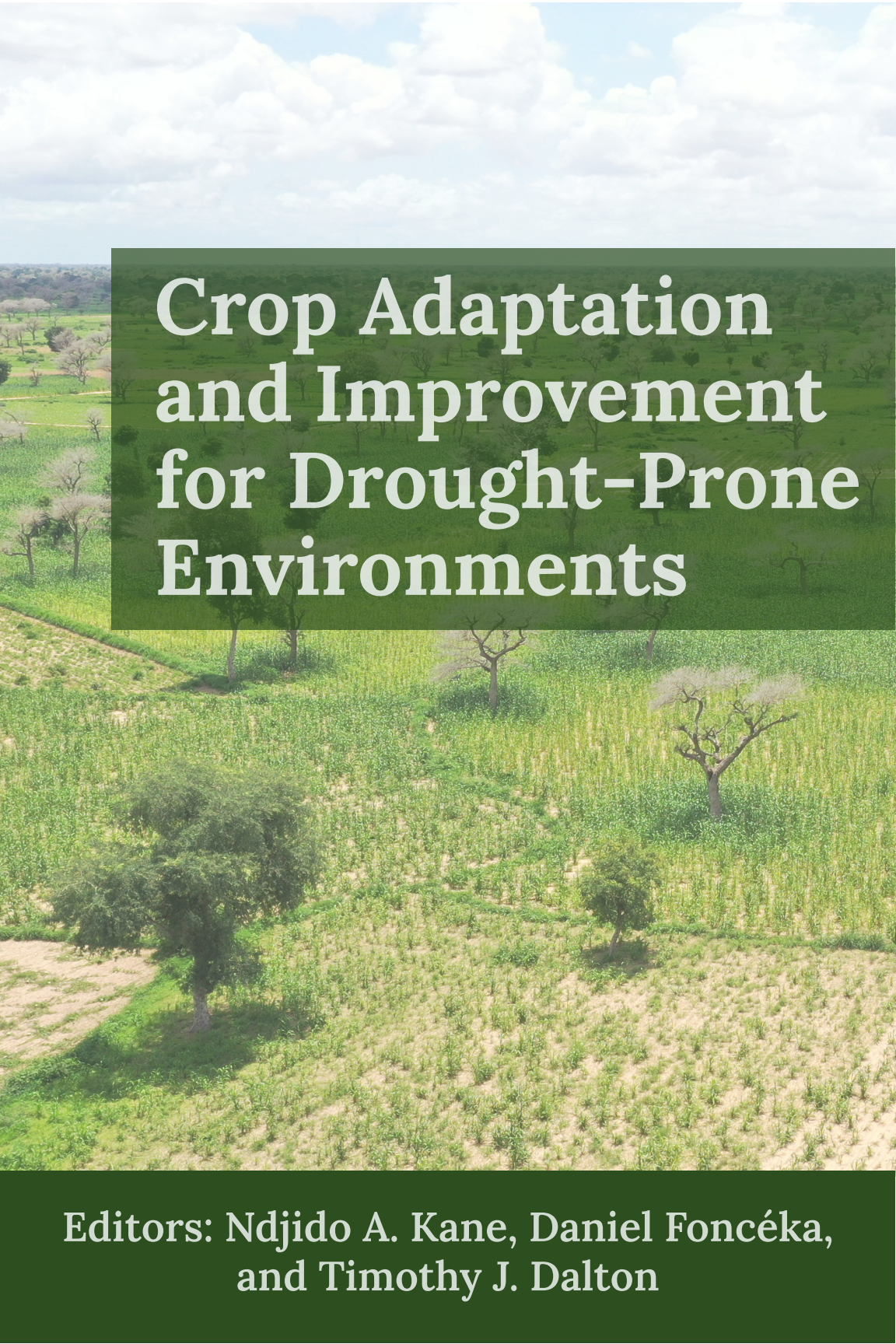

Crop Adaptation and Improvement for Drought-Prone Environments

Editors: Ndjido A. Kane, Daniel Foncéka, and Timothy J. Dalton

Cover image courtesy of: Alain Audebert (CIRAD), August 2021.

Famers fields with millet and groundnut grown in rotation in a *Faidherbia albida* park located in the Groundnut Basin (Niakhar, Senegal).

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PART I

SOCIO-ECONOMIC ANALYSIS OF DRYLAND CROPS PRODUCTION

5. Economic Risks and Uncertainties in a Context of Climate Change: Teachings on the Use of Information Systems in the Senegalese Groundnut Basin

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Abstract

This chapter aims to show the benefits of systematically using information systems as a basis for agricultural decisions and strategies in the Senegalese groundnut basin. The research involved two surveys conducted by ISRA/Bame in 2016. The first, which focuses on market information, was conducted on a sample of 105 cowpea farmers who use the *Yeugglé* Market Information System (MIS) to obtain information on the current price in the markets of Diourbel, Bambey, and Fatick from weekly telephone messages. The second, based on a sample of 82 farmers in the regions of Diourbel, Kaolack, and Kaffrine, focuses on Climate Information (CI). The approach is based on a statistical analysis of variables related to the influence of market

and climatic information on production, marketing, and agricultural input investment decisions. The results show that for 49% of farmers, market information influences their choice of markets. For most farmers (85%), market information influences the decision of sale, period, and allows farmers to make trade-offs in time and space. Regarding climate information, the results show that 67% of respondents use it and that the national meteorological service is the main provider (52%), followed by the radio (6%), and the *Yeugglé* platform (4%).

Keywords: Information system, risks, groundnut basin, climate change, Senegal

Introduction

In economics, "the principle of rationality means that individuals act by making the best use of the resources available to them, given the constraints they face" (Simon, 1965,). However, the rationality of agents basing their decisions only on prices and maximizing the difference between the value of inputs and the value of outputs is not a reality. In fact, agents do not and cannot behave in a way that maximizes utility, but instead adopt strategies that consider cognitive limits (i.e., the limits encountered in the knowledge and processing of information). Rationality is therefore linked to information mastery (Fraval, 2000).

According to neoclassicists, the "market game" allows economic agents to coordinate the best possible individual decisions. Indeed, economic and social activity is often characterized by situations where the well-being of an economic agent depends, not only on their own actions, but also on the decisions of other agents. Being aware of the existence of this type of interdependence, everyone takes it into account and incorporates it into their decision-making (Fraval, 2000).

In the agricultural sector, production and marketing decisions are often dependent on the level of information available to farmers. For that reason, Senegal, like most of the countries in the Sahel, has had a few Market Information System (MIS) experiments beyond that of the Food Security Commission (CSA), which was set up in the 1980s. These MISs, both public and private, do not all have the same objectives or targets. The channels and

frequencies of information dissemination may differ as some use traditional channels (e.g., radio, word of mouth) while others use second generation channels to transmit information through the website and/or cell phone.

In the groundnut basin of Senegal, cowpea producers use the *Yeugglé*[1] MIS to obtain information on the product's price. This MIS, like others, broadcasts weekly information on cowpea prices in the markets of Diourbel, Bambey, and Fatick via telephone short message services (SMS). It is managed by the cowpea sector table set up by the Support Program for Agricultural Sectors (PAFA). Like other MIS's, cowpea prices are collected weekly at urban and rural markets (Ngom, 2018).

Another experiment was developed on a large scale in the Groundnut Basin (which includes Diourbel, Fatick, and Kaffrine) in 2016 on the use of Climate Information (CI) and the impacts that it could have on farm management and more specifically on securing income. To this end, representatives of the PAFA network attended a training session on the concept of climate-smart agriculture with a particular focus on climate products.

This information impacts producers' production and marketing decisions, even if they also face the risk and uncertainty inherent in agricultural activity. Indeed, risk and uncertainty are two fundamental notions for understanding the strategies of rural households in Sub-Saharan Africa, particularly Senegal. They are so important that uncertainty is omnipresent in this context, whether it relates to climatic conditions, crop pest problems, the internal functioning of commodity chains (i.e., production, transport, marketing) or product prices. This raises the question of what influence the use of information can have on the economic decisions of producers? These decisions have the sole aim of maximizing their utility (i.e., consumers) or their profit (i.e., firms).

Overall, this chapter aims to show the benefits of using information systems in decision-making and on agricultural strategies of the farms in the Senegalese groundnut basin.

This chapter is structured as follows: first, we will analyze the influence of market information use on cowpea farmers' economic decisions. Next, we

focus on access to and use of climate information by farms. Finally, following the conclusion, we provide recommendations.

Methodology

1. Sample

Three communes were chosen: Ndinguiraye (Bambey), Ndindy (Diourbel), and Niakhar (Fatick). In total, 14 villages belonging to these three communes benefit from the *Yeugglé* information system. We adopted a sampling rate of 50% to randomly select 7 villages through stratification by village. In each village, 15 producers were randomly selected. Thus, a group of 105 cowpea producers using the *Yeugglé* MIS were surveyed.

1.1 Market Information

We conducted a survey targeting cowpea producers in the Senegalese groundnut basin with a sample made up of cowpea producers who use the *Yeugglé* information system. This system is managed by the cowpea commodity chain sector setup within the framework of the Support Program for Agricultural Sectors (PAFA). Like other MISs, cowpea prices are collected weekly at the markets—mainly the markets of Diourbel, Bambey Serère, Ndiguiraye, and Gaouane—and are distributed by SMS to the producers of this commodity chain sector, which has become a national framework for sector consultation.

1.2 Climate Information

With regard to climate information, the complexity and heterogeneity of the farms as well as the size of the study area led us to adopt a "multi-stage" sampling methodology, which consists of consecutive stages developed to arrive at the selection of basic observation units (i.e., farms) where the requirements of representativeness are respected. A reasoned choice was made for the selection of the PAFA zone as well as for the villages, which

were dictated by the option of the millet/sorghum and sorrel (bissap) sectors, the focus of the PAFA. For the farms, all the members who participated in the training sessions were retained, as well as those with extensive experience in climate information at the Kaffrine level. The trainings were organized for the representatives of the PAFA network to share with them the concept of climate-smart agriculture with an emphasis on climate products. These were three-day workshops that trained farmers, defined the needed products, and identified a framework for transmission of climate information. These were held in Diourbel for the northern Groundnut Basin area and in Kaolack for the southern Groundnut Basin, with each workshop bringing together about 20 producers.

Our sample consisted of 82 farmers in three regions (Diourbel, Fatick and Kaffrine) as presented in Table 1. For the controls (i.e., no training in climate information), they were chosen at random from similar villages.

Table 1
Type of Actor

Region	Type of Actor				Total
	Participated in the Training	**Extensive Experience on CI**	**No Training but CI**	**No Training and No CI**	
Diourbel	14	4	2	0	20
Fatick	17	2	11	9	39
Kaffrine	9	13	0	1	23
Groundnut Basin	40	19	13	10	**82**

Source: Author based on ISRA/BAME survey data, 2016. Farmers answered a questionnaire with three modules: farm characteristics; access, use and appreciation of climate information; and usefulness of climate information.

1.3 Approach Analysis

The approach is based on a statistical analysis of variables related to the influence of market and climate information in production, marketing, and agricultural input investment decisions. Additionally, as far as climate information is concerned, the comparative analysis of these two sites will

make it possible to: (i) define the added value of the adoption of climate information by farmers; (ii) observe how it can be integrated with other CSA technologies or practices; and (iii) identify the factors that facilitate or limit the diffusion of these technologies and practices.

Teachings on the Influence of MIS Use on Cowpea Farmers' Economic Decisions

1. Market Information Does Not Always Influence the Point of Sale

For half of the cowpea producers (51%), the market information received does not influence the choice of the market where to make the sale. The reason given is the lack of means of transportation and the related costs to be borne. On the other hand, for 49% of the producers, this information influences the place of sale because it allows them to sell at more remunerative prices. Thus, as Egg et al (1996) points out, MIS are supposed to enable producers to make special trade-offs.

2. Market Information Guides the Timing of Sales

For the vast majority of cowpea producers (85%), the market information received influences the time of sale. Actually, the sale is made when the price of cowpea on the market is remunerative, showing that MIS allows farmers to make trade-offs by considering their opportunities. However, for 15% of producers, the time of sale is not influenced by the information received, but depends on social needs and to a lesser extent on the lack of storage infrastructure, hence the need to continue to focus on storage infrastructure for better management of opportunities.

3. Cowpea Price Trends in Reference Markets Drive Pricing

For the majority of cowpea producers (62%), market information influences their choice of selling price. The decision to sell is not made without first knowing the price trends of cowpeas in reference markets, which has a positive impact on their bargaining power vis-à-vis traders who are considered to be better informed. For slightly more than a third (38.1%), market information does not influence the selling price because producers generally engage in tied or loyalty transactions to avoid the risk of not finding any buyer for their produce. The uncertainty that results from the way a farmer finances their campaign can also influence the price. It can include the rising cost of capital, interest rate, limited availability, and degree of creditworthiness (Wade, 2009).

4. Privileging Group Sales Means that Market Information Does Not Influence the Quantity to be Sold

Market information does not influence the choice of the quantity to sell for most cowpea producers (75%). The reason given is that generally the sale of the crop is not done in a sequential manner but rather grouped together, which avoids post-harvest losses. On the other hand, for nearly 25% of these producers, market information influences the choice of the quantity to sell. The quantity sold is greater when the price is high. Conversely, it is low when the price is not remunerative. In other words, the higher the price, the greater the incentive for producers to sell a large quantity.

5. Market Information Influences the Choice of Crop

Market information influences the majority of producers (56%) in their choice of crop. It allows them to cultivate the crops for which prices are the most remunerative, beyond millet, which is a food crop in this zone. In fact, more and more food crops are being sold on the markets, which is why it

is important to be able to identify the most profitable crops for the zone in order to have a substantial cash income to meet the family's financial needs. Indeed, when the price of a good increases, suppliers are encouraged to increase their supply in order to increase their profit.

6. Market Information Influences the Choice of Plot Size

For the vast majority of cowpea producers (82%), market information influences the choice of plot size. Depending on the prices of the crops observed on the markets during the past raining season and during the dry season, producers decide to increase or maintain a given plot size for a given crop for the next season. This decision is influenced by market risk and environmental uncertainty. In fact, being in a situation of uncertainty, farmers favor flexibility by minimizing the investments (i.e., monetary or in time) that they devote to production. In the event that the crops are effectively destroyed, the loss of investment will be less important with this posture than if the feared event were not to occur (i.e., as if it were a certain universe). In a certain (favorable) universe, producers can safely make the investments required to maximize their production, which they know from the outset will be good at harvest time (Fraval, 2000).

7. Market Information Influences the Decision to Invest in Agricultural Inputs

For most cowpea farmers (94%), market information influences the decision to invest in agricultural inputs. Thus, producers prefer to invest in agricultural inputs for which prices are much more remunerative. In other words, prices guide producers towards the use of production factors. Nevertheless, they face production uncertainty because agriculture is affected by many uncontrollable events that are often related to climatic conditions (i.e., excessive or insufficient rainfall, extreme temperatures, hail), as well as diseases and pests. These factors have a direct impact on the quantity and quality of production (Wade, 2009). Such influences create an

increase in the quantity of inputs used (58%) and with particular attention paid to the quality of inputs used (34%)

Access and Use of Climate Information

1. ANACIM: The Main Provider of Climate Information

The information on the climatic and meteorological forecasts are broadcasted every day by the National Agency of Civil Aviation and Meteorology (ANACIM) via radio and television. Their information includes temperature, rainfall, and humidity. Sometimes, if there are abnormal situations in sight (i.e., strong wind, heavy rains, etc.), the weather service alerts producers, and even fishermen, so that they can make arrangements. However, as part of its collaboration with projects in certain areas, particularly in Kaffrine, in addition to training, ANACIM broadcasts weekly climate information during production periods, particularly the rainy season, via radio and SMS. The forecast period is generally 1, 3, and 10 days.

In the groundnut basin, 67% of producers are accustomed to receiving climate information (Table 2). ANACIM is the main provider of this information (52%), a trend that can be explained by the presence of the CCAFS project in the area since 2010, which instilled in farmers the importance of using climate information. Various annual training sessions and the ANACIM's sharing of seasonal forecasts have finally convinced farmers, who have confidence (94%) in the information provided by ANACIM. This confidence is owed to the accuracy of past forecasts. However, 5% still do not trust ANACIM and 1% do not follow its information.

Besides ANACIM, the radio, with 6%, ranks second because of its widespread use in rural areas. The *Yeugglé* platform (4%), however, is becoming increasingly important, particularly in Diourbel, where ¾ of the "highly experienced CI" group get their information the platform, especially after it integrated climate information into its services. These services are followed by the decentralized services of the Ministry of Agriculture, the sector tables (PAFA), television, and traditional news, each with 1%. Thus, the

sharing of climate information is more important when there is a regrouping of actors during training workshops or other meetings.

Table 2
Habit of Receiving Climate Information

Region	Type of Actor	Habit of receiving climate information?							
		No	Yes						
			Source						
			Agriculture	ANACIM	Yeuglé Platform	Cowpea Sector Platform	Radio	Television	Traditional Information
Diourbel	Participated in the Training	29%	–	57%	–	7%	7%	–	–
	Extensive Experience on CI	–	–	25%	75%	–	0%	–	–
	No Training but CI	100%	–	0%	–	–	0%	–	–
	No Training and No CI	–	–	–	–	–	–	–	–
Fatick	Participated in the Training	12%	–	82%	–	–	0%	6%	–
	Extensive Experience on CI		–	100%	–	–	0%	–	
	No Training but CI	64%	–	9%	–	–	18%	–	9%
	No Training and No CI	89%	–	11%	–	–	0%	–	–

Region	Type of Actor	Habit of receiving climate information?							
		No	Yes						
			Source						
			Agriculture	ANACIM	Yeuglé Platform	Cowpea Sector Platform	Radio	Television	Traditional Information
Kaffrine	Participated in the Training	11%	11%	67%	–	–	11%	–	–
	Extensive Experience on CI	15%	–	77%	–	–	8%	–	–
	No Training but CI	–	–	–	–	–	–	–	–
	No Training and No CI	100%	–	–	–	–	–	–	–
Sample		33%	1%	52%	4%	1%	6%	1%	1%

Source: Author based on ISRA/BAME survey data, 2016.

2. Community-Based Learning Promotes the Use of Climate Information

The use of climate information is generally community-based, especially for the two groups that "attended the training" and "had a lot of experience on CI." In short, these trainings, in addition to providing climate information, promote dialogue between actors for better decision making and especially for knowledge sharing. In contrast, for the other two groups—"no training but CI" and "no training and no CI"—the use of climate information is individualized with little sharing at the community level (Table 3).

Among those who received climate information (whether they were involved in the program or not), 84% actually used it. In Diourbel and Fatick, all of those who received climate information used it, while in Kaffrine, only 11% of those in the "attended the training" category did not. Several reasons were given by the latter, including not having received the information, not trusting the information because of its randomness, and that the information was not in the local language.

Table 3
Use of Climate Information

Region	**Type of Actor**	**Did you use the climate and weather information you received to conduct your campaign?**		
		Yes	No	Not Received
Diourbel	Participated in the Training	93%	0%	7%
	Extensive Experience on CI	100%	0%	0%
	No Training but CI	100%	0%	0%
Fatick	Participated in the Training	100%	0%	0%
	Extensive Experience on CI	100%	0%	0%
	No Training but IC	82%	9%	9%

Region	Type of Actor	Did you use the climate and weather information you received to conduct your campaign?		
		Yes	No	Not Received
	No Training and No CI	11%	0%	89%
Kaffrine	Participated in the Training	89%	11%	0%
	Extensive Experience on CI	100%	0%	0%
	No Training and No CI	0%	0%	100%
Sample		84%	2%	13%

Source: Author based on ISRA/BAME survey data, 2016.

3. More Information Means More Choices on Crops and Varieties

Climate information has enabled farmers to better orient their agricultural activities, including the choice of crop (48%), the variety to be sown (35%), and what was needed to complete the cycle and the sowing periods (12%). Producers, through their experience, have some knowledge of the crops or varieties that are best suited to the given seasonal forecast. Sometimes they ask agricultural advisors for information. At this point, they can choose to plant more peanuts than another crop, for example. Thus, we note that climatic information allows farmers to implement a strategy in relation to their agro-climatic environment. Indeed, farmers would like to have information on the nature of the rainy season (54%), and therefore its course (seasonal forecast), along with the duration of the season (25%). In addition, they would also like to have daily information on rainfall in order to have better control over resource allocation. Finally, 1% would also like to have information at the beginning of the rainy season (Table 4).

Table 4
Types of Use of Climate Information

Region	Type of actor	Types of use of climate information						
		Crop Selection	Variety Selection	Plot Preparation	Ploughing Period	Sowing/Seeding Period	NPK Application Period	Weeding/ Hoeing Period
Diourbel	Participated in the Training	54%	39%	0%	0%	8%	0%	0%
	Extensive Experience on CI	50%	50%	0%	0%	0%	0%	0%
	No Training but CI	50%	50%	0%	0%	0%	0%	0%
Fatick	Participated in the Training	18%	65%	0%	6%	12%	0%	0%
	Extensive Experience on CI	0%	0%	50%	0%	50%	0%	0%
	No Training but CI	22%	11%	0%	0%	44%	11%	11%
	No Training and No CI	100%	0%	0%	0%	0%	0%	0%
Kaffrine	Participated in the Training	100%	0%	0%	0%	0%	0%	0%
	Extensive Experience on CI	77%	23%	0%	0%	0%	0%	0%
	No Training and No CI	–	–	–	–	–	–	–

Region	Type of actor	Types of use of climate information						
		Crop Selection	Variety Selection	Plot Preparation	Ploughing Period	Sowing/Seeding Period	NPK Application Period	Weeding/ Hoeing Period
Sample		48%	35%	1%	1%	12%	1%	1%

Source: Author based on ISRA/BAME survey data, 2016.

4. Consent to Pay (WTP) for Climate Information

All farmers in the area have heard of weather and climate information. Almost all (99%) agree with the usefulness of climate information, but 1% of them, and particularly the "no training and no CI" category (11% in Fatick), still doubt the usefulness of this tool. This doubt can be explained by attachments to traditional practices, but also by a lack of information on this tool.

As for the effective use of climate information for agricultural activities, we see the same trend with an affirmative response for the Kaffrine and Diourbel zones. However, in Fatick, 10% of the "no training but IC" category and 55.6% of the "no training and no IC" category claim not to have used weather information in their production. Thus, it would be interesting to know if farmers are willing to spend money to have this information.

5. Experience in Using Weather Information Favors Producers' WTP

The willingness to pay for weather information is quite ambiguous even though a slight majority (58%) are willing to pay for it (Table 5). However, the category with a large experience in CI is the most willing to pay for weather information, perhaps due to the experience these producers had in using climate information over the years. The "participated in the training" and "no training but IC" categories are also in favor of payment, but a significant portion (between 40 and 45%) remain hesitant to pay.

Table 5
Willingness to Pay for Climate Information

Region	Type of Actor	Are you willing to pay for weather information for your farming operation?	
		Yes	No
Diourbel	Participated in the Training	57.1%	42.9%
	Extensive Experience on CI	75%	25%
	No Training but CI	50%	50%
Fatick	Participated in the Training	58.8%	41.2%
	Extensive Experience on CI	100%	0%
	No Training but CI	50%	50%
	No Training and No CI	56.6%	44.4%
Kaffrine	Participated in the Training	56.6%	44.4%
	Extensive Experience on CI	61.5%	38.5%
	No Training and No CI	0%	100%
Sample		58%	42%

Source: Author based on ISRA/BAME survey data, 2016.

Two main reasons may explain this trend: not knowing payment methods (44%) and lack of means (44%) (Table 5). We also note the weak structuring of farmers' organizations (7%) and others who think they can get the information through their acquaintances (4%) (Table 6).

Table 6
Reasons Given for Not Paying for Climate Information

Region	Type of Actor	Main reasons for not wanting to pay for climate information			
		Availability of other sources to capture information	Lack of knowledge of payment methods	Lack of resources	Lack of organized structure
Diourbel	Participated in the Training	0%	25%	50%	25%
	Extensive Experience on CI	0%	100%	0%	0%
	No Training but CI	–	–	–	–
Fatick	Participated in the Training	13%	38%	50%	0%
	Extensive Experience on CI	–	–	–	–
	No Training but CI	0%	0%	67%	33%
Kaffrine	No Training and no CI	0%	67%	33%	0%
	Participated in the Training	0%	50%	50%	0%
	Extensive Experience on CI	0%	60%	40%	0%
	No Training and No CI	0%	100%	0%	0%
Sample		4%	44%	44%	7%

Source: Author based on ISRA/BAME survey data, 2016.

Farmers are willing to pay for different products: seasonal forecast, decadal information, daily information, and for agrometeorological advice (Table 7). Respondents in the "extensive CI experience" and "participated in the training" categories are the most willing to pay for all of these products, especially in Kaffrine. Reasons why include the fact that prices fluctuate

greatly and this variability is explained by the fact that the service is not well appreciated.

As noted above, the information that is really sought concerns the nature of the rainy season, its duration, and other daily information. The vectors for accessing this information are quite diversified but focus on the latest generation of communication tools (e.g., SMS, email, telephone, television, etc.) and information provided through the sharing workshops. Depending on the area, the actors, and the communication channel selected, the prices offered vary in relation to their income level. Thus, farmers understand the importance of climate information for the proper conduct of their agricultural activities and are willing to invest in this tool to secure their production.

Table 7
Types of Climate Information and Willingness to Pay

Region	Type of Actor	Types of Ready-to-pay Climate Information	Minimum Price	Average Price	Maximum Price
Diourbel	Participated in the Training	Seasonal Forecasts	100	167	280
		Decadal information	100	125	150
		Daily information	50	50	75
		Agro-meteorological advice	100	150	200
	Extensive Experience on CI	Seasonal Forecasts	25	50	70
		Agro-meteorological advice	2000	2500	2500
Fatick	Participated in the Training	Seasonal Forecasts	500	750	750
		Daily information	200	300	500
	Extensive Experience on CI	Seasonal Forecasts	18	20	23
		Daily information	15	20	25
		Agro-meteorological advice	500	500	1000
	No training but CI	Seasonal Forecasts	667	833	1000
		Decadal information	1750	1875	2000

Region	Type of Actor	Types of Ready-to-pay Climate Information	Minimum Price	Average Price	Maximum Price
Kaffrine	No Training and No CI	Daily information	500	600	600
	Participated in the Training	Seasonal Forecasts	1900	2650	4000
		Decadal information	513	765	1025
		Daily information	500	500	1000
		Agro-meteorological advice	750	1000	1500
	Extensive Experience on CI	Seasonal Forecasts	2168	3188	3821
		Decadal information	353	228	541
		Daily information	38	58	58
		Agro-meteorological advice	2365	751	3504
	No Training but CI	Decadal information	1000	1000	1000
	No Training and no CI	Daily information	500	600	600

Source: Author based on ISRA/BAME survey data, 2016.

Conclusion

This chapter aimed to show the benefits of using information systems in decision-making and on agricultural strategies of the farms in the Senegalese Groundnut Basin using surveys conducted in that basin. The methodological approach conducted statistical analysis of variables related to the influence of market and climatic information on production, marketing, and agricultural input investment decisions.

The analyses show that for almost half of the cowpea producers (49%), this information influences their choice of markets. For most cowpea producers (85%), the market information received also influences the decision of when to sell the crop. This allows producers to make trade-offs in time and space.

For the majority of cowpea producers (62%), market information influences their choice of selling price. However, it does not influence the choice of the quantity to sell for most cowpea producers (75%). For more than half of the cowpea producers (56%), market information influences the choice of which crop to grow. In addition, market information influences the choice of plot size and the decision to invest in agricultural inputs for 82% and 94% of cowpea producers respectively.

The analyses show that climate information has enabled various actions to be taken to ensure that agricultural activities run smoothly. The availability of climatic information has made it possible to better orient the choice of crops and the sowing period, as well as the preparation of soil and the period for spreading fertilizer. In addition, the majority (67%) of respondents are accustomed to using climate information, and ANACIM (52%) is the main provider of this information, followed by the radio (6%) and the *Yeugglé* MIS (4%). The use of climate information is generally community-based and is effectively used by 84% of those who have received it. This climatic information allowed farmers to choose the crop to be cultivated (48%), the variety to be grown (35%) in order to complete the cycle, and the sowing periods (12%). Thus, almost all (99%) agree that climate information is useful, but only a small majority (58%) agree to pay for it. The main reasons given were not knowing how to pay (44%) and lack of means (44%).

However, the price of the product is not the only criterion influencing producers' economic decisions. They are also confronted with the risk and uncertainty of markets and environmental factors. Agricultural activity depends on climate, cultivation practices, government policies, and global markets, all of which have a definite impact on agricultural supply in the long and short terms. However, there is no optimal reference situation that agents can use to take measures that will allow them to get closer to that optimal situation. With respect to uncertainty, the producer can seek to: i). transfer it by concluding a purchase or sale contract; ii). limit its effects by choosing several complementary productions, in order to stabilize income through diversification; iii). reduce it by improving knowledge of the environment, by resorting to futures markets for example. (Wade, 2009). Thus, the producer adopts mechanisms that Robison and Barry (1987) describe as managerial.

In terms of recommendations, we propose: an extension of agricultural

information systems to all agro-ecological zones. This information system will consider all the information needed by the actors in the value chain (i.e., market information, climatic, and agronomic information). It will also be necessary to promote the establishment of consultative frameworks to discuss information and technologies related to climate change and their repercussions for the development of agro-sylvo pastoral activities (agriculture, livestock and forestry).

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ENDNOTES

[1]*Yeugglé* means to inform in *wolof*.