel

Daily rainfall forecasts was collected by technicians every day between 7 a.m. and 8 a.m. or evening, but alternating was not allowed. Technician connects his smart phone to the internet for reading the day's forecast according to his position. Rainfall forecasts was provided as percentage (%) of occurrence of rain event and the minimum and maximum temperatures in degrees Celsius (°C). Data was daily recorded on the observation sheet later digitalized using excel sheet. Data collection started in July 2021 and end up by September 2021.

For weekly forecast data collection, the approach is similar to daily method except that the weekly observation was done once a week. Each Friday, technician recorded the forecast in percentage (%) and the temperatures for each day of the week.

4.2.1 Sharing daily rainfall with the community and their perception

A black board was installed (Figure 9) in the public place on which was recorded the daily amount of rainfall as well as the monthly cumulative amount.

A survey was

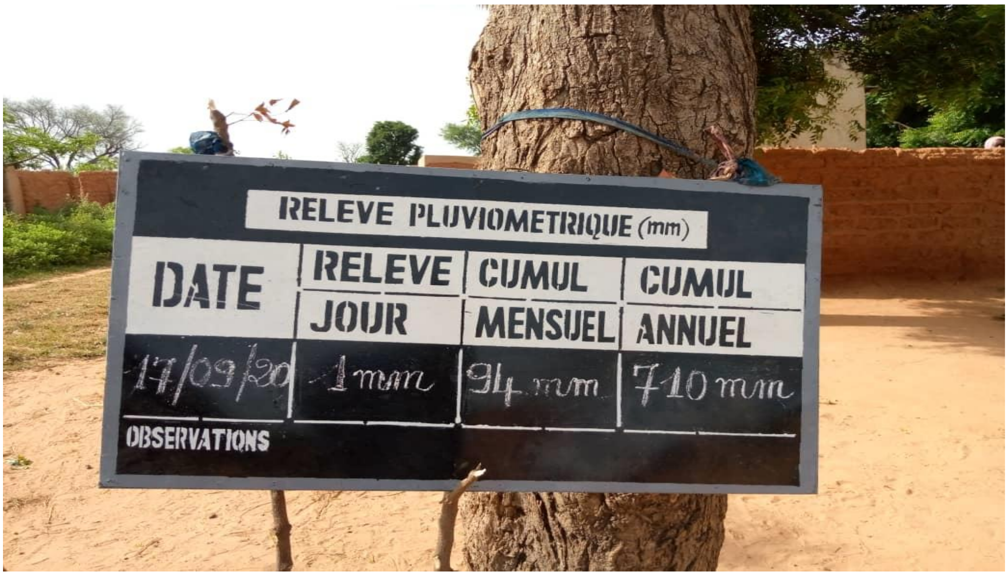


Figure 10: Black board for daily registration of rainfall.

conducted with farmers to identify the difficulties related to the collection and dissemination of rainfall information and list the decision that can be taken based on rainfall information.

CHAPTER 5: RESULTS

5.1 Forecast with Accuweather

Analysis with Accuweather shows that the higher effective forecast was within 91- 100% interval with an efficiency of 67%. For the forecasts within 71%-80% and 81-90% interval, the efficiency rate is respectively 47% and 57%. The most forecast occurrence was within 21%-30% with an effectiveness of 24%. Forecasts within 1-20 interval have an effectiveness less than 10%. Generally, results showed that the higher is the forecast percentage, the greater is rainfall occurrence. The amount of observed rainfall is neither related to the forecast percentage nor to the effectiveness of occurrence.

Table 1:Forecast with Accuweather

Rainfall forecast (%)	*Forecast number*	*Number of Effective forecast*	*% of effective rainfall forecast*	*Average rainfall (mm)*	*Standard Deviation (rain)*
1-10	49	3	6	18.67	7.09
11-20	79	7	9	27.17	18.77
21-30	201	49	24	24.81	21.55
31-40	57	21	37	18.04	11.53
41-50	45	13	29	26.12	27.01
51-60	97	33	34	22.3	21.22
61-70	75	24	32	27.73	23.91
71-80	38	18	47	23.22	19.32
81-90	14	8	57	37.25	26.34
91-100	6	4	67	24.5	6.35

The percentage of success was calculated from all possible forecasts whether true or false. Simulation results showed a logarithmic correlation between daily rainfall forecast and the success forecast with R2 of 0.94. Above 70%, success of rainfall forecast remains unchanged.

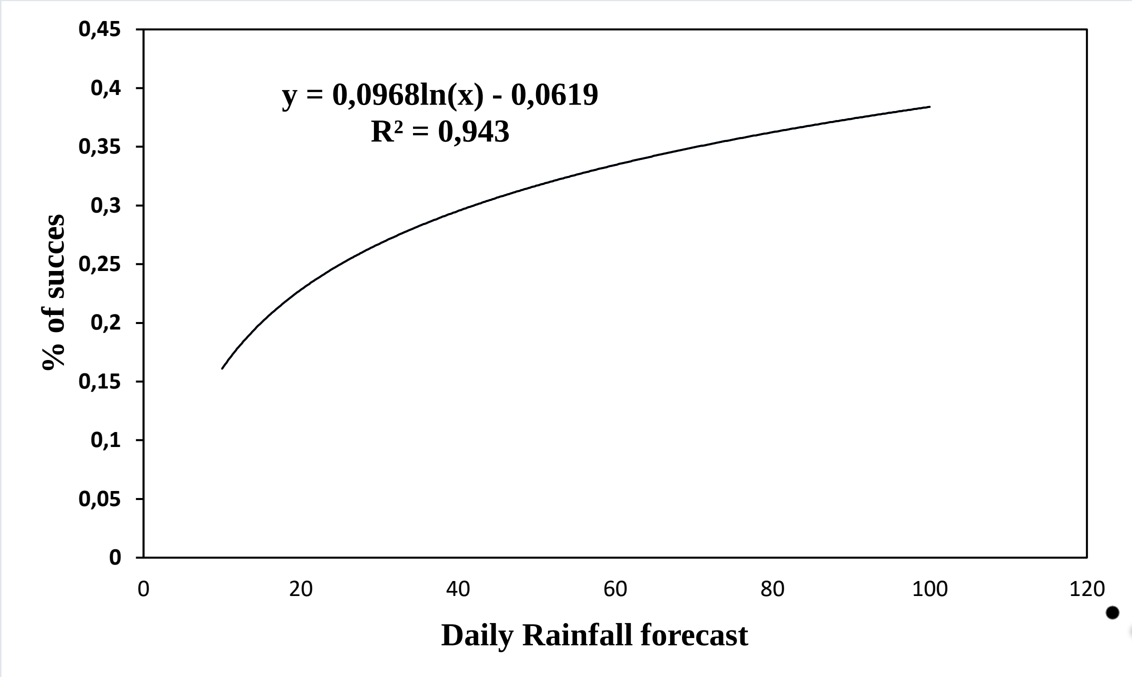


Figure 11: Forecast effectiveness with the Accuweather forecast tool.

Figure 12 shows a logarithmic correlation between the number of daily and weekly forecasts with an R2 coefficient of 0.80 (Figure 11). Whatever daily or weekly rainfall forecast, there is similar trend of forecasts depending on the intervals. The greatest number of forecasts was within 21 and 30% interval while only fewer forecasts were within 91 and 100% interval (Figure 12)**.**

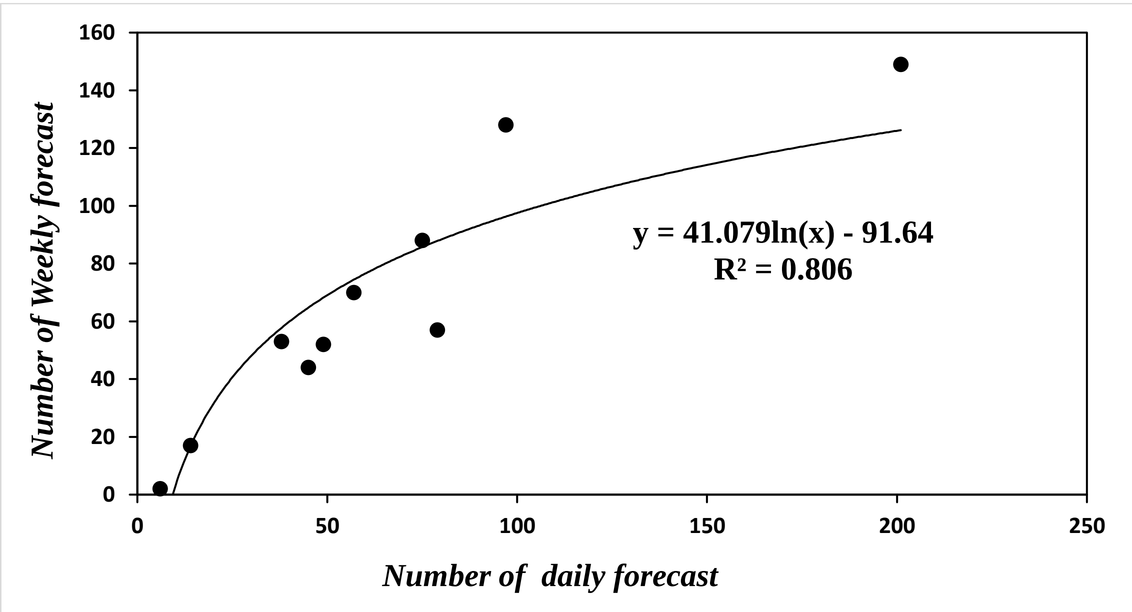


Figure 12: Correlation Highest daily forecast and highest weekly forecast.

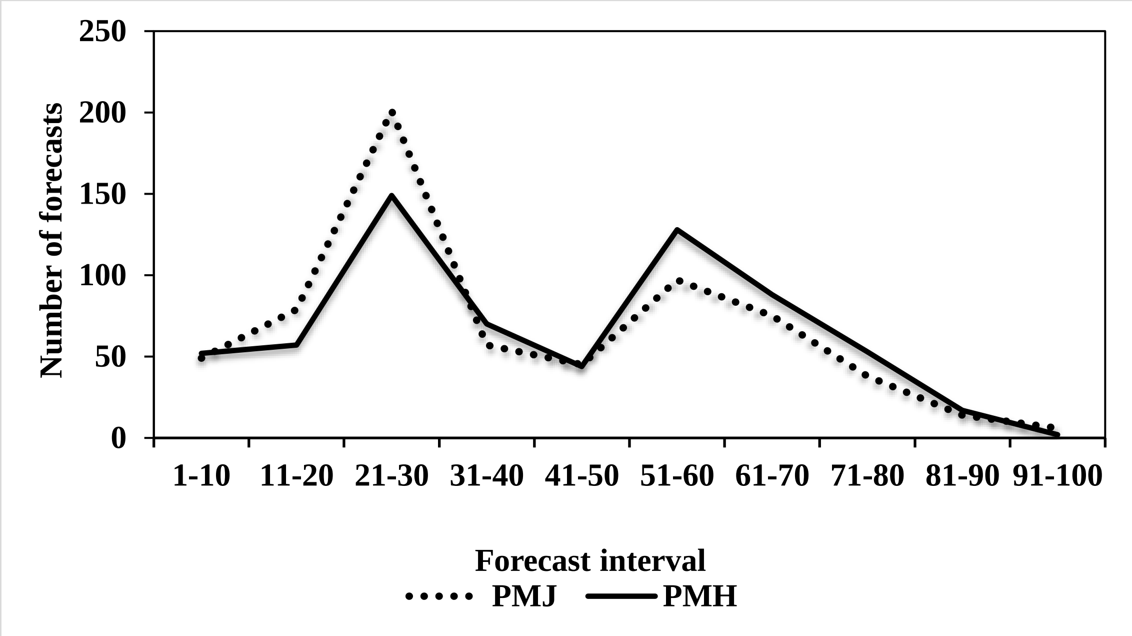


Figure 13: Daily and weekly forecast trend by interval; PMH: weekly forecast trend and PMJ: daily forecast trend.

5.2 Forecast with Weather Channel

Analysis with Weather Channel showed that the higher effective forecast was within 81-90% interval with an efficiency of 73% while that of the forecasts within 71-80% the was 45% (Table 2). The highest forecast occurrence was within 21-30% with an effectiveness of 21%. Forecasts within 1-20 have an effectiveness less than 20%. In general, results showed that the higher is forecast percentage, the greater is rainfall occurrence. The amount of observed rainfall is neither related to the forecast percentage nor to the effectiveness of occurrence.

The percentage of forecast success was calculated from all possible forecasts whether true or false. Simulation results showed a logarithmic correlation between daily rainfall forecast and the success forecast with R2 of 0.92 (Figure 13). Success varied linearly from 10 to 50% forecast and remained constant even with 100 % forecast.

Table 2: Forecast with weather Channel.

Rainfall forecast	Forecast number	Number of effective forecasts	% of effective rainfall forecast	Average rainfall (mm)	Standard Deviation (rain)
1-10	70	8	11	15.88	9.00
11-20	119	25	21	20.88	15.91
21-30	67	17	25	23.68	18.71
31-40	55	13	24	18.85	13.19
41-50	51	22	43	18.95	11.63
51-60	39	19	49	24.95	14.36
61-70	20	7	35	25.00	16.68
71-80	53	24	45	30.85	22.07
81-90	11	8	73	24.14	20.83

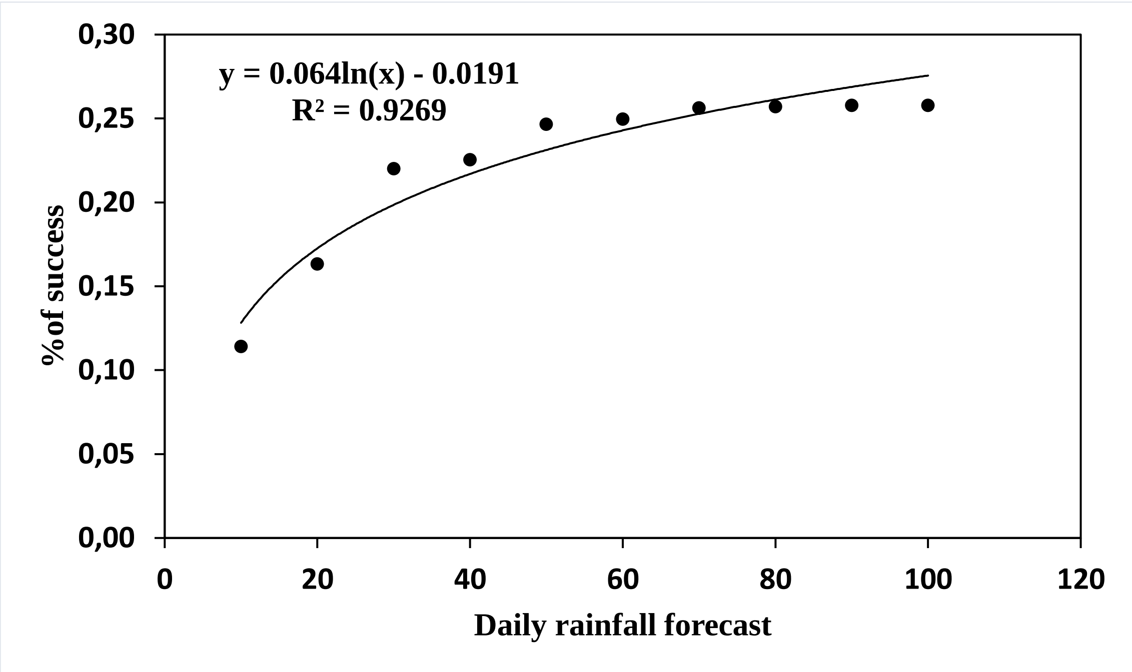


Figure 14: Forecast effectiveness with the AccuWeather forecast application.

5.3 Relationship between daily and weekly forecast with Weather Channel

Figure 15 shows a positive correlation between the daily and weekly forecasts with an R2 coefficient of 0.43 (Figure 15). Although the linear regression analysis between the two variables was significant ($P<0.001$) and although there was great variability with the two forecasts types. Whatever daily or weekly rainfall forecast, there is similar trend of forecasts depending on the intervals. The greatest number of forecasts was within 11 and 20% interval while only fewer forecasts were within 61 and 70% interval (Figure 15).

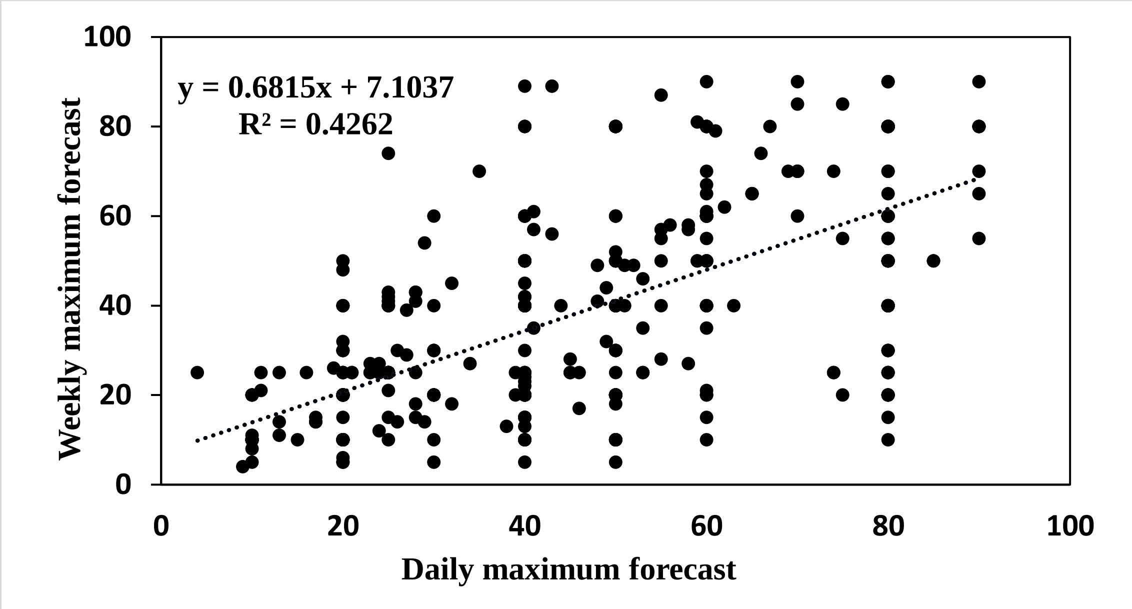


Figure 15: Correlation between daily and weekly rainfall forecast with Weather Channel.

5.4 Rainfall distribution in the villages

The start of the rainy season varied from one village to another and was between May and July. The rainfall starts in June in the villages of Malan bade, Angoual gandji 1, Zanan zabou and Sawaya; while for Jere, Makerou, Gaounaou, Takey and Bada sale, it begins in July. Tanti is the only village where the rainy season starts early in May.

The cumulative rainfall recorded throughout the rainy season was between 500 mm to 800 mm per year. The highest cumulative rainfall was observed in the village of Tanti, while the lowest was recorded in the village of Takey, respectivetly 801 mm and 526.2 mm (all the two villages was located in the department of Dungass).

Rainfall was more evently distributed for almost villages except for the villages of Angoual gandji 1, Gaounaou and Sawaya, where a dry spell of 12 to 21 days occurred and coincided mostly with the floraison, grain filling or maturing stage of crops.

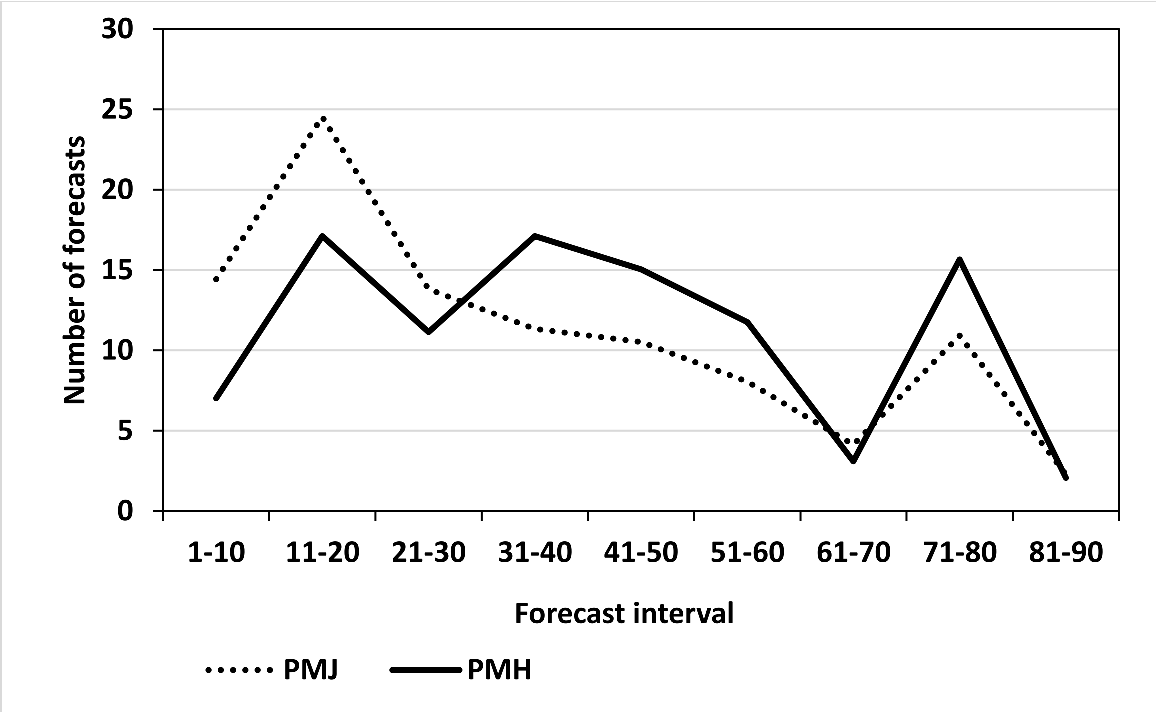
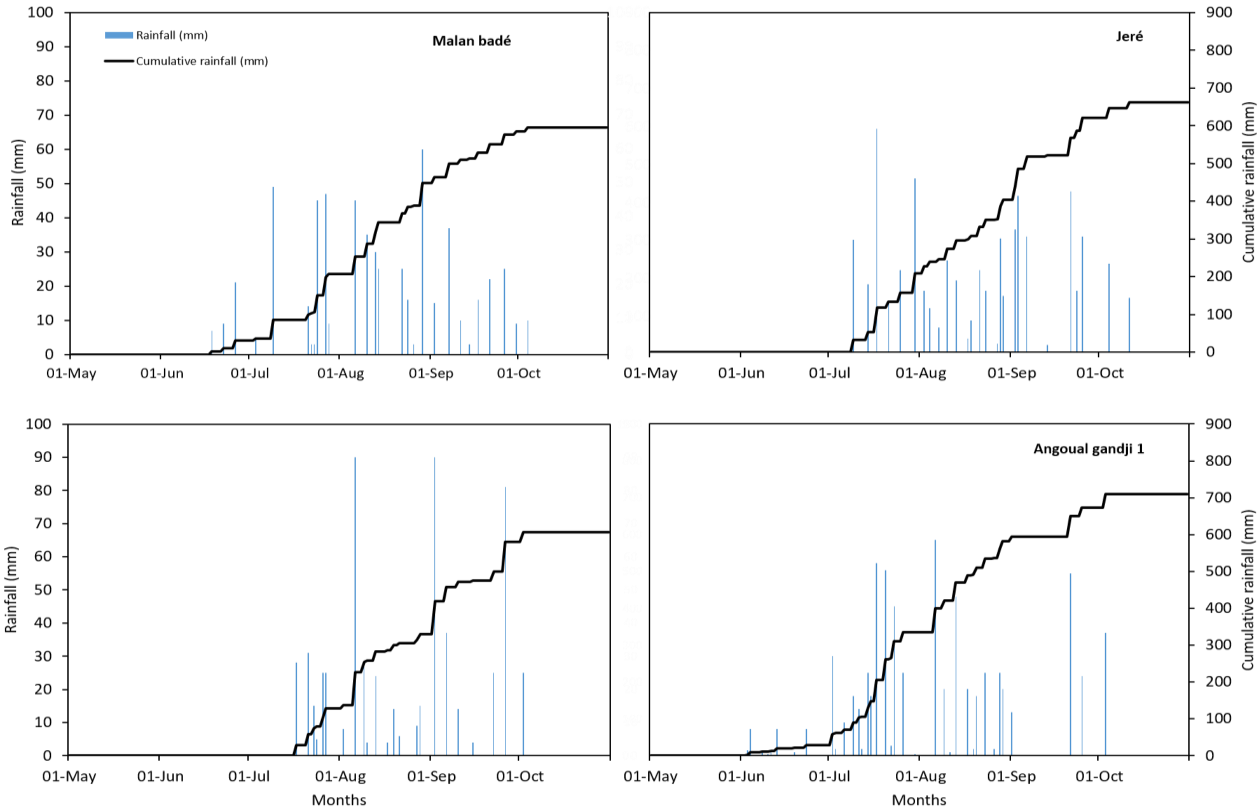


Figure 16: Daily and weekly forecast trend by interval with Weather Channel; PMH: weekly forecast trend and PMJ: daily forecast trend.



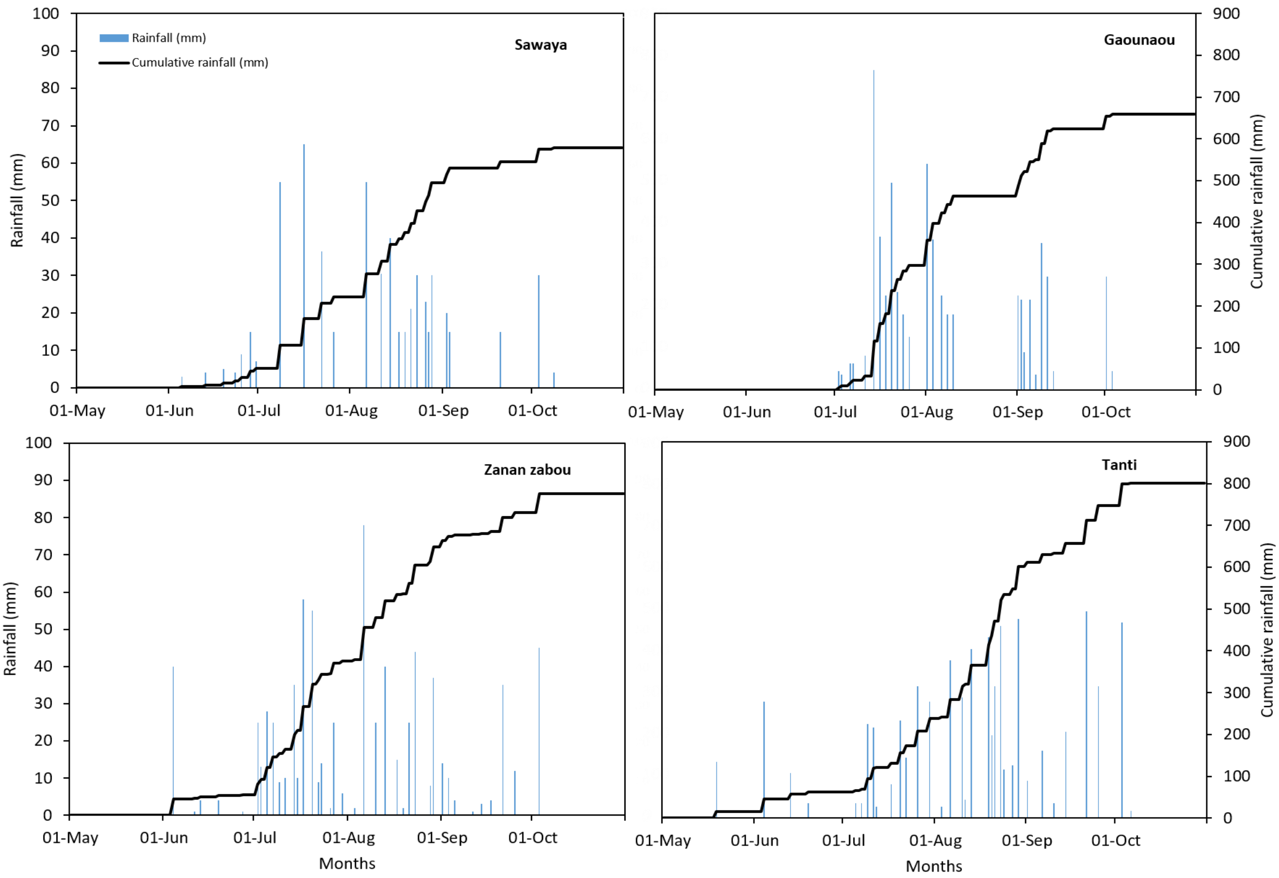


Figure 17:Rainfall distribution (1).

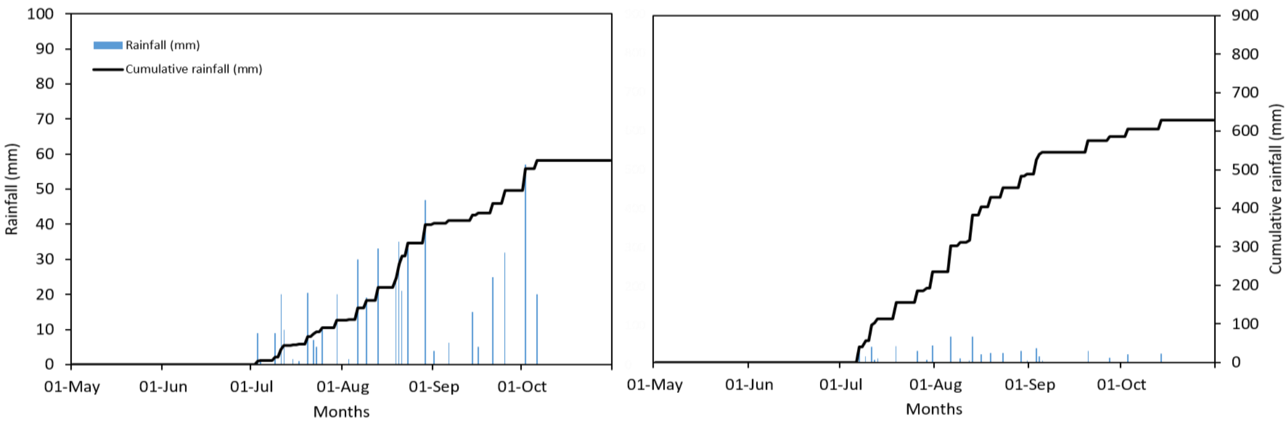


Figure 18: Rainfall distribution (2).

5.5 Access to climate information

The Figure (17) shows the percentage of farmers' access to rainfall information through different channels. Results showed that 77% of farmer have access to rainfall information through public place, while 35% get information through local radio broadcasting. Results also showed that 65% of farmers also get climate information from neighbour information system which consists of sharing information from one person to another. We also find that some farmers use more than one source for information. In terms of reading and understanding, we found that up to 87% of farmer were able to read rainfall from rain gauge installed in the public place and only 13% of farmers need assistance.

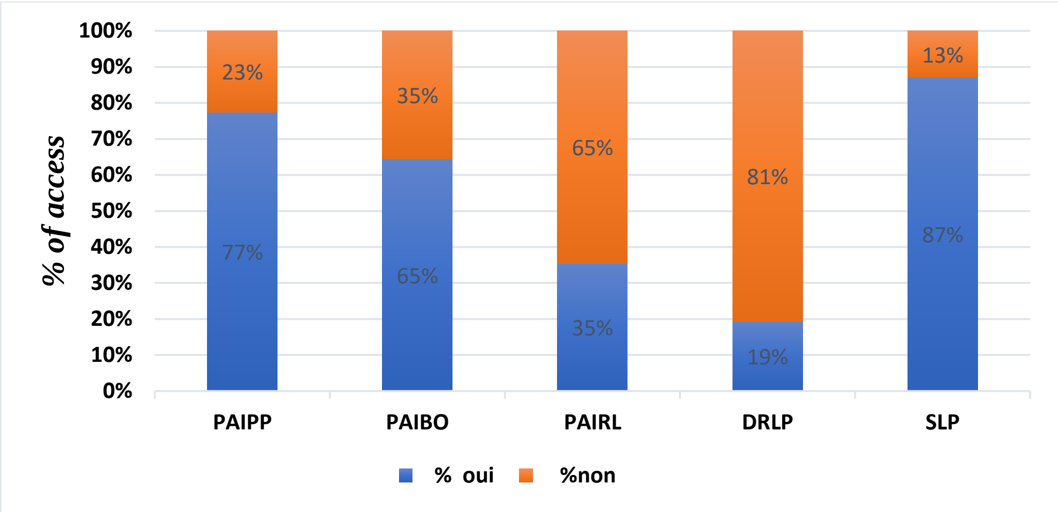


Figure 19: Access to climate Information by the community: PAIPP: access to rainfall amount from public place; PAIBO: Access to rainfall amount from neighbour; PAIRL: Access to rainfall amount through local radio broadcasting; DRLP: Constraint for reading rainfall information; SLP: Capacity for reading rainfall information.

5.6 Decision making related to climate information

Results showed that 94% of farmers sow seed based on rainfall information received while 29% and 10% apply fertilizer and weeding, respectively. The survey showed that 16% of farmer make also out field decisions such as travelling based rainfall information (Figure18).

For 55% of farmers information from rain gauge provides indications on the beginning and end of the season while, 45% this information does not contribute to avoiding consequences of drought sequences during the season (Figure 18). For 100% of farmers, installation of the rain gauge in the village is useful for field decision-making and for 97% of farmers, the benefit goes beyond their village to benefit surrounding villages (Figure 18).

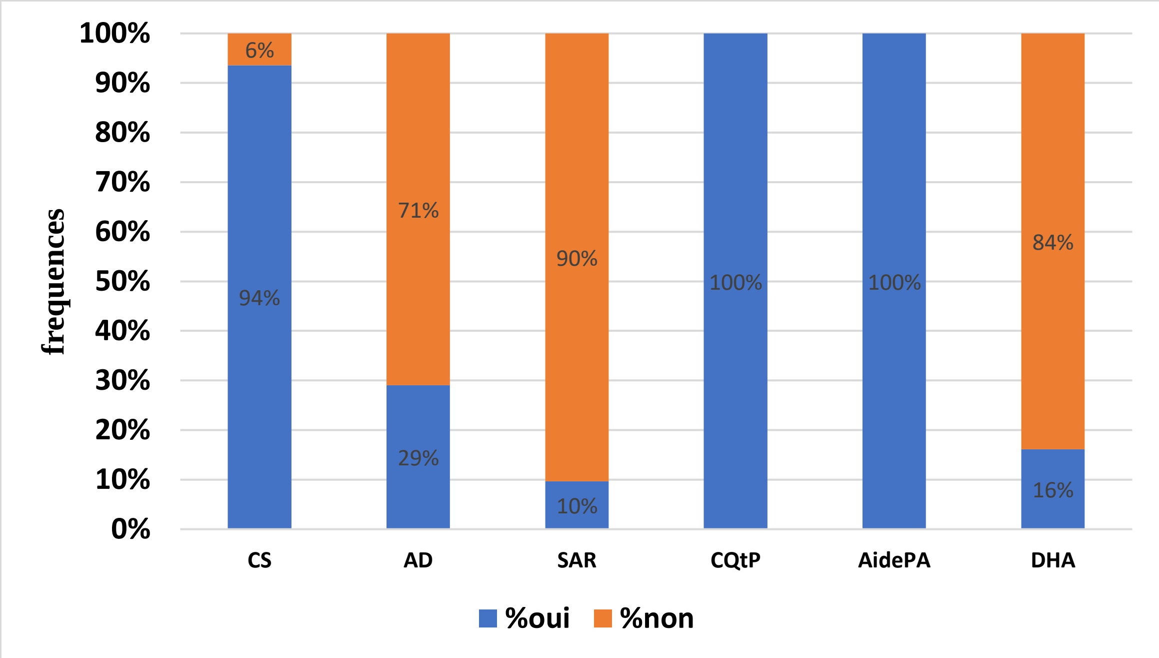


Figure 20: Farmer decision making based on rainfall information.

CHAPTER 6: DISCUSSIONS

6.1 Effectiveness of rainfall forecast

Our results showed that the best forecast efficiency was 67% with Accuweather against 73% for weather channel and with an occurrence of rain above 91% and 81% respectively. For both applications, the higher is forecast percentage, the greater is the chance of occurrence. We can infer that forecast percentage threshold is important for user for decision making. For example, with rainfall forecast above 70%, chance of having rainfall is high. Research have shown that if effectiveness of the rainfall forecasts is above 70% farmer could easily trust and plan daily activities accordingly (B. Traore et al., 2017). Knowledge of rainfall forecasting information enables the farmer to choose the dates for ploughing and seeding depending on soil characteristics. It also allows the farmer to schedule the application of fertilizers based on rain forecasts as well as household activities such as laundry or food drying based on rainfall events. Under this circumstance farmers are satisfied with the forecasts and use weather application as a tool for disseminating rainfall forecast while with the traditional method by contrast, seems more imprecise and is carried out on a regional scale through television networks or national radio stations (DMN, 2021b).

With rainfall forecast below 50%, rainfall occurrence is low. In that context, it is important to take into account forecasts frequencies in relation to the rainfall effectiveness or not. For example, with Accuweather, there was 200 rainfall forecasts within 21-30% interval with only an effectiveness of 24% versus 119 forecasts for weather channel with only an effectiveness of 21%. This low efficiency rate is mainly related to the uncertainties associated with forecasts. In this case, it is difficult for the farmer to plan daily activities because there is a high probability that the weather forecast provided is not relevant. The accuracy of rainfall forecasts depends on the methods used (stochastic or deterministic) for uncertainty mitigation (Ghareb et al., 2019). Deterministic forecasting are developed based on the physical laws related to land–ocean–atmosphere interactions and are thus able to predict changes in rainfall due to changes in Earth's atmosphere. However, the forecasted rainfall provided by dynamical models is often prone to large error at the local scale (Ghareb et al., 2019).

6.2 Forecast for decision making

What do producers do when the forecast indicates it's going to rain in the next 24 hours? Our results showed that 29% of farmer use rainfall forecast information for fertilizer application and 10% for weeding while 16% carry out off farm activity like the example of Malam Nassirou from Zanan Zaboua who decides to cancel his trip to the neighboring market because of high rainfall forecast. In most cases, the rainfall forecast information allows farmers to plan agricultural activities such as plowing, weeding, fertilizer application, phytosanitary treatments (Traore, B., Ouédraogo, M., Birhanu, Z.B., Zougmoré, 2018). When the forecast indicates no rain especially in August where it rains almost everyday women plan to do the laundry or dry my food in the sun every day.

6.3 Rainfall variability

Our results showed that start of the rainy season varied from one village to another and was between May and July. This variation has an impact on agricultural activities and also determines farming conditions (Ati et al., 2002; Dodd & Jolliffe, 2001; Omotosho et al., 2000). A good understanding of seasonal variability patterns is of critical importance because of the highly unstable onset of the rainy season and the high frequency of dry spells. A review by (P. C. S. Traore et al., 2007) of current knowledge on the regional climate in Sudano-Sahelian West Africa revealed that rainfall remains unpredictable. This rainfall unpredictability is a major constraint for farmers who have to plan the start of the cropping season (Piéri, 1989). The first rains are not always followed by the full start of the rainy season, dry spells can occur afterwards, i.e. during the early stages of the crop growth so that seeds may not germinate properly or germinated plants may die off.

We also found that cumulative rainfall recorded throughout the rainy season varied 500 mm to 800 mm per year. The highest cumulative rainfall was observed in the village of Tanti, while the lowest was recorded in the village of Takey, respectivetly 801 mm and 526.2 mm (all the two villages was located in the department of Dungass). This indicates that rainfall was more evently distributed for almost villages except for the villages of Angoual gandji 1, Gaounaou and Sawaya, where a dry spell of 12 to 21 days occurred and coincided mostly with the floraison, grain filling or maturing stage of crops. Frequent dry spell associated with high evapotranspiration demand may lead to a decrease in yield of up to 40% because of insufficient water supply during grain filling stage (Sultan et al., 2013). Consequently, the significant increase of the number of dry days during the rainy season and its impact on yield makes it one of the most important characteristic of climate change

(B. Traore et al., 2013).

6.4 Constraints for using weather forecast application

The main constraints encountered were related to literacy levels, costs and language barriers. Literacy levels are still low (about 31% for the country, but lower in rural areas and also for women. The low number of literate individuals negatively impacted the reading forecast on mobile phone. To access to forecast from both applications (Accuweather and Weather channel), a minimum internet access is required whereas in Niger internet coverage is not effective especially in rural areas. Furthermore, very few farmers have a telephone with an Android operating system.

We also noticed forecast with smartphone does not provide rainfall quantity. For example, our results showed that forecast for 20% and 80% of rainfall occurrence may result in the same amount of effective rain. Forecast to be helpful for farmer, must be effective goes along with with indication of amount of rain. Farmer decision to plant or apply fertilizer would depend on effective amount of rainfall.

CHAPTER 7: CONCLUSION

This study found that the best forecast effectiveness was 67% with Accuweather against 73% for weather channel and with rainfall occurrence above 91% and 81%, respectively. For both applications, the higher is forecast, and the greater is the rainfall occurrence. We infer that forecast percentage threshold is important for users for decision making. For example, with a forecast above 70% indicates high rainfall occurrence. In this context, farmers can trust forecasts and schedule their agricultural activities. However, there was a maximum number of forecasts within 21-30% interval with an effectiveness below 25%. Here, it needs not trust the forecasts of these two applications for making agricultural decisions.

In this study, many farmers were interested in using these applications. At this stage, it is highly recommended to repeat the experimentation while focusing on acceptance threshold, which could better serve farmers in their decision making.

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