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Farmers experiences of climate information forecast use in Benin, West Africa

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Abstract

Climate forecast information is becoming an important alternative for managing climate change. By strengthening farmers' resilience to adapt to climate change, the program "Communal Approach for the Agricultural Market in Benin - phase 2" (ACMA2) in partnership with the company Ignitia, provided weather information to farmers by SMS. This study seeks to understand farmers' experiences on the use of climate information forecast in the municipality of Dassa-Zoumè, which is one of the intervention areas of the ACMA2 program. Data were collected from 180 randomly selected farmers (120 Ignitia users and 60 non-Ignitia users). With the data from focus group discussions and structured questionnaire, we performed descriptive statistics and used the two-sample t-test to compare the crop yields between Ignitia users and non-Ignitia users. All respondents perceived climate change as a risk which affected crop yield (85%), crop failure (80%), soil poverty (76%), pest and disease outbreaks (64%). Farmers relied on the climate information forecast through Ignitia SMS service, informal network, local radio and extension workers to adjust their farming activities. Results also showed that Ignitia farmers recorded higher yields than non-Ignitia farmers, with a difference of 30% for peppers, 22% for maize, 20% for soybeans, 17% for peanuts and 13% for cassava. The two-sample t-test is significant ($P \leq 0.001$) and shows that the use of climate forecast information has a positive impact on the crop yields. Facilitating farmers access to climate information can help them to make informed decisions to better manage climate risks.

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Introduction

Climate change remains one of the biggest contemporary environmental challenge in the world affecting food security through changing precipitation patterns, increasing temperatures, and greater frequency of some extreme climate events (IPCC, 2022). It has emerged as an existing major problem of agricultural development with erratic rainfall patterns and high temperatures in Sub-Saharan Africa (SSA) where farming system is largely rainfed (Shimeles *et al.*, 2018; Fadairo *et al.*, 2019). Agricultural losses due to the negative impact of climate change are estimated to be 5 to 15 % of SSA GDP by 2100 (Onyeneke *et al.*, 2024). In addition, several studies have estimated significant declines in the performance of the farming system in SSA unless anticipatory adaptation measures are considered across scales (IPCC, 2022).

Benin, a developing country in West Africa, is one of the most vulnerable countries in SSA, where the climate change has already been felt, with the latest decades being marked by mean annual temperature increases, fewer rainy days per year, with a shift of precipitation regimes, and increased frequency and intensity of droughts and floods (MCVDD, 2022). By 2100, temperatures may rise in Benin by as much as 2°C or even 4°C, while rainfall will become more erratic, within and between years, leading to a more frequent flooding and droughts (Aho *et al.*, 2018). The influence of rising temperatures and deep rainfall uncertainty as effects of climate change affect severely agricultural development which is an important economic sector in Benin (Aho *et al.*, 2018; MCVDD, 2022). Adaptation to climate change is an urgent concern for farmers and policy makers because of increasing level of losses, damages and the growth of climate risks (Zoundji *et al.*, 2017; IPCC, 2022). Many adaptation strategies or options exist and are based on the sustainable agricultural practices which are determined by economic, environmental, demographical, institutional, and socio-cultural factors (Marie *et al.*, 2020). However, in the agricultural sector, one of the major barriers to effective climate change adaptation is the lack of appropriate climate information (Muema *et al.*, 2018). Climate information is a main component for farmers to make climate smart decision-making in relation land preparation, crop variety choice, planting dates, timing of fertilization, harvesting and market for output (Sen *et al.*, 2021). Facilitating farmers access and use of climate information can help them to exploit climate opportunities for improving their production and make informed decisions to better manage uncertainty related to climate risks and adaptation measures (Machingura *et al.*, 2018). Climate information is crucial to strengthen resilience, support climate change adaptation, and improve sustainable livelihoods of farmers (WMO, 2021).

By strengthening farmers' resilience and ability to adapt to climate change, a Swedish company, Ignitia, has developed a tropical forecasting model for West Africa with 80% accuracy, providing daily weather information to farmers by SMS in their local language (for the day and the following day) of expected rainfall, its intensity, and the probability of the time slot (Jacquemot, 2023). International Fertilizer Development Center (IFDC), through the Program "Communal Approach for the Agricultural Market in Benin - phase 2" (ACMA2), has contracted with this Swedish company to provide climate forecasts to farmers at farm level in the country since 2019. Beforehand, information on beneficiaries (identities, GPS coordinates of the farm, telephone number, level of education, etc.) was shared with Ignitia through the ACMA2 program's stakeholder management platform. The objective of the ACMA2 program is to increase the agricultural incomes of the economic actors at the local level. This study aims to understand farmers' experiences on the use of climate information forecast.

Material and methods

Study area

The study was conducted in the municipality of Dassa-Zoumè, which is located at the centre of the Republic of Benin, between 7°25' and 7°41' North latitude and 2°6' and 2°25' East longitude (Aho *et al.*, 2018). This municipality belongs to the Soudano-Guinean transition zone and characterized by Soudano-Guinean climate with two seasons namely a dry season and a rainy. Dassa-Zoumè is a large food producing area and has experienced significant climate risks, including rising temperatures, delayed onset of rainfall, and shortened seasons. Firstly, this municipality was chosen due to its vulnerability to climate change which limits agricultural production and secondly, because it constitutes one of the intervention areas of the ACMA2 program. This program is providing climate forecasts to farmers via Ignitia platform. Six villages (Arigbokoto, Erokowari, Igoho, Kere, Tangbé and Lema) were selected for this study in the municipality.

Data collection and analysis

Data were collected in three phases from February to March 2024. Firstly, an exploratory study was carried out by using an interview guide to gather initial data from the main key factors such as presidents of farmers' organization, staff of the ACMA2 program, the person in charge of the Territorial Agency for Agricultural Development (ATDA), and the agricultural extension officers.

Discussions were organized in the form of exchanges on the operation of the Ignitia platform and their perceptions and experiences towards adaptation to climate change. In the second phase, four Focus Group Discussions (FGD) were organized in each village with farmers in the local language. According to Greenbaum (2000), each FGD would ideally include a maximum of ten people and a minimum of eight. The principal themes of the FGDs were farmers' perception on the effects of climate change, main sources of access on the climate forecast information, types of climate information received and their regularity and reliability, use of climate information, cultivation operation, types of crops and crops yields etc. In the third phase, a list of all farmers in each village was obtained from the Territorial Agency for Agricultural Development (ATDA), and our sample included 180 farmers (20 farmers who had received the climate information via Ignitia platform and 10 who had not received the climate information per village) selected through a random sampling technique (Table 1). In addition, these farmers had farming experience of 15 years and above in the selected village. We individually interviewed in total 180 farmers, followed by a field visit to see some practices that people had mentioned in the interviews.

Table 1. Research sample structure

Villages	Farmers		Total
	Ignitia	Non-Ignitia	
Arigbokoto	20	10	30
Erokowari	20	10	30
Igoho	20	10	30
Kere	20	10	30
Tangbé	20	10	30
Lema	20	10	30
Total	120	60	180

A formal method in ethnography, which was based on thematic trends in farmers' statements (Sanjek, 2000), was used to analyse the qualitative data and quotes have been also used to bring vegetable farmers' views into the analysis. Concerning the quantitative data, the descriptive statistics were used to calculate the means, frequencies and standard deviations of the various socioeconomic indicators. In addition, the two-sample t-test was used to compare the crop yields between Ignitia farmers and non-Ignitia farmers.

Results and discussion

Socio-economic characteristics of respondents

Table 2 presents the socio-economic characteristics of respondents and shows that majority of them were men (82%), with an average age of 50 years and had more than 20.5 years' experience of farming. However, Ignitia farmers were on average 4 years younger and 3 years less experience than non-Ignitia farmers. This implies that young farmers are comfortable using ICT platforms such as short message services (SMS) via mobile phones or Ignitia plateform. According to Tamirat *et al.* (2018), young farmers are more likely to use digital innovations in agriculture. In addition, young farmers are more concerned about climate change than older ones and are looking for the reliable information to strengthen their adaptation capacity (Sorvali *et al.*, 2021).

Table 2. Socio-economic characteristics of farmers (n=180)

Variables	Modality	farmers		Average
		Ignitia (n=120)	Non ignitia (n=60)	
Age		48	52	50
Farming experience (years)		19	22	20.5
Gender	Female	15	21	18
	Male	85	79	82
Marital status	Married	85	90	87.5
	Single	9	2	5.5
	Widowed	6	8	7
Education level	No formal	49	58	50
	Primary level	35	30	36
	Secondary level	16	12	14
Main occupation	Agriculture	82	85	83.5
	Other	18	15	16.5
Household size		7.75	7.80	7.73
Farmers group membership	Yes	78	72	75
	No	22	28	25
Agricultural credit access	Yes	39	42	40.5
	No	61	58	59.5

Regarding educational level, around 51% of Ignitia farmers are educated compared to 42% of non-Ignitia farmers. This suggests that the level of education would have a positive influence on the access and use of climate information. Awolala *et al.* (2022) observed that education has a positive significant effect on farmers' access to climate information and their ability to understand weather predictions for the farming decisions. It is also important to note that most respondents were married (87.5%) with an average of eight household members and their main occupation was agricultural activities (83.5%). Most respondents were members of farmers' organisations (75%), and 40.5% of them had access to agricultural credit.

Farmers' perception and effects of climate change

All respondents perceived climate change as a risk for farming (100%) and observed in the last 15 years a long dry season (75%), a warm temperature (68.5%) and delay onset of rainfall (66%) as climate change parameters. This climate manifestation affects crop productivity and the farmers' economic return since they noticed crop yield loss (85%), followed by crop failure (80%), soil poverty (76%), pest and disease outbreaks (64%) as effects of climate change. This finding concurs with a study by Fadairo *et al.* (2020) which showed the declining crop yield, increase in pests and disease attack, crop failure, high post-harvest losses as climate change impacts in Ghana, Uganda and Nigeria.

Access and use of climate forecasts information

Except for the Ignitia plateform allowing climate information access, all respondents noticed that they used to observe the sky cloud and baobab tree to predict the weather. These cultural ways of forecasting climate information in many African countries were mentioned by several studies. For example, many authors found that older farmers often use indigenous weather climate knowledge by observing and interpreting specific phenomena, such as trees, sky, birds, to plan their farming activities (Zoundji *et al.*, 2017; Amegnaglo *et al.*, 2022). However, farmers' main sources of climate information are informal network (family, friends, peers and neighbours) (71.5%), local radio (59%) and extension workers (40.5%). Similar results were obtained by Sarku *et al.* (2022) in Ghana and Zorrilla-Miras *et al.* (2024) in Mozambique where informal network, local radio and extension agents were the preferred source of the farmers' climate information. However, climate information provided by digital service using satellite-based forecast such as Ignitia platform is more regular than above sources (World Bank, 2023).

The most frequent climate information received by farmers (Ignitia and non-Ignitia) is respectively rainfall forecasts, seasonal forecasts, temperature forecasts and drought forecasts. This information is received by Ignitia farmers every day (45%), 3 to 4 days a week (58%) and 1 to 2 days a week (67%).

Table 3. Climate information reception, regularity and reliability

Parameters	Farmers	
	Ignitia (n= 120)	Non-Ignitia (n= 60)
Climate information received (%)		
Rainfall forecast	88	33
Seasonal forecasts	76	21
Temperature forecast	74	12
Drought risk	31	5
Regularity of climate information (%)		
Everyday / week	45	0
3-4 days/ week	58	7
1-2 days/ week	67	12
1-2 days/ month	91	35
Reliability of climate information (%)		
Reliable	86	27
Fairly reliable	14	49
Unreliable	0	24

Ignatia farmers who receive climate information regularly are generally located in a good area of phone network coverage with a reliable mobile phone and energy sources for easy battery recharging. However, 7% and 12% of non-Ignitia farmers received respectively climate information 3 to 4 days a week and 1 to 2 days a week (Table 3). Farmers' accessibility to timely and accurate climate information is a determinant factor for strategic farming decision making such as farmland preparation, date of planting, crop variety, application of pesticides or fertilizer, anticipated date of harvest, in order to cope with and adapt to climate variability (Ncoyini *et al.*, 2022).

Around 77% of Ignitia farmers have understood the climate information received by SMS, while the rest (25%) often get help from a family member. Education level would have a positive influence on the farmers understanding of climate information since Ignitia farmers are more educated than non-Ignitia farmers. In addition, most Ignitia farmers (86%) believe that the climate forecasts are reliable, while the rest (14%) found them fairly reliable. However, 27%, 49% and 24% of non-Ignitia farmers consider respectively the climate forecasts reliable, fairly reliable and unreliable (Table 3). As the lack of understanding and reliability about an innovation, limits its adoption, climate information should be reliable and understandable for farmers to be used (Reveco-Umana, 2023).

Nevertheless, in this study, some Ignitia farmers are not able to understand the content of the climate information messages they received on their mobile phone because of low levels of literacy or inability to operate the mobile phone without the assistance of relatives. Despite the relevance of climate information, some farmers are not able to access it due to their high illiteracy rates, technical information, and sociocultural barriers (Singh *et al.*, 2018).

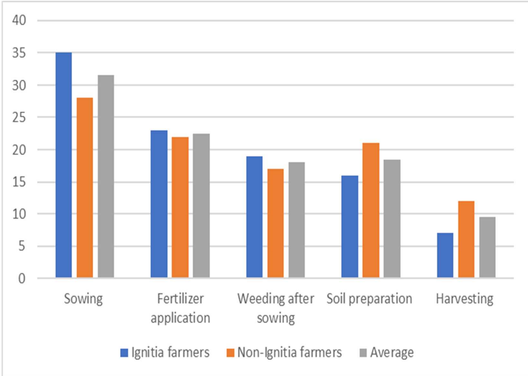

Fig. 1. Different cultivation operations

Fig. 1 shows the most frequent farming operations carried out by farmers after receiving the climate forecast information. These farming operations are the sowing (31.5%), the fertilizer application (22%) and the weeding (18%).

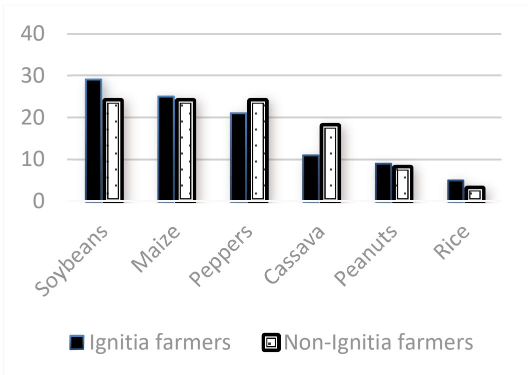

Fig. 2. Crops benefits of climate information

According to farmers, the main crops that have benefited from the use of the climate information forecasts are soybeans, maize, peppers, cassava and peanuts (Fig. 2). Majority of Ignitia farmers noticed that climate information helps them to make better use of seeds, fertilizers and pesticides by sowing, applying inputs and harvesting at the right time, either before or after the rain. For example, a farmer can cancel his crop-spraying program or delay seeding as soon as he receives a rain forecast for the next day or 24 hours. Climate information enable farmers to adapt to changing climatic conditions. These results are aligned with the study by Nkiaka *et al.* (2019) which indicated that farmers often need information that applies to their specific needs. Furthermore, the increasing recognition of climate information is due to its importance in the climate change adaptation through farmers' decision making and resilience building (Hansen *et al.*, 2019). However, the potential benefits of climate information can be realized if it is accessible, accurate, and relevant for the farming decision making (Muema *et al.*, 2018). Facilitating farmers' access to regular and reliable climate information could help them to easily handle climate events they have been witnessing. Farmers' testimonies below illustrate this point.

M. Chabi, a farmer testimony

"For example, this year, I did not resow and used around 15 kg of maize seed per hectare, because I received Ignitia climate information. But before Ignitia, two years ago, I used almost 45kg of the same maize seed for one hectare because of several reseeding operations. Climate information has enabled me to sow at the right time, so I don't have to resow and save seed".

Ms. Flore, a farmer testimony

"Ignitia message allows me to plan my day and decide what activities I must do each day. I can tell you, Ignitia climate information helped me a lot to save money, since I choose to engage in farming activities at the right time and this contributes to decrease my farming expenses".

Yield of main crops

Comparing crop yields, the results showed that Ignitia farmers recorded higher yields than non-Ignitia farmers (Table 4). The difference was 1279kg/ha (30%) for peppers, 280kg/ha (22%) for maize, 255 kg/ha (20%) for soybeans, 185kg/ha (17%) for peanuts and 1498kg/ha (13%) for cassava. These results revealed an increase in crop yield of the Ignitia farmers over the non-Ignitia. In addition, the two-sample t-test is significant (P≤0.001) and shows that the use of climate forecast information has a positive impact on the crop yields (Table 5). This increasing trend is confirmed by the testimony of M. Paul, an Ignatia farmer.

Table 4. Yield of main crops

	Crop yield (kg/ha)				
Farmers	Pepper	Maize	Soybean	Peanuts	Cassava
Ignitia	4290	1275	1280	1095	11698
Non-Ignitia	3011	995	1025	910	10200
Difference kg/ha	1279	280	255	185	1498
Difference %	30	22	20	17	13

Table 5. Differences in average yields (Kg) of different crops with 'Two-sample t test'

Farmers	Crops				
	Pepper	Maize	Soybean	Peanut	Cassava
Ignitia	4290.04^{i} (±244.25)	1275.025^{c} (±80.68)	1280.05^{a} (±63.39)	1095.04^{g} (±95.26)	11698.33^{e} ±403.39)
Non Ignitia	3011.00^{j} (±113.82)	995.00^{d} (±56.97)	1025.08^{b} (±37.69)	910.00^{h} (±62.61)	10200.00^{f} (±504.76)

Note: Different letters in exponents of the average yields of a same crop in a same column express a significant difference at 1% with the Two-sample t test.

"As a farmer, I can assure you that we all farmers, in this village, who receive climate information, are unanimous on the fact that our production has evolved compared to last year. Our production yields have increased because of the climate information we receive".

These results are similar to those found by Onyeneke *et al.* (2022) in Nigeria where the use of climate information in farming planning activities significantly increased the crops yields. Benefits of using climate information were revealed in reduced crop loss, increased yield as well as improved household income and food security (Nkiaka *et al.*, 2019; Matere *et al.*, 2023). By using climate information, farmers can exploit climate opportunities by increasing their productivity and make informed decisions to better manage uncertainty related to climate risks and adaptation measures (Machingura *et al.*, 2018). However, attributing changes in crop yield to climate information only is often challenging since farmer decision-making is complex and may be based on several factors such as producers' attitude to risk, insurance, environmental policy and scale of adoption (Tall *et al.*, 2018).

Conclusion

This study sought to understand the farmers' experiences on the use of climate information forecast in Benin. As a result, farmers perceived the highest negative climate effects on their farming activities. Consequently, farmers relied mainly on the climate information forecast through Ignitia SMS service, informal network, local radio and extension workers to adjust their calendar of farming activities. Rainfall forecasts, seasonal forecasts, temperature forecasts and drought forecasts are respectively the most frequent climate information that farmers received. This information is received by Ignitia farmers every day (45%), 3 to 4 days a week (58%) and 1 to 2 days a week (67%), while 7% and 12% of non-Ignitia farmers received it respectively 3 to 4 days a week and 1 to 2 days a week. Climate information provided by Ignitia SMS service is more regular than other sources. Soybeans, maize, peppers, cassava and peanuts are the main crops that have benefited from the use of the climate information forecasts. By comparing crop yields, the results showed that Ignitia farmers recorded higher yields than non-Ignitia farmers. The study revealed that the use of climate forecast information has a positive impact on the crop yields and proved the vulnerability differences between Ignitia users and non-Ignitia users. It also demonstrated the farmers' need for climate information in the process of adaptation planning and actions. This study could serve as a basis for evidence for policymakers to address climate change impacts on the farmer's level.

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