American Journal of Climate Change, 2025, 14(2), 147-169
https://www.scirp.org/journal/ajcc
ISSN Online: 2167-9509
ISSN Print: 2167-9495

Dissemination and On-Farm Use of the Seasonal Forecast and Other Climate Services in Southwest Niger

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How to cite this paper: Sitta, A., Traoré, S. B., Balogun, I. A., Laux, P., & Paeth, H. (2025). Dissemination and On-Farm Use of the Seasonal Forecast and Other Climate Services in Southwest Niger. *American Journal of Climate Change, 14,* 147-169.
https://doi.org/10.4236/ajcc.2025.142008

Received: December 7, 2024
Accepted: April 7, 2025
Published: April 10, 2025

Abstract

Continuous improvement of the skills of seasonal forecasts in West Africa over decades has made the forecast information a potential on-farm decision-making tool to mitigate climate risks in agriculture, and a highly potential adaptation strategy to climate change side effects in the agricultural sector. This study assesses the current use of seasonal forecast products at the farm level, the farmers' perception of the seasonal forecast products, and how those products are disseminated to identify strategies to increase farmers' use of climate services in general and forecast information in particular. A sample of 619 farmers was interviewed through a survey conducted in November - December 2022 in 16 villages located within 4 municipalities (Guéchémé, Tounouga, Kiota, and N'Dounga) in the Southwest of Niger. Information about the proportion of farmers receiving and using forecast information, farmers' perception of the forecast products, and information dissemination channels, were collected and analyzed. The perspectives for conducting further research through on-farm demonstration trials with a view of assessing the possible gains in using the forecast information were explored as well. Findings from the survey data analysis showed a low proportion (42%) of farmers receiving agroclimatic information and 62% of the respondents receiving the information found it useful to very useful. For the forecast information communication ways, 81% of farmers receiving the information got it through radio broadcast, and 49% of the total sample recommended radio as the fastest and most effective means of dissemination way, though 29% preferred receiving the information via the village chief. Therefore, Radio broadcast remains the best option for disseminating seasonal forecast information to farmers. Strategies to engage smallholders for more use of forecast information could focus on radio mode, the ICT, and community leaders for timely dissemination of the information. Seasonal forecast information would be more beneficial to farming operations if they were integrated with other adaptative technologies such as high potential yield crops and varieties, research selected varieties, fertilizers, and good practices.

Keywords

Climate Change, Seasonal Forecast, Season Onset, Season Cessation, Southwest Niger

1. Introduction

Climate change and its related side effects affected people's livelihoods, especially in African rural areas where communities' main incomes are based on rainfed agriculture. Extreme climatic phenomena threatening agriculture and food security include insufficient rainfall totals, delayed season onset, early cessation, prolonged dry spells at crucial crop stages, flash floods, and extreme winds. Seasonal forecast information may help farmers cope with the high rainfall variability and negative impacts on agriculture. Knowing in advance the optimal planting date, the rain cessation period, and cumulative rainfall are valuable tools in the process of on-farm decision-making.

Cyclic drought periods observed over the Sahel region in the early 1970s and 1980s were the triggering factors for the development of several coping strategies. Early landmark studies have laid the foundation for the seasonal forecast and applications in agriculture over sub-Saharan Africa. Hulme et al. (1992a) investigated the scientific aspects of an experimental seasonal rainfall forecast for Africa released by the UK Meteorological Office in 1986 and have foreseen potential benefits related to those types of forecasts. Glantz (1977) investigated the constraints seasonal forecast applications could face in the West African Sahel if they were available during the severe drought of the early 1970s.

According to Hansen et al. (2011), sub-Saharan Africa has the longest continuous records of RCOFs in the history of anywhere in the World and the timing of the forum has been initially defined based on agriculture needs. According to Ogallo et al. (2008), the precipitation outlook provided by the West Africa Regional Climatic Outlook Forum (WARCOF), locally named PRESASS (Prévisions Climatiques Saisonnières en Afrique Soudano-Sahelienne) for the sahelian part of West Africa or PRESAGG (Prévisions Saisonnières des caractéristiques Agro-hydro-climatiques de la grande saison des pluies dans les Pays du Golfe de Guinée) for Gulf of Guinea countries is one of the earliest RCOF products. WARCOF is a forecasting initiative of the national weather and hydrological services of West Africa and some central African countries (Chad and Cameroon), coordinated by the African Centre of Meteorological Applications for Development (ACMAD) and the Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationelle (AGRHYMET Regional Centre). The forum meets annually and is usually complemented by experts from several Global Producing Centers for Long-Range Forecasts and other climate specialists (Bliefernicht et al., 2019). A detailed overview of the information and methods used by the West African RCOF to provide seasonal precipitation outlook is given in the study by Mason & Chidzambwa (2009).

The outcomes of the forum are adapted to the needs of different end users and released through several channels including press communication, workshops, new information and communication technologies (ICT), radio broadcasts, personal communications, interdisciplinary working group meetings, information bulletins, etc. Each of the West African countries participating in the process uses some of those channels based on available facilities to disseminate the information. Despite the progress made to reduce the climate services communication gap in the region, the information is not reaching farmers at the last miles.

In the case of the area covered by the present study, the national meteorological Service of Niger and its partners disseminated the forecast information to farmers' communities through a workshop with pilot farmers from a sample of villages chosen in each of the municipalities for those to convey the information to other farmers from their villages and neighboring villages. The target villages and municipalities of this survey were covered by such kind of seminars just before the growing season 2021 and 2022 through ANADIA (French acronym for climate change adaptation, disaster prevention and agricultural development for food security) and PASEC (French acronym for Climate-Smart Agriculture Support Project) initiatives.

Previous studies carried out in the early years when the climate scientists' community started providing seasonal forecasts for the West Africa region showed limited use of forecast information by farmers to improve crop productivity during that period (Hulme et al., 1992b; Tarhule & Lamb, 2003). The low uptake of forecast information by Agricultural communities over the region is still ongoing though the benefits of the use of such kind of information may have on crop productivity. Several possible reasons have been stated to justify that situation. The limiting factors were the information not reaching the farmers' level, the format in which the information is released, the tercile-based characteristics of the forecast (Hansen et al., 2019; 2022), the lack of access to credit, capital, and agricultural technologies for the full application of forecasts on the field, intraseasonal aspects (season onset and cessation, dry spells) missing in the forecast released at that period, making it insufficient to farmers' needs (Ingram et al., 2002), the broad scale of the forecast that does not fit local decision making (Hansen et al., 2022; Diallo & Ndiaye, 2024) such as where to plant and where to move animals for instance, low incomes and vulnerability of smallholders' farmers (Hulme et al., 1992b).

Socio-economical, environmental and institutional impediments constraining the integration of forecast information by farmers include gender, age, level of education, income and land size (Masesi et al., 2018). Alexander & Block (2022) highlighted that even a perfect forecast that is well-trusted may prove challenging to integrate to decision-making due to farmers' very limited resources that may not allow them to invest in ex-ante options for coping with climate variability. Zagre et al. (2024) identified a statistically significant impact of socioeconomic and institutional factors on farmers' decisions to adopt Climate-Smart Technology (CST).

Some studies have assessed the impacts of forecast information use over farm outcomes under semi-arid conditions using simulation models (Roncoli et al., 2009; Roudier et al., 2014; 2012; Alexander & Block, 2022) or in-situ data measurement (Hellmuth et al., 2007; Ouédraogo et al., 2015; Tarchiani et al., 2018; 2021). The major findings from previous research revealed various benefits related to the use of forecast information and other climate information in farming systems. The most popular benefits mentioned remain crop yield increase, financial incomes improvement, nutritional profit, inputs costs and labor time saving, farmers and other stakeholders' capacity building in Climate-Smart Agriculture technologies and their adoption.

As financial profit increase reported, the adoption of the seasonal forecast and other climate services resulted in a 25,300 birr ($700) benefit increase per farmer agent, or 31,886,000 birr ($884,850) per community of 1260 farmers agents in Ethiopia (Alexander & Block 2022), 41% increase of income in Mauritania (Tarchiani et al., 2021), an income increases of about 73,000 FCFA ($116.52) from an average farmland of 3 ha per farmer in Southwest Niger (Seydou et al., 2023). Hellmuth et al. (2007) compared the millet and sorghum yields based on traditional practices and agrometeorological advisory—based yield in two localities in Mali across 4 years and found an average increase of about 37% of millet yield in both of the localities, 20% and 14% increase of sorghum yield in Bancoumana and Keniéroba, respectively. In the Mauritania case study, Tarchiani et al. (2018) found that farmers using agrometeorological information saved 12% of total farming expenses compared to control ones just in terms of number of seeding. On the contrary, control farmers lost 25% of their total costs due to additional weeding operations charges in terms of opportunity costs. Regarding capacity building, Tall et al. (2014) reported from the Climate Forecasting for Agricultural Resources (CFAR) case study that seasonal forecast training workshops participants were more likely than non-participants to share the information with others, to understand the probabilistic aspect of seasonal climate forecasts and their limitations, to use forecasts in making management decisions by a wider range of responses, and to evaluate the information more positively.

The increasing farmer's willingness and interest to invest in climate services (Tall et al., 2014; Ouédraogo et al., 2015; Tarchiani et al., 2021; Hounnou et al.,

2023) may be evidence of those benefits. Ouédraogo et al. (2015) reported that about 68% of farmers exposed to climate information out of a sample of farmers participating in the assessment of the benefit of using of climate information for cowpea and sesame growth, accepted to pay for the seasonal forecast and 69% for the daily climate information.

However, most of those studies agree on the challenge to isolate the contribution of climate services benefits from the improvement resulting from other factors affecting yields and or economic benefits. Ouédraogo et al. (2015) found non statically significant impact of climate information on sesame productivity, which illustrated how the impact of climate information is not straightforward and do not guarantee returns in some cases. Climate forecast services cannot be disconnected with other climate-smart tools, including crop insurance, high quality inputs. They can be more effective if they are used in a wider procedure integrating other Climate Smart Agriculture technologies such as adapted crop varieties, fertilizers (Ingram et al., 2002), crop insurance (Ouédraogo et al., 2015; Roudier et al., 2012), in a favorable political and institutional context (Totin et al., 2018).

The forecasting system of season characteristics through the West Africa Regional Climatic Outlook Forum (WARCOF/PRESASS) has undergone continuous improvements over the decades. Recent developments resulted in a new generation of forecasting systems (NextGen) that offers solutions to the issues related to conventional seasonal forecasts (Hansen et al., 2022). However, the status of their dissemination and use needs also to be updated. The limiting factors to the forecast information dissemination may include the weakness and technical incapacity of extension agents to present probabilistic predictions in any form useful to farmers, farmers' illiteracy, inaccessibility to other forms of media in rural areas, the multilingual communication way needed to touch a larger number of users. Feedback and perceptions from farmers about the quality of the forecast products need to be assessed as well. According to Blench (1999), there is no systematic survey on users' needs or the impact of the information released.

From the foregoing, it has become evident that more investigation is needed to update the status of seasonal forecast information used by rural communities in Sahelian West Africa and to identify strategies to engage farmers for a larger use of the information in their activities. The main objective of this study is to assess the current use of seasonal forecast products at the farm level. Thus, farmers' perceptions of the forecast products, the dissemination means, and the use of the forecast information were investigated through a field survey in four municipalities in the Southwest of Niger.

2. Materials and Methods

2.1. Materials

As materials, a survey protocol and questionnaire were pre-established and discussed among the research team before the survey administration on the field. IBM SPSS statistics and Microsoft Excel were used for survey data entry and analysis.

2.2. Study Area

A sample of 619 farmers were interviewed through a paper-based survey conducted in 16 villages located in 4 rural municipalities over Southwest Niger (Figure 1), where seasonal forecast information was disseminated just before the rainy season either in 2021 or in 2022 through roving seminars. These are Guéchémé (2021), Tounouga (2021), N'Dounga (2022) and Kiota (2022). The survey sites were identified according to the main agro-ecological zones where rainfed agriculture is practiced over the country; i.e., the Sudanian zone (where Tounouga is located), the Sudan-Sahelian zone (where Guéchémé is located) and the Sahelian zone (where N'Dounga and Kiota are located). Millet is widely cultivated either alone or in association with cowpea or sorghum in the study area.

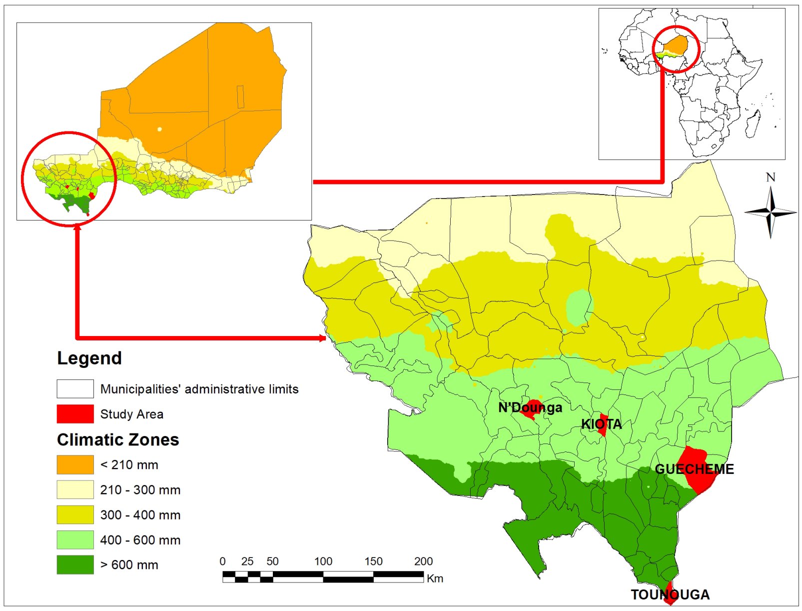

Figure 1. Study area, municipalities of Kiota, N'Dounga, Guéchémé, and Tounouga (in red color on the map).

To perform the yield assessment related to the use of forecast information, yield appreciation data collected from farmers through the survey were completed with quantitative data from a 2-year on-farm demonstration trials carried-out in 2023 and 2024 over four villages within Guéchémé, one of the municipalities in the study area. During the experimentation, three treatments, i.e., seasonal forecast with full technologies package (T1), seasonal forecast information and recommendations only (T2), and farmer's practices or business as usual (T0) as control treatment have been applied over the fields of five farmers in each of the four targeted villages. In T1, farmers were supplied all the inputs needed for the full package of recommendations related to the seasonal forecast, whereas for T2, they have to apply those recommendations based on their own resources. That is only the seasonal forecast information and recommendations were provided to them in the second case. In the third treatment, they operated as they used to do.

2.3. Methods

The sampling method for selecting villages and individuals to be surveyed consisted first, in applying the Sloven formula (Equation (1)) to determine the sample size. This method allows us to draw, with the same probability, a sample that will be considered representative of the municipality. Thus, 156 individuals were selected for each of the municipalities of Guéchémé and Tounouga and 155 for the municipalities of Kiota and N'Dounga.

$$n = \frac{N}{1 + \left(N * e^2\right)} \tag{1}$$

With:

n	sample size
e	accuracy level = 0.08
N	total agricultural population of the municipality

N is estimated by weighing the total population of the municipality over the number of agricultural households assuming only the same average household size for agricultural households and non-agricultural households. Thus, the size of the agricultural population of the municipality was obtained by the following Equation (2):

$$N = \frac{P \cdot H_{agr}}{H} \tag{2}$$

With

P	total population of the municipality
H_{agr}	number of agricultural households
H	total number of the municipality's households

The total population of each municipality as well as the number of households are extracted from the national register of localities of Niger (RENALOC) resulting from the 2012 population census (INS, 2014). An annual population growth rate of 0.03% was applied to update the population in 2021 and 2022.

The total number of villages to be surveyed was calculated by dividing the sample size by the total number of farmers who participated in the forecast results restitution workshops at the level of each municipality. After calculating the weight of the population of the villages that benefited from the dissemination of seasonal forecasts to the total agricultural population of the municipality, this number of villages to be surveyed was divided between the 2 categories (direct beneficiary and indirect-beneficiary villages of seasonal forecast results restitution workshops) each according to the weight of its population to the overall agricultural population of the municipality. The individuals to be surveyed were thus divided into those two categories of villages.

The survey was administered from the end of November through early December 2022. At each of the 16 villages visited, targeted farmers were interviewed individually based on the questionnaire according to the instructions given to the investigators through the survey protocol and Terms of References.

3. Results

3.1. Sample Characteristics

The survey participants include 509 males (82%) and 110 Females (18%). The respondents' age ranges from 17 to 95 years old with an average value of 48 years old. The sample is characterized by a high illiteracy rate with 60% of the respondents being illiterate or going only to qur'anic school (Figure 2). About 97% out of the whole sample use millet as their main crop and 25% use cash crops such as cowpea, sesame, groundnut, roselle in intercropping with millet. The high rate of food crops and low rate of cash crops in the farming system made it more substantial than business-oriented agriculture.

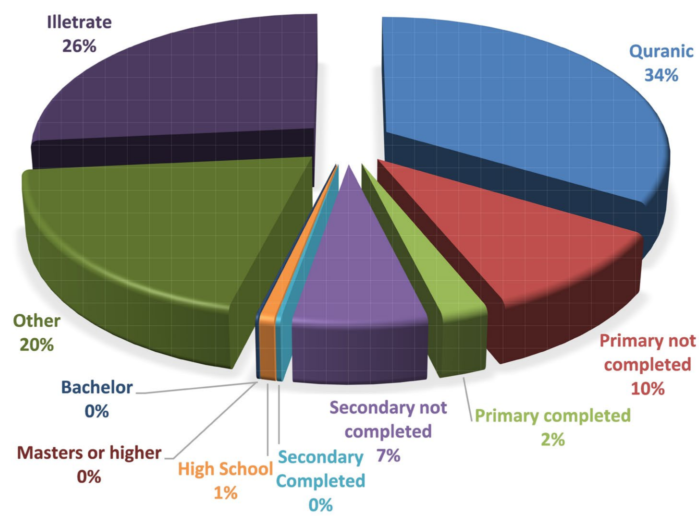

Figure 2. Level of education of respondents.

3.2. Forecast Information Dissemination

Findings from the survey data analysis showed a low proportion (42.3%) of farmers receiving agroclimatic information released by the meteorological service and other climate services suppliers. This agrees with Roncoli et al. (2009) who found inequitable dissemination of information across the communities due to social tensions related to political power, leadership, or land ownership.

It comes out from the survey results that the forecast dissemination through roving seminars/workshops does not make the information to be widely diffused as expected. 81% of farmers receiving the information declared getting that through radio broadcasts while only 5% of farmers declared receiving the information through roving seminars way (Table 1). From the discussion with survey respondents, one of the reasons behind the message not being well transmitted through the workshops' participants who were supposed to do so throughout their neighborhoods is their education level. Most of the time, the village chief sends a family member to the workshops without considering if the person can assimilate or not the training/information to be delivered at the workshops. Another important observation is the lack of interest from the farmers who did not participate in the workshop having believed that it is a waste of time to listen to information that they may not be able to use as a result of resource limitations or religious belief. Survey records in Table 2 show that 49% of the whole sample suggests radio broadcasts as the fastest and most adapted way to get the information to the farmers while 27% prefer to pass the information through the village chief for timely dissemination. Therefore, future strategies to enhance climate information dissemination across rural communities should engage mixed methods such as combining radios, community leaders, and ITC technologies for efficiency.

Table 1. Information reception status through the various dissemination channels.

Dissemination Channels	Number of respondents	Proportion out of the total number of respondents who received the information (%)	Proportion out of the total sample (%)
TV	26	10	4
Radio	212	81	34
Village Chief	23	9	4
Local Agricultural Extension Agent	15	6	2
Roving Seminars/Workshops	14	5	2
Others (Community relay at the mosque, local rainfall data observer, WhatsApp, Facebook Personal communication)	58	22	9

Table 2. Preferred information dissemination channels by farmers.

Dissemination Channels	Number of respondents	Proportion out of the total sample (%)
TV	26	4
Radio	212	34
Village Chief	23	4
Local Agricultural Extension Agent	15	2
Roving Seminars/Workshops	14	2
Other (Community relay at the mosque, local rainfall data observer, WhatsApp, Facebook, Personal communication)	58	9

3.3. Perception and Use of the Forecast Products and Other Climate Services

Seasonal forecast information seems to be the most appreciated information among the package of climate services provided by the Meteorological Service to farmers during the implementation of ANADIA and PASEC initiatives. 63% of the respondents receiving the agroclimatic information affirmed that seasonal forecast is the most relevant information to them. This is followed by information about the crops' evolution throughout the season (13% of respondents) and the daily weather forecast information (11%) (Figure 3).

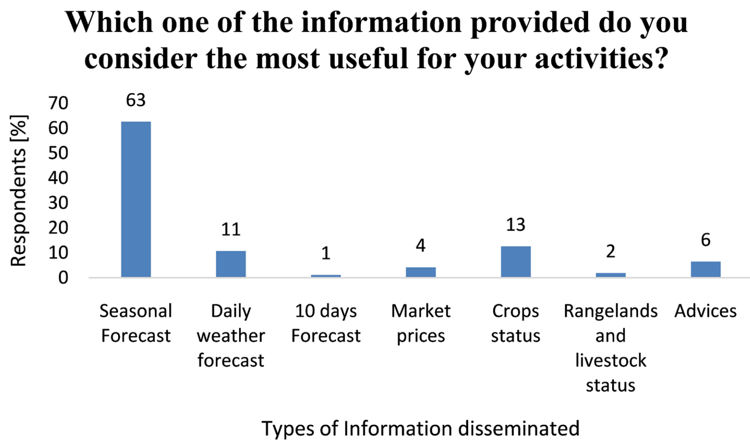

Figure 3. Farmer's perception of the different types of climate information provided to them.

Figure 4 shows farmers' appreciation of the various seasonal forecast information provided to them. The results show that 62% of the respondents receiving the information found the forecast information useful to very useful for application to their agricultural activities. Most of those receiving the information (93%) declared that they have effectively used at least one of the seasonal forecast products and 96% of those users affirmed that it has been beneficial to apply the information in their decision-making process. However, out of the total survey sample (i.e. sample including farmers not receiving the information), only 39% of respondents use the forecast information for their agricultural activities. A large proportion (78%) of farmers among survey respondents who have declared no use or a very low to fairly use of the information are either illiterate, or having primary school level or only qur'anic education. Those outcomes show that despite the efforts to reduce the communication gap of climate services, the rate of utilization of seasonal forecast information in farming systems is still low as was revealed by Tarhule and Lamb (2003), and Tarchiani et al. (2017), and Wood et al. (2014) who found evidence that households reported making farming changes in recent years in west Africa are associated with access to weather information, assets, and participation in social institutions such as saving/credits and loan groups and/or agricultural or natural resources management-related group.

For the proportion of farmers using the forecast information, the application of seasonal forecasts depends on the type of activities and the opportunities available to them. Field preparation (85% of respondents), variety choice (45% of respondents), and choice of the planting date (47%) were the three main activities for which they declared they had made their decision based on forecast information

(**Figure 5**). This is in agreement with Roudier et al. (2014) who simulated crop management based on seasonal and 10-day forecasts with farmers in Senegal and found that change in sowing date and crop variety choice, if applicable, were the most prevalent use of forecast information.

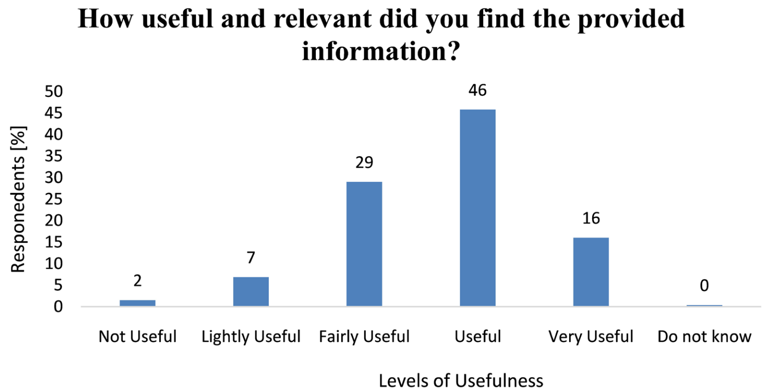

Figure 4. Farmer's appreciation of the different types of seasonal forecast products.

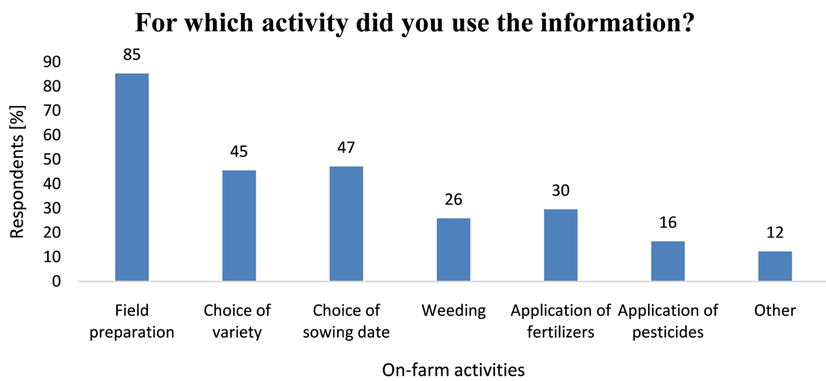

Figure 5. Application of climate information to on-farm activities.

To differentiate the relevance of each of the forecast products for on-farm decision-making, respondents were asked which of them, they consider to be the most important for their agricultural activities. The results showed that season onset and season cumulative rainfall forecast are respectively considered by 45% and 34% of the farmers as the most important information for their activities while early season dry spells, end of season dry spells, and cessation dates forecast information are considered to be the most important information by 9%, 8%, and 4% respectively of farmers receiving forecast information (**Figure 6**).

3.4. Participatory Verification of 2022 Seasonal Forecast

Farmers' perception of the occurrence of the four rainy season characteristics was investigated during the survey. For that purpose, the 2022 seasonal forecast disseminated a few months earlier (the last one before the survey administration) was compared to the participants' responses about the season onset and cessation periods, the length of early and late season dry spells as they had observed them throughout the season and to the actual values of those parameters as estimated based on rainfall records. Table 3 shows the participants' responses in terms of percentage in each of the 3 forecast categories at the municipality level and out of the whole sample. Most respondents declared delayed onset (60%), early cessation (50%), and long dry spells at the early stage of the rainy season. Most of them declared no dry spells at mid-season (52%) and in the late season (33%). The long dry spells during the season beginning may be the reason for crop sowing failure mentioned through the discussion with farmers as one of the major constraints faced during the 2022 cropping season (Figure 7).

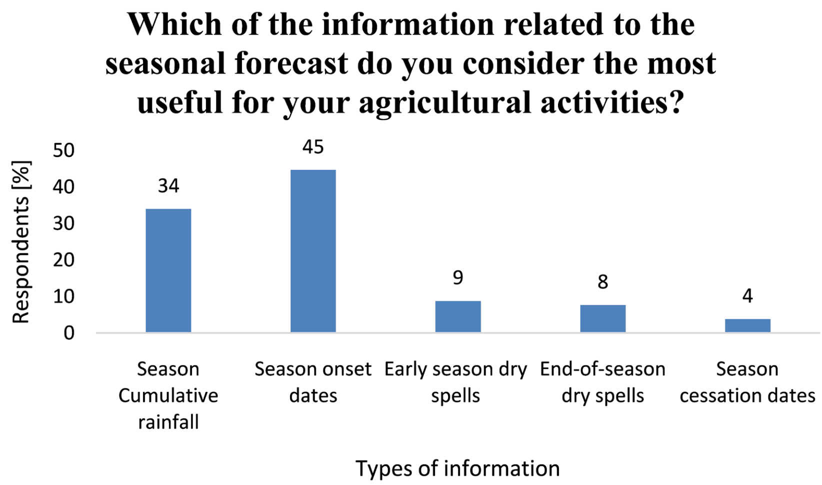

Figure 6. Farmers' appreciation of seasonal forecast products.

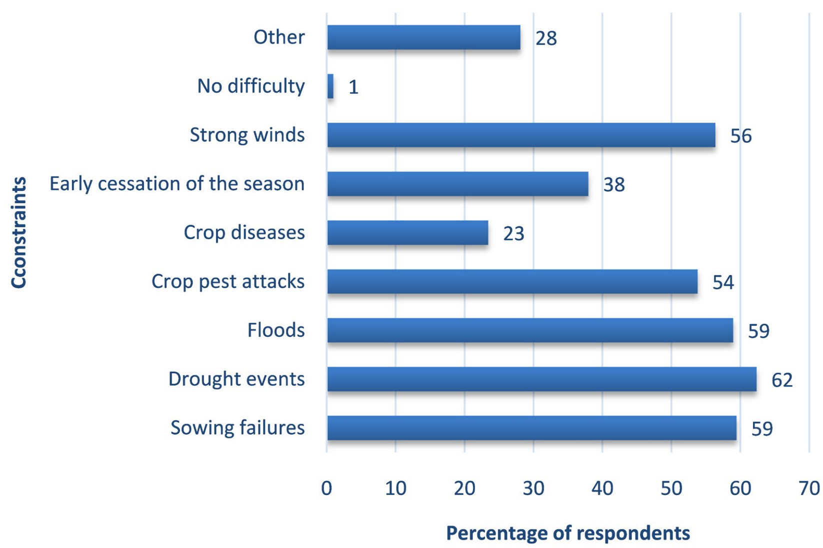

Figure 7. Major constraints encountered during the growing season.

Table 3. Farmers' perception of season onset dates, cessation dates, and the occurrence of dry spells.

Season characteristics	Categories	Proportion of respondents at municipality level (%) N'Dounga	Kiota	Guecheme	Tounouga	Proportion of total
Onset	Normal	16	3	25	28	18
	Early	18	8	22	37	21
	Delayed	64	88	53	35	**60**
	Do not know	1	1	0	0	0
Cessation	Normal	6	5	35	33	20
	Early	78	77	32	14	**50**
	Delayed	15	17	33	51	29
	Do not know	1	1	0	1	1
Early season dry spells	Normal	2	1	11	5	5
	Short	9	11	8	15	11
	Long	67	64	54	56	**60**
	Do not know	5	5	1	2	3
	No Dry spells	18	19	26	22	21
Dry spells at Mid-season	Normal	5	3	7	5	5
	Short	7	11	19	29	17
	Long	31	37	5	12	21
	Do not know	31	37	5	12	21
	No Dry spells	45	44	66	51	**52**
Late-season dry spells	Normal	3	3	7	3	5
	Short	7	10	17	33	17
	Long	76	68	16	12	20
	Do not know	5	4	1	1	5
	No Dry spells	8	16	58	49	**33**

The comparison of farmers' responses to the actual values of onset dates, cessation dates, and dry spells' length and the forecast categories is given in Table 4. Regarding the onset and cessation dates occurrence, farmers' responses match with the actual dates; contrary to the forecast that mismatched them (Table 4a, Table 4b). However, their responses did not hit both the forecast results and the actual values regarding the dry spells' length in the early and late seasons (Table 4c and Table 4d). Based on that, we can conclude that farmers perceived well the occurrence of the rainy season onset and cessation but not the duration of dry spells. That may be due to the farmers' tendency to exaggerate the duration of dry spells.

Table 4. Seasonal forecast verification based on farmer's perception and the actual values of the season parameters.

4a	N'Dounga	Kiota	Guecheme	Tounouga	Whole study area
Onset category Observed according to the majority of respondents	Delayed	Delayed	Delayed	*	Delayed
Forecast	Normal	Normal	Normal	Normal	Normal
Actual Cessation	Delayed	Delayed	Delayed	Delayed	Delayed
Farmers' response vs forecast	X	X	X	*	X
Farmers' response vs actual onset	√	√	√	*	√
Forecast vs actual onset	X	X	X	X	X
4b	N'Dounga	Kiota	Guecheme	Tounouga	Whole study area
Cessation category observed according to the majority of respondents	Early	Early	*	Delayed	Early
Forecast	Delayed	Delayed	Delayed	Delayed	Delayed
Actual Cessation	Normal	Early	Early	Delayed	Early
Farmers' response vs forecast	X	X	*	√	X
Farmers' response vs actual cessation	X	√	*	√	√
Forecast vs actual cessation	X	X	X	√	X
4c	N'Dounga	Kiota	Guecheme	Tounouga	Whole study area
ESDS length category Observed according to the majority of respondents	Long	Long	Long	Long	Long
Forecast	Normal	Normal	Normal	Normal	Normal
Actual Cessation	Normal	Long	Normal	Short	Normal
Farmers' response vs forecast	X	X	X	X	X
Farmers' response vs actual ESDS	X	√	X	X	X
Forecast vs actual ESDS	√	X	√	X	√
4d	N'Dounga	Kiota	Guecheme	Tounouga	Whole study area
LSDS length category Observed according to the majority of respondents	Long	Long	No Dry Spell	No Dry Spell	Long
Forecast	Short	Short	Short	Short	Short
Actual Cessation	Short	Normal	Short	Short	Short
Farmers' response vs forecast	X	X	√	√	X
Farmers' response vs actual LSDS	X	X	√	√	X
Forecast vs actual LSDS	√	X	√	√	√

4a. Season onset, 4b. Season Cessation, 4c. Early Season Dry Spells (ESDS), 4d. Late Season Dry Spells (LSDS), * No clear majority from farmers' responses, √ matching, X mismatching.

3.5. Major Constraints to Agriculture Productivity and Crop Yield

Major constraints faced in the farming system were discussed during the survey. Figure 7 shows that most of the respondents consider Drought (62%), followed by floods (59%), sowing failure (59%), extreme winds (56%), and crop pest attacks (54%) as major risks to Agricultural productivity. Early cessation of the rainy season and crop diseases were also identified as major risks by 38% and 23% of the respondents respectively. Other limitations have been mentioned by 28% of the respondents. Those include the farmer's inaccessibility to fertilizers, improved seeds, late season onset, extreme rainfall events, and extreme winds. It comes from those results that most farmers are aware of the area's major climatic risks for agriculture and food production.

We attempted to investigate whether the use of forecast information by some of the respondents had any benefit on crop yield for the year 2022, the most recent in memory as the survey was conducted just after the end of the growing season. To achieve that, respondents were asked to give a quantitative and qualitative estimation of the harvest from their plots. Quantitively, during the survey, they failed to give the area of their fields and the number of bundles harvested from which the yield could be estimated. Figure 8 shows a qualitative appreciation of the 2022 crop yield based on respondents' declarations. Most of them affirmed that their crop yields were low (47%) to very low (27%). Only 21% found the yield fair and 4% showed satisfaction with the crop yield resulting from the 2022 cropping season. That qualitative appreciation has to be considered with caution as that may be biased by farmers' susceptibility to underestimate the crop yield due to the usual food assistance supplied to vulnerable households in case of a worse season with low crop production. Overall, the information collected from the survey was not enough to relate the crop yield to the use or not of forecast information for farm activities.

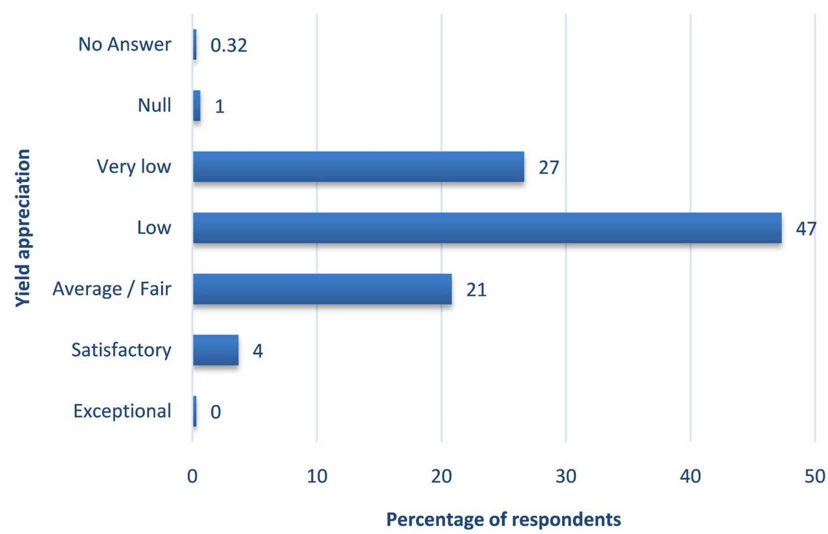

Figure 8. Crop yield appreciation from farmers for 2022 growing season.

To complement the yield assessment based on survey outcomes, data from the two-year demonstration trial implemented over four villages within Guéchémé and involving 20 farmers were analyzed. Figure 9 compares the average yield over the two years and across the four villages. The full application of forecast information resulted in an average millet yield increase of 430 kg/ha compared to the traditional farmers practice and an increase of 336 kg/ha compared to the seasonal forecast information application based on farmers' own resources. Those results are in accordance with Hellmuth et al. (2007) and Tarchiani et al. (2017) who found millet yield improvement respectively in Mali and Mauritania following the use of agrometeorological information services.

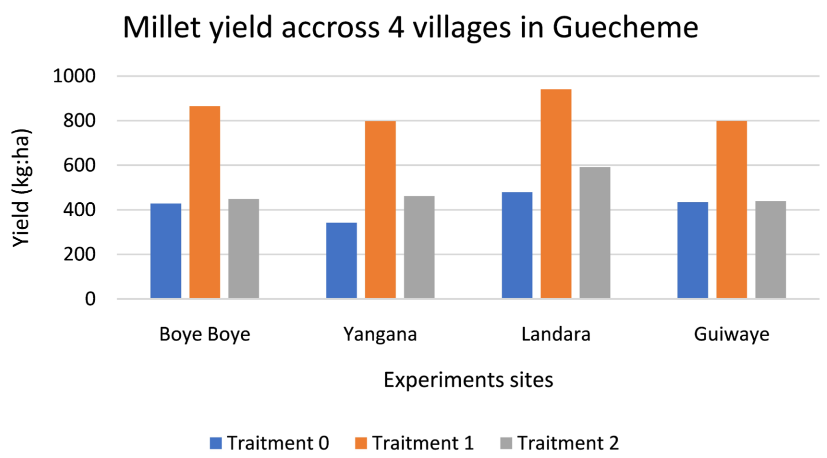

Figure 9. Average millet yield from a two-year (2023 and 2024) demonstration trial on the use of seasonal forecast information in farm decision making at Boye Boye, Yangana, Landara and Guiwaye in Guéchémé municipality: blue correspond to the yield from control treatment, orange is for yield from full application of forecast information and recommendation and grey is for yield from application of forecast recommendations based on farmers' own resources.

3.6. Needs Assessment for Further Climate Services

Besides the information already available to them, survey participants were asked about their needs for further climate services for their daily activities. Figure 10 indicates that the largest number of responses came for weather information for pest management (37%), followed by information on crop insurance (22%) and Temperature forecast (19%). The proportions of respondents declaring the need for dust storm forecast, dry haze forecast, dust concentration information, and some other information, including extreme rainfall alert and extreme wind event forecast, were lower than for the previous categories.

4. Discussion

The results from the present study show that most farmers perceived well climate risks and the relevance of forecast information to cope with them. 62% of the respondents receiving the information found the forecast information useful to very useful for agricultural activities. Rainy season onset and cessation dates, season cumulative rainfall, and the intra-seasonal distribution (dry/wet spells length) are key determinants in Sahelian rainfed agriculture because of the high intra- and inter-annual variability in rainfall patterns. Farmers need to adapt to the changing environment highlighted in many studies. Tarhule & Lamb (2003) have given evidence that rainfall varies erratically both at spatial scale (even within a few kilometers as shown over west Niger) and temporal scale (annual, monthly, and daily) over Sahelian West Africa (Laux et al., 2008; 2009).

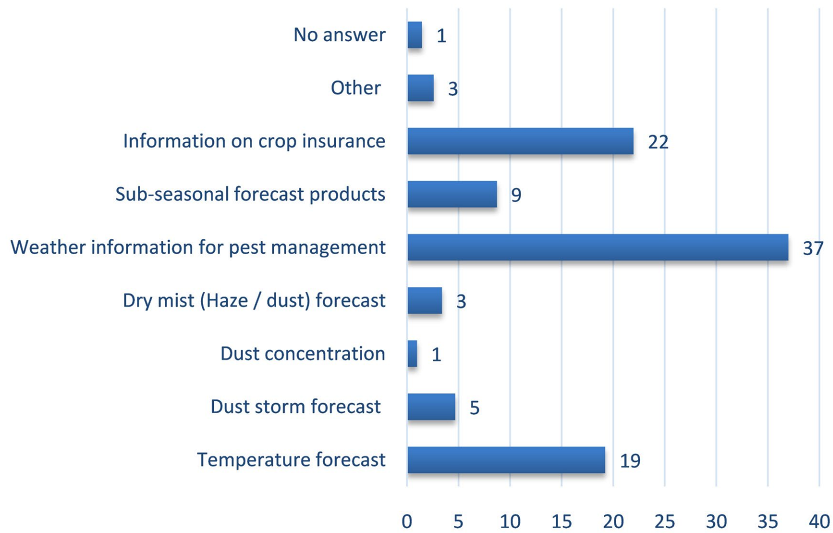

Figure 10. Additional climate services needed by farmers.

Survey outcomes show that farmers are aware of choosing the optimum planting dates and the adequate crop and varieties based on the forecast of season onset and the cumulative rainfall are important on-farm good practices to cope with the variability. Respectively, 45% and 34% of respondents among those having access to forecast information found the season onset and the cumulative rainfall forecast as the most relevant information. That agrees with the findings from Bojang et al. (2020) and Sivakumar et al. (1992).

However, it comes from the survey results that there is still an insufficient application of forecast information in farming systems. Our study revealed low access of farmers to the information even though it has been disseminated in the study area through workshops. That is in accordance with studies by Tarhule & Lamb (2003), and Hansen (2015) that showed the low-uptake of the information due to the difficulty and high-cost related to the scaling up of the seasonal forecast restitution workshops with farmers at a larger scale despite of their effectiveness at a pilot scale. The discussion with farmers during the survey revealed that they could not access or use seasonal forecast information appropriately because of socio-economic impediments and inappropriate information dissemination ways; as found by Roncoli et al. (2009) in Burkina Faso, Masesi et al. (2018) in semi-arid eastern Kenya, Alexander & Block (2022) highlighting the inability of limited resources farmers to invest in an ex-ante option integrating forecast information in decision-making, and Zagre et al. (2024) who found a statistically significant impact of socioeconomic and institutional factors on farmers' decisions to adopt Climate-Smart Technology (CST) in Senegal.

The survey outcomes indicated that 81% of farmers receiving the information got it through radio broadcast which is a one-way communication channel that would not allow interaction with experts for a better understanding and application of the information received. Similarly, Tall et al. (2014) reported that face-to-face dialogue between farmers and experts is the comprehensive way to communicate complex seasonal climate information rather than media-based dissemination. Even though forecast information restitution workshops allow the interaction between information providers and users, our study results show that they cannot cover a large scale of users. From the present survey, only 2% of the total sample and 5% of those receiving the information got it through workshops. Our findings align with previous studies in Senegal by Roudier et al. (2014) and in Niger by Seydou et al. (2023); Tarchiani et al. (2017) who also reported that radio is the most widely used dissemination channel for seasonal forecasts information. However, unlike these studies, our results highlight a significant role of village chiefs in information dissemination, particularly in more isolated communities. This suggests that hybrid dissemination strategies, combining radio broadcasts with community leader involvement, may be more effective in regions with high illiteracy rates.

A large proportion (78%) of farmers that do not use or use it at low rate has low level of education, showing the evidence of farmers illiteracy being a hindering factor to an extensive use of forecast information in those rural areas. That is in line with Masesi et al. (2018) who concluded that socio-economic factors such as gender, age, level of education, income, land size have significant positive correlation with forecast use in semi-arid lower eastern Kenya. Our findings agree also with Nyoni et al. (2024), who highlighted the key role farmers' education play in awareness, access, use, value, and uptake characterizing the process of adoption of a climate information service. The low level of education of farmers is thus a major limiting factor to the use of the information as the probabilistic and complex aspect (Tall et al., 2014) and the dissemination format of the forecast remain inaccessible even for those who have a certain level of education. Based on that and as previously recommended by Sultan et al. (2020), Our findings infer the need for more face-to-face information dissemination workshops and other capacity-building activities in advance before deploying a hybrid dissemination scheme to make the users understand the information provided and allow extensive use of forecast information.

In the present case study, the sample characteristics show that the farming system in the study area is dominated by millet-based systems either in pure form or intercropped with cowpea, groundnut, sorghum, sesame or roselle likewise in the rest of rainfed agricultural zone in Niger reported by Wezel & Haigis (2002).

Hence, cash crops produce remain low compared to the food crops leading the cropping system to be more subsistent than business-oriented agriculture. Institutional factors such as low access of farmers to extension services, to market outlets, to production inputs reported by Totin et al. (2018) and environmental factors such as soil poverty, erratically rainfall regimes, pests, and plant diseases may put emphasis on the low-income generation from the cropping system. Insufficient and/or bad transportation network limiting the trade flows between remote rural area and urban agglomerations is one of the limiting factors to an improvement of farmers' in-comes (Totin et al., 2018) as it reduces farmers' access to market.

Through the discussion, some of the survey respondents mentioned that they do not believe in or use forecast information because of religious beliefs, however our study did not investigate deeper the role of religious beliefs and social inequalities as factors influencing the adoption of seasonal forecasts by farmers. Additionally, we did not examine the role of Participatory Action Research strategies in involving farmers in the co-production of climate services to enhance trust, engagement, and uptake of forecast information as that was done in the studies reported by Chiputwa et al. (2022) and Tall et al. (2014).

Our study suggests that, improving farmers' access to credits and to adapted technologies such as improved varieties, fertilizers, mechanization and capacity building of all stakeholders may be good strategies to increase the adoption and application of seasonal forecasts in the on-farm decision-making process. An adequate information system involving climate services providers, community radios and leaders, farmers, and relaying on new ITC would allow a timely diffusion of forecast information.

5. Summary and Conclusion

Climate extremes such as drought, sand/dust storms, extreme winds, flash floods, and extreme rainfall events negatively impact the rainfed agriculture in the Sahelian West Africa region. Forecasting the expected rainy season characteristics has become important to better adapt to climate and meteorological extreme events. Many efforts were made to improve the forecasting system of rainy season parameters. However, the assessment of farmers' perception of climate risks and the on-farm use of the forecast products needs to be further investigated for a better definition of their needs.

The study shows that farmers become progressively aware of extreme climatic phenomena and need to be assisted in accessing forecast information such as season cumulative rainfall and season onset, which they found to be the most useful information for their agricultural activities. Dry spells during the cropping season and season cessation dates are also in their interest.

Our research provides valuable insights into the key factors influencing farmers' adoption of seasonal forecasts, helping to refine the design and dissemination of climate services. By identifying critical drivers and barriers, the findings contribute to more effective strategies for integrating seasonal forecasts into agricultural decision-making, ultimately enhancing climate resilience in farming communities.

The results reveal the need to investigate more on the strategies to be developed to scale up the on-farm use of climate services in general and seasonal forecasts in particular.

To enhance the applicability of the current investigation and to provide a more comprehensive understanding of the issue related to framers' access and use of climate services over the region, further studies could explore the role of participatory approaches in improving trust and engagement in forecast adoption, as well as the impact of broader sociocultural factors such as religion in this region, but also in other agroecological and socioeconomic contexts across West-Africa.

Acknowledgments

Special thanks to the West African Science Service Centre for Climate Change and Adapted Land Use (WASCAL) for sponsoring the entire doctoral program. Similar appreciation goes to AGRHYMET Regional Center for hosting the doctorand's field data collection work and funding the survey through the collaboration with the intra ACP/GFCS/ClimSA project.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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