Austin Journal of Business Administration and Management

Open Access

Austin Publishing Group

Review Article

Climatic Anticipation of Dry Cereal Producers in the Groundnut Basin of Senegal

Pape Bilal Diakhaté[1*]; Moussa Sall[1]; Mor Ngom[1]; Djiby Dia[1]; Birahim Bouna Niang[2]; Mouhamadou Dieye[3]

[1]Institut Sénégalais de Recherches Agricoles, Bureau d'Analyses Macroéconomiques, BP 3120 – Dakar, Sénégal

[2]Faculté des Sciences Économiques et de Gestion, Université Cheikh Anta Diop de Dakar (Sénégal)

[3]Institut Sénégalais de Recherches Agricoles, Bureau d'Analyses Macroéconomiques, BP 3120 – Dakar, Sénégal

***Corresponding author:** Pape Bilal Diakhaté

Institut Sénégalais de Recherches Agricoles, Bureau d'Analyses Macroéconomiques, BP 3120 – Dakar, Sénégal.

Email: dpapebilal@hotmail.fr

Received: August 19, 2023

Accepted: October 03, 2023

Published: October 10, 2023

Abstract

The Groundnut Basin is one of six agro-ecological zones in Senegal where farmers are very affected by climate uncertainty during the rainy season. This paper examines the types of climate anticipation of dry cereal producers before the start of the rainy season. The main parameter used to determine the types of anticipation is based on climate information. Farmers are characterized according to their ability to formulate a climate forecast from climate information sources for which they have a degree of confidence. The results show that the majority of farmers formulate adaptive expectations on the climate by defining a margin of error to the received information (35.41%), while only 1.65% makes expectations without a formal source. This study suggests that insurance policies should take into account the profile of farmers in the face of climatic information, in particular the level of tolerable loss anticipated by the producer and his other socio-economic characteristics, accessibility to basic social services and the production system practiced.

Keywords: Senegal; Groundnut basin; Climate information; Anticipation; Probit model

***Classification J.E.L**: C91 – D81 – D82 – Q12*

Introduction

Climate information is an agricultural input along with seeds, fertilizers, and equipment that form the basis of production [1]. Its importance is justified by the uncertain nature of the climate and the strong dependence of agricultural production on rainfall. Indeed, since 1996, the Sahel has been marked by alternating wet and dry years (Agrhymet, 2013). In Senegal, climate forecasts show an average temperature variation that ranges from of +1.1°C to 1.8°C. During extreme rainfall periods average temperature varies between -30% and +30% by 2035 (Republic of Senegal, 2015b). This climate variability affects the level of production and particularly dry cereal yields. Indeed, from 1980 to 2015, the agricultural sector has experienced at least eleven (11) major climatic shocks that occurred on average every three to four years and resulted in irregular growth in production (Republic of Senegal, 2015a). These shocks resulted in losses of more than 5% of the gross value of production every third year, on average, due to natural hazards. Production losses during years of extreme rainfall can be three to four (4) times higher (Republic of Senegal, 2015a). The decline in cereal production recorded between 2012 and 2014 was 12% and 17% between 2010 and 2014.

However, an institutional mechanism has been created to facilitate the appropriation of climate information by farmers. The National Agency for Civil Aviation and Meteorology of Senegal (ANACIM) and the Multidisciplinary Working Group (GTP) are key players in the production and dissemination of climate information. This information is disseminated to producers on request, but also through community radio stations and institutional and village relays. The village relays also set up demonstration fields allowing a comparison of yields obtained using traditional information sources with those resulting from strategies based on climate data during the preceding three months. In 2014, seasonal forecasts predicted a very late start of the season around August 10 in many places, a situation not seen since 1966. Despite this, the results showed an increase in yields between 85% and 100% for millet, 66% and 140% for groundnut and cowpea (Republic of Senegal, 2015a). This is attributable, among other things, to the use of climate forecasts that prompted the authorities to launch an emergency operation to distribute improved short-cycle seeds to compensate for the expected deficit in cereal production (ANACIM, 2015). These seeds, granted by the state, are those received by households that contributed to the rural tax. The use of climate information by farmers reduces the uncertainly associated with decisions of crops to selection, the variety of seed, land preparation, planting date, weeding practices, use of herbicides and pesticides (Hansen and al. 2004).

Citation: Diakhaté PB, Sall M, Ngom M, Dia D, Niang BB, et al. Climatic Anticipation of Dry Cereal Producers in the Groundnut Basin of Senegal. Austin J Bus Adm Manage. 2023; 7(2): 1063.

Despite the importance of climate information and its good perception by farmers, the number of producers using it is still low (ANACIM, 2014). This situation is explained by access difficulties, on the one hand, and the existence of several sources of climate information, on the other hand (PARM, 2017). In addition, in areas where the access is easy, it is noted that the information does not arrive on time, that is, the desired time for the producer [2].

In the presence of several sources of climate information, the choice of the producer is oriented towards the one for which he/she has more confidence. Indeed, agricultural producers do not place the same degree of importance on their information sources. Some give priority to meteorology, while others use it only as an indication, and tend to compare it with their own traditional knowledge and individual convictions. In addition, the actor does not seem to be able to change his disposition regarding his production decision insofar as each additional piece of information is likely to modify his choice because it partially calls into question his point of view. In this respect, questions such as: "What is the level of climatic information of farmers? "or "How much confidence do they have in this information?" become necessary for to understanding expectations in front of the climate change. The answers to these questions allow us to understand to what extent a farmer decides to adopt or not an adaptative strategy to face of climate change.

To answer to these questions, this study seeks to determine the type of climate anticipation strategy adopted by farmers in the Senegalese Groundnut Basin by identifying the main sources of climate information, and the form of climate anticipation as this relates to socioeconomic characteristics.

The hypothesis of this work is that membership in a producer group increases the probability of using climate information. Thus, within a group, individuals can modify the state of knowledge of others thereby influencing decision making and facilitating change and thus lead them to adopt certain new behaviors.

After a conceptual development of the notion of anticipation in decision making, we will present the analysis framework, the results and the conclusion.

Economic Development of the Notion of Anticipation in Decision Making

The neoclassical model has shown its limits in decision-making in a world under uncertainty. Indeed, neoclassical analysis considers that the producer and the consumer can anticipate exactly the result of their choice because they are supposed to have the perfect information at the time of the decision and are capable of analyzing it (Menger (1840-1921), Jevons (1835-1882) and Walras (1834-1910) [3-5]. However, neoclassical analysis encountered two main obstacles, namely the "irrationality" of economic agents and the imperfect information [6].

Economic literature considers “anticipation” as individual representations, more or less informed, of random future events (Myrdal, 1931). Models of decision-making in an uncertain universe emphasize the importance of information in improving the quality of anticipations (Kast, 2002). As such, each additional piece of information is likely to reduce the uncertainty of the decision maker (Cayatte, 2009). Economic theory distinguishes three types of anticipation. The first, known as "naive anticipation", is observed when the agent relies solely on information from the previous year and believes that it will be exactly the same in the current year and the following years (Chavas, 1999). The simplest way to represent "naive anticipation" is to consider that tomorrow will be identical to today. However, this representation has the disadvantage of describing myopic behavior [7]. Thus, agents are not interested in their past mistakes to improve their present and future. There is therefore no adaptation process.

The second form of anticipation is called adaptive or "quasi-rational". It occurs when the actor makes anticipations by taking into account the mistakes made in previous years (Nerlove and Fornari, 1998). This hypothesis requires a gradual learning process on the part of the decision-maker, who must necessarily take the past into account.

Thus, actors do not include in their forecasts, the future events they expect with certainty. Similarly, the development of adaptative anticipations leads to systematic forecast errors even in situations where they have been well identified. A third type of anticipation is known as "rational" anticipation. These anticipations are observed when the decision-maker uses all the information at his disposal to determine the future value of a variable (Lucas, 1970). In this model, anticipations are made as if future events were known by the agents. In other words, in the absence of surprises, the assumption of rational anticipations is equivalent to the assumption of perfect foresight on the part of agents (Devoluy, 1998).

In this study, the concept of anticipation was considered in terms of the use of seasonal climate information disseminated by traditional and modern sources and the degree of confidence given to this information. Thus, the margin of error given to the source of information allows us to characterize farmers who make "adaptive" and "rational" anticipations.

Framework for Analysis

Study Area

This work was carried out in the Groundnut Basin of Senegal located in the semi-arid part of the country with an estimated population of 6,409,201 inhabitants, i.e. 47% of the territory's inhabitants. The rainy season lasts three months (from July to September) with isohyets ranging from 400 to 500 mm in the north and 800 to 900 mm in the south. However, the duration of the rainy season is highly volatile due to uncertainty regarding the actual beginning start of the rains (Diop, 1996).

The main activity in the Groundnut Basin remains agriculture. This zone includes 52% of the country's farming households and most of the cultivated area (ANSD, 2015). The proportion of farming households practicing rainfed agriculture in the Basin represents 57% of the 87.1% estimated at the national level (ANSD, 2015). The regions that make up the Basin provide 35% of the country's cereal production and accounts for 62% of the national area devoted to cereal crops (ANSD, 2015). Despite the importance of cereal crops, observed yields (0.70 tons/hectare) remain below the national average (1.23 tons/hectare in 2015).

Three regions were chosen according to their level of aridity. These are the Louga region, an arid north, with average rainfall levels close to those of the Niayes [8] (200 mm); the Kaolack region, a semi-arid center, with rainfall levels between 400 and 600 mm; and the Kaffrine region, a humid south, close to Tambacounda, where the rainfall recorded per year exceeds 600 mm (Figure 1).

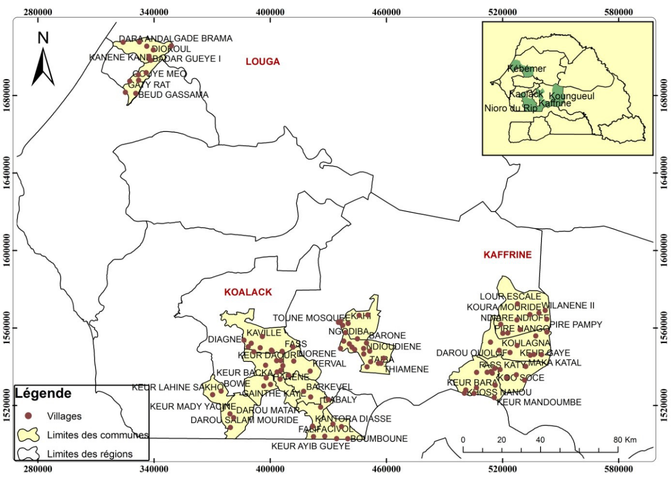

Figure 1: Regions, departments and selected villages in the study.

Analysis Method

The analysis method used is based on two approaches: a descriptive analysis of the types of anticipation and an econometric estimation of the probability of using climate information.

Descriptive analysis method of types of anticipation: The descriptive analysis categorizes farmers according to the type of anticipations they formulate. The main parameter used to determine the type of anticipation is based on climate information. In fact, in the farmers' anticipation process, four types of profiles appear that are distinguished from each other, according to three criteria. In the first criterion, the farmer is classified according to his ability to formulate anticipation on the climate. Next, he defines the main source of his anticipations. And, finally, the farmer gives the degree of confidence granted to the source. Thus, we have:

− A first form of anticipation that distinguishes the type of farmer who has no idea about the future evolution of the climate. For these producers, the future cannot be anticipated by "human rationality". These agents are considered to be individuals who are not interested “in climate information”;

− A second form of anticipation is inspired by the work of Metzler (1941) and the definition of "myopic" behaviour. Thus, the selected producers are those who consider that the climate of the current season will be exactly the same as the previous season, without any source of meteorological or traditional information. Indeed, the only references for these actors are the characteristics of the climate during the previous season. These farmers make "naïve" anticipations ;

− A third type of anticipation that highlights farmers who are able to give an idea of the future evolution of the climate based mainly on a reference source of climatic information that they consider to be less certain (Cagan, 1956). Thus, they incorporate uncertainties (errors) from the main information source into their anticipation. This type of farmer adopts an "adaptive" anticipation because he considers that the information on the climate includes errors that must be taken into account;

− A fourth category of anticipation is related to farmers who, beyond their ability to anticipate the climate of the current season from a main source of information, place a high level of confidence in the source. These producers make "rational" anticipations. They are sure of their forecasts because they integrate all of the elements deemed key to their anticipation (Lucas, 1972).

Box: Questions asked to determine types of anticipation

For this purpose, three main questions were progressively asked:

(i) What do you think about the current climate crop year compared to the previous one?

For this question, 4 modalities are possible: No idea, Better, Same or Bad. If the answer is No idea, it is concluded that the farmer is not interested in climate information. But if the answer is about the other modalities, we ask the second question:

(ii) What is your main source of information?

For this question, 2 modalities are possible either the producer has No source or he indicates his main source. If he does not have a source, this is a naive anticipation. In the case where he specifies a source, we ask him a third question:

(iii) How much confidence do you have in this source?

For this question, 2 modalities are possible. Either he does not have much confidence in this source, so the anticipations are adaptative or he is confident in the source, so we speak of rational anticipation.

Specification of the multinomial logit model : regression in types of anticipation: The choice of the type of anticipation obeys an order. The use of climatic information in the choice of anticipation makes it possible to establish this order of magnitude. Indeed, producers have the choice between different alternatives with a predefined order based on the use or not of climate information. The choice of one type of anticipation over another can be estimated by the multinomial logit model. This model is part of a polytomous representation system used when the qualitative variable to be explained has more than two modalities. This model has the advantage of being less computationally intensive and do not requires the test of the non-violation of the independence of irrelevant alternatives hypothesis (Cramer and Ridder, 1991) whereas other polytomous probit models are more computationally demanding.

The multinomial logit model is specified in this work as follows :

Let a farmer i formulate an anticipation on the climate of the current season. This anticipation is made at the beginning of the wintering season. Farmer i then has four alternatives (j=0, 1, 2 and 3) previously explained (no anticipation, naive, adaptive and rational). The model is then written :

$$Y_{ij} = \beta' z_{ij} + \varepsilon_{ij} \quad (1)$$

- The decision whether or not to formulate an anticipation Y_{ij} depends on the individual characteristics of producer i (z_{ij}) and a random error term (ε_{ij}) that takes into account other unobservable factors. Thus, the dependent variable Y_{ij} takes the following values j J = 0 if the farmer does not make anticipation,

- J = 1 if the farmer makes a naïve anticipation,

- J = 2 if the farmer makes a adaptative anticipation,

- J = 3 if the farmer makes a rational anticipation.

The multinomial logit model allows to estimate the probability of the 3 modalities with respect to a modality taken as reference. We thus propose to estimate the probabilities of j=1,

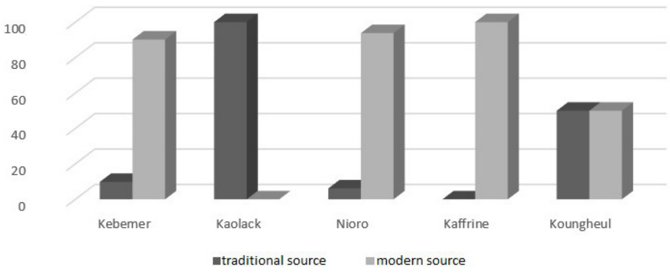

Figure 2: Proportion (%) of producers who have climate information sources by department.

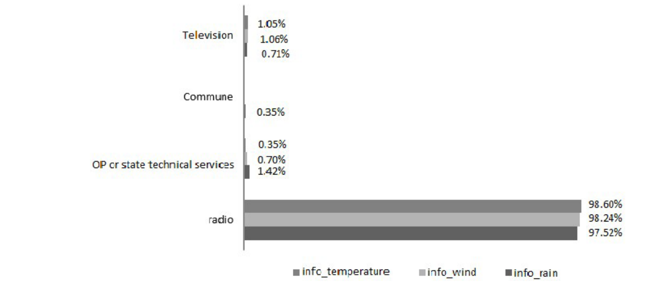

Figure 3: Proportion of producers who used modern source of climate information channels**.**

2 or 3 in reference to the modality j=0.

In the logistic model, the random errors are assumed to follow a logistic distribution. Thus, with the maximum likelihood estimator, it is possible to estimate the sign of the parameters β and to calculate the relative risk ratios that measure the contribution of each variable in the model compared to the reference model.

The expression(z_{ij}) is a vector composed of three groups of variables : (i) 'Farmer' characteristics, (ii) 'Geospatial or location' and (iii) 'Farming System' characteristics. These variables were identified from the literature and the others are included to take into account the specificity of the study area (Ryler, 2014). Empirically, the final model is written as:

$$\begin{aligned}
&Anticipation_{ij}\\
&= \theta_0 + \text{"Farmer" characteristics } (\theta_1 Victim\ of\ climate\ change_{ij} + \theta_2 Tolerable\ loss\ production_{ij}\\
&+ \theta_3 Membership\ in\ a\ group_{ij} + \theta_4 Initial\ investment_{i}j)\\
&+ \text{"Geospatial or location" } characteristics\ (\theta_5 Distance\ village\ field_{ij}\\
&+ \theta_6 Presence\ of\ village\ less\ than\ one\ kilometer_{ij} + \theta_7 Presence\ of\ market\ less\ than\ one\ kilometer_{ij})\\
&+ \text{Farming System" } characteristics\ (\theta_8 Ownership\ of\ small\ ruminants_{ij} + \theta_9 Growing\ groundnuts_{ij}\\
&+ \theta_{10} Growing\ millet_{ij} + \theta_{11} Growing\ sorghum_{ij} + \theta_{12} Growing\ cowpea_{ij}) + \varepsilon_i \quad (2)
\end{aligned}$$

These explanatory variables are the ones most often cited in the literature concerning the use of climate information (Ouedraogo et al. 2018). Other socio-economic variables were included (location and farming system) but they made the model insignificant.

Description of model variables: The variables selected are of three types: i) the dependent variable, which is categorical, is composed of 4 modalities explained above by the index j. For the independent variables, ii) some are continuous and iii) others are bi-variate or "dummy". The continuous variables can all take positive values while the dummy variables are coded 1 and 0. The nature of the variables and the label of the qualitative variables are given in the following table.

Data

The sampling frame was obtained from the « Senegalese Association for Promotion of Development [9] and the Network of Peasant and Pastoral Organisations of Senegal [10]». These two organizations work with producer associations, cooperatives, Non-Governmental Organizations (NGOs), economic interest groups and producer federations to improve the living conditions of rural people, mainly through agriculture This choice was made to test the hypothesis defined in this study.

The sampling was done in four steps. First, the regions were selected by reasoned choice according to their degree of aridity. Then, according to the importance of cereal production, the departments were selected. Then, the villages were selected according to the size of the population and their coverage by a producers' organization. Finally, farmers are randomly selected in each village.

The proportion of farmers who are members of producer organizations varies according to the regions studied. It is esti-

Table 1: Nature of the variables included in the model.

	Type of variables	Modality of the variable	Label of the modalities
DEPENDANT VARIABLE			
Anticipation	categorical	0	*No anticipation*
		1	*Naïve anticipation*
		2	*Adaptative anticipation*
		3	*Rational anticipation*
EXPLANATORY VARIABLES			
Farmer characteristics			
Victim of climate change	dummy	0	non
		1	oui
Tolerable loss production	continue		
Membership in a group	dummy	0	non
		1	oui
Initial investment	continue		
Geospatial or location			
Distance village field	continue		
Presence of village less than one kilometer	dummy	0	non
		1	oui
Presence of market less than one kilometer	dummy	0	non
		1	oui
Farming system			
Ownership of small ruminants	dummy	0	non
		1	oui
Growing grounuts	dummy	0	non
		1	oui
Growing millet	dummy	0	non
		1	oui
Growing sorghum	dummy	0	non
		1	oui
Growing cowpea	dummy	0	non
		1	oui

mated at 15% in the Kaolack region, 14.2% in the Kaffrine region and 5% in the Louga region. Thus, to maximize the sample size, a proportion of 15% of the total population is retained. To this end, with a confidence level of 95% and a margin of error of 3%, the size obtained is 545 farmers for a probabilistic survey model (Table 1). Data collection was conducted in July 2015 over a period of one month.

Results

The use of climatic information allows the best possible production decisions to be made in a context of climate variability. For example, a producer who anticipates a shortage of rainfall can choose to plant short-cycle seed varieties or diversify his production. The climatic information used comes either from modern source or traditional forecasting systems (traditional source). This information is disseminated through various channels.

Modern Source is the Main Source of Climate Information

Farmers used the modern source as the main source of climate information (56.70% of farmers). Among those who used climate information, 72.42% preferred modern source of climate information and 27.58% used the traditional source. However, the modern source was not used in the same way everywhere. While the departments of Kébémer, Nioro and Kaffrine recorded very high usage rates, at 90.18%, 93.83% and 99% respectively, producers in the Kaolack area made more use of traditional forecasting systems, with about 99% of producers using them. However, farmers in Koungheul used both sources equally (Figure 1). It should be noted that the climatic information concerns seasonal forecasts (3 months) made before the start of the raining season.

In general, modern information sources predict rain, temperature, and wind while traditional sources are interested in rain and extreme climate events that may occur during the season including drought and floods. The forecast model from the modern source of climate information is based on observed pre-winter sea temperatures, whereas the traditional sources are based on dreams or behaviour of certain animals and plants.

Radio is the Principal Channel for Disseminating Modern Source of Climate Information

The channel most used by farmers to transmit modern source of climate information is the radio, representing 97% of producers (Figure 2). The other sources are rarely used. for example, producers used producer Organizations (OP) and state technical services to get climate information, accounting for 1.5%. However, for television and the communes, the information collected is very low.

Comparing among traditional sources, rainfall anticipations were made mainly by observing the behavior of birds and other animal species (65.42%) (Figure 4). On the other hand, for information on wind, farmers obtained information from village elders (66.7%) and from observing the wind at the beginning of the season (23.53%). Similarly, for temperature, farmers turned mainly to village elders, i.e. 66.67% of actors who used indigenous knowledge.

Farmers Give a Margin of Error to Their Main Source of Climate Information

Although climate information is well regarded by producers, there are errors in the information. Farmers do not have complete confidence in the various sources of climate information. In fact, they trust modern source of climate information more than traditional ones. The results show that about 65% trust the modern source of climate information compared to 56% trust traditional sources (Figure 4). Difference tests show a significant difference between those who place more confidence and those who place less confidence in both traditional and modern sources with a margin of error of 0%.

Even if Good Rainfall Years Follow a Cycle, Producers' Anticipations are Mostly Adaptive

Rainfall in the Groundnut Basin is very volatile from one year to the next. It is generally rare to observe two successive good winter seasons. In fact, 92% of farmers consider that good rainfall years have a cycle of three (3) out of five (5) years. On average, 2.035/5 years of periodicity.

Furthermore, the observations show a high percentage of farmers who are not interested in climate information, whether

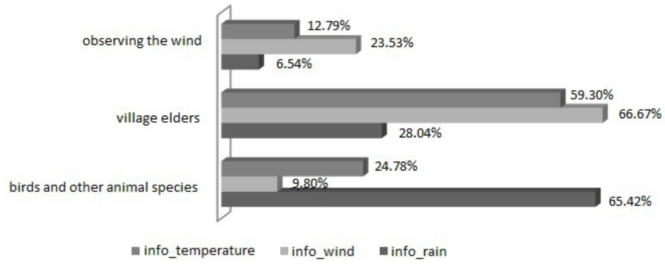

Figure 4: Proportion of producers who used traditional information dissemination channels.

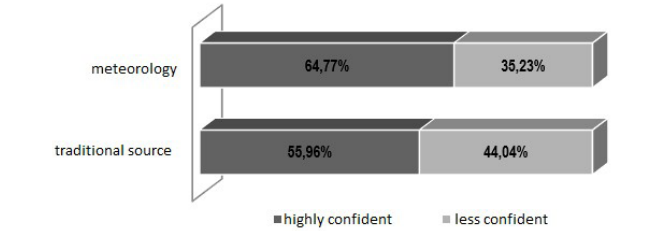

Figure 5: Confidence level of climate information sources.

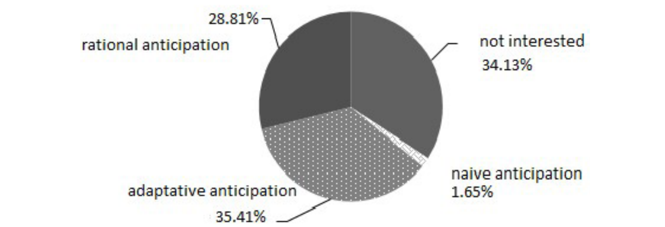

Figure 6: Classification of farmers according to their type of anticipation.

traditional or modern, i.e. 34.13% of producers. In addition, for those farmers who used climate information, the majority made adaptive anticipations, 35.41% (Guido et al. 2020). The percentage of producers formulating rational anticipations represents only 28.81% of the sample. The lowest level was observed among farmers who made naïve anticipations, i.e., 1.65% of producers (Figure 5).

Farmers who have formulated "rational expectations" and those who have not formulated any expectations are the most optimistic about the climate. For them, rainfall has a cycle of 3/5 years, i.e. 38.57% for the "rational" anticipators and 36.62% for those who are not interested in climate information. This situation shows that even if some agents are not able to anticipate the climate, their optimism leads them to envisage the future as if they had all the information available.

Table 2: descriptive statistics of the variables retained in the 4 models.

	N	mean	sd	min	Max
NO ANTICIPATION					
Farmer characteristics					
Victim of climate change	186	0.86	0.35	0	1
Tolerable loss production	186	40.87	45.37	0	100
Membership in a group	186	0.46	0.50	0	1
Initial investment	186	7697.86	16042.86	0	100000
Geospatial or location					
Distance village field	186	1.57	0.60	1	5
Presence of village less than one kilometer	186	0.50	0.50	0	1
Presence of market less than one kilometer	186	0.04	0.19	0	1
Farming system					
Ownership of small ruminants	186	0.76	0.43	0	1
Growing grounuts	186	0.85	0.36	0	1
Growing millet	186	0.86	0.35	0	1
Growing sorghum	186	0.30	0.46	0	1
Growing cowpea	186	0.09	0.29	0	1
NAIVE ANTICIPATION					
Farmer characteristics					
Victim of climate change	9	0.78	0.44	0	1
Tolerable loss production	9	11.33	15.80	0	50
Membership in a group	9	0.56	0.53	0	1
Initial investment	9	9000.00	12903.49	0	35000
Geospatial or location					
Distance village field	9	1.67	0.50	1	2
Presence of village less than one kilometer	9	0.56	0.53	0	1
Presence of market less than one kilometer	9	0.00	0.00	0	0
Farming system					
Ownership of small ruminants	9	0.67	0.50	0	1
Growing grounuts	9	1.00	0.00	1	1
Growing millet	9	1.00	0.00	1	1
Growing sorghum	9	0.22	0.44	0	1
Growing cowpea	9	0.11	0.33	0	1
ADAPTATIVE ANTICIPATION					
Farmer characteristics					
Victim of climate change	193	0.60	0.49	0	1
Tolerable loss production	193	17.80	23.19	0	100
Membership in a group	193	0.43	0.50	0	1
Initial investment	193	16730.57	31736.38	0	285000
Geospatial or location					
Distance village field	193	1.55	0.63	1	5
Presence of village less than one kilometer	193	0.67	0.47	0	1
Presence of market less than one kilometer	193	0.11	0.31	0	1
Farming system					
Ownership of small ruminants	193	0.48	0.50	0	1
Growing grounuts	193	0.88	0.33	0	1
Growing millet	193	0.83	0.37	0	1
Growing sorghum	193	0.08	0.27	0	1
Growing cowpea	193	0.21	0.41	0	1
RATIONAL ANTICIPATION					
Farmer characteristics					
Victim of climate change	157	0.69	0.47	0	1
Tolerable loss production	157	15.04	20.75	0	100
Membership in a group	157	0.55	0.50	0	1
Initial investment	157	16692.68	25631.63	0	140000
Geospatial or location					
Distance village field	157	1.47	0.51	1	3
Presence of village less than one kilometer	157	0.62	0.49	0	1
Presence of market less than one kilometer	157	0.04	0.19	0	1
Farming system					
Ownership of small ruminants	157	0.68	0.47	0	1
Growing grounuts	157	0.77	0.42	0	1
Growing millet	157	0.89	0.31	0	1
Growing sorghum	157	0.06	0.23	0	1
Growing cowpea	157	0.13	0.34	0	1

Exploratory Analysis of the Variables Retained in the Four Models

When distinguishing between the four categories of anticipation, it appears that the tolerable production loss in percentage and the pre-campaign investments show high standard deviations. This is due to the fact that these values have not been reduced to a per hectare basis. However, even if these values are not calculated in units of hectare, their variation gives key information on the differences in behaviour between types of anticipators. For example, it is observed that tolerable production losses decrease as producers become more interested in climate information. Also, pre-campaign investments are greater for producers who use climate information in their anticipation

With regard to the characteristics of producers, the statistics show a variation according to the level of anticipation. Indeed, apart from membership of a producer group, all other factors are discriminating factors in the type of anticipation. For example, being a victim of climate change and the level of tolerable loss decreases as the producer improves his anticipation. This result shows that the use of climate information is perceived as an adaptation and resilience strategy in the face of climate variation. Furthermore, we find that the location variables do not reflect a true trend in expectations. This absence of trend can be explained by the fact that anticipation is first of all an individual will before being collective in the sense that two producers can live in the same neighbourhood and have different behaviours with regard to the use of climate information.

In addition, the production system, particularly the possession of small ruminants, seems to be a discriminating factor in anticipation choices. This difference can be explained by the fact that small ruminants are more mobile than cattle and as such can move on their own to find food in rainfall deficit situations. These statistics on production systems also show that producers cultivate the same crops regardless of the type of anticipation (Table 2).

Significance of Factors in the Four Anticipation Models Reveals a Trend

The statistics presented in the table above do not allow us to know whether the factors are discriminating in relation to the type of anticipation. The individual tests of the coefficients in their respective equations offer more precision on the individual contribution of the factors to the choice of anticipation (Appendix 1). Thus, on the "producer characteristics", the significance tests show that only membership of a producer group is not significant in the four models selected. Similarly, the results of the tests on "location or geospatial" show that the village-field distance variable is not significant in the four models. In addition, cowpea cultivation is the only 'production system' variable that is not significant in all four equations. However, the test of these variables in their respective groups shows a significant contribution, which demonstrates that they have been well specified in the group (Appendix 2). These tests of the individual significance of the variables within their group or in the equations do not provide sufficient information on the profile of the anticipators, which is a simultaneous combination of several factors.L'analyse descriptive, dont l'approche est purement statistique produit des résultats et des implications qui sont loin d'être définitifs. Il s'agit d'une tentative de validation empirique. L'analyse économétrique qui suit offre une base plus formelle de tests de ces hypothèses.

Table 3: Econometric estimation of coefficients and RRR.

	Estimates of coefficients			Estimates of RRR		
Type of anticipation	Coef.	St.Err.	Sig	rrr	St.Err.	Sig
NO ANTICIPATION						
NAÏVE ANTICIPATION						
Farmer characteristics						
Victim of climate change	-0.54	0.91		2.80	0.89	***
Tolerable loss production	-0.03	0.02	*	1.03	0.00	***
Membership in a group	0.32	0.71		0.99	0.26	
Initial investment	0	0		1	0	***
Geospatial or location						
Distance village field	0.09	0.62		1.16	.24	
Presence of village less than one kilometer	0.81	0.73		0.42	0.12	***
Presence of market less than one kilometer	-13.95	1697.7		0.40	0.21	*
Farming system						
Ownership of small ruminants	-0.26	0.8		3.63	1	***
Growing grounuts	14.17	1066.3		0.60	0.23	
Growing millet	14.24	1063.9		0.84	0.31	
Growing sorghum	-1.28	0.88		9.1	3.54	***
Growing cowpea	0.68	1.23		0.53	0.21	
Constant	-30.49	1506.3		0.26	0.16	**
ADAPTATIVE ANTICIPATION						
Farmer characteristics						
Victim of climate change	-1.03	0.32	***	1.63	1.46	
Tolerable loss production	-.025	0.00	***	0.99	0.02	
Membership in a group	0.012	0.26		1.36	0.96	
Initial investment	0	0	***	1	0	
Geospatial or location						
Distance village field	-.153	0.21		1.28	0.80	
Presence of village less than one kilometer	0.872	0.28	***	0.94	0.68	
Presence of market less than one kilometer	0.927	0.53	*	0	0.00	
Farming system						
Ownership of small ruminants	-1.289	0.27	***	2.79	2.21	
Growing grounuts	0.504	0.38		863151.93	9.204e+08	
Growing millet	0.176	0.376		1281089.2	1.363e+09	
Growing sorghum	-2.208	0.389	***	2.54	2.32	
Growing cowpea	0.634	0.402		1.05	1.28	
Constant	1.337	0.598	**	0	0	
RATIONAL ANTICIPATION						
Farmer characteristics						
Victim of climate change	-0.8	0.33	**	1.26	0.33	
Tolerable loss production	-0.03	0.00	***	0.99	0.00	
Membership in a group	0.465	0.265	*	1.58	0.37	*
Initial investment	0	0	***	1	0	
Geospatial or location						
Distance village field	-0.47	0.227	**	0.73	0.15	
Presence of village less than one kilometer	0.74	0.28	***	0.87	0.22	
Presence of market less than one kilometer	-0.23	0.63		0.31	0.16	**
Farming system						
Ownership of small ruminants	-0.45	0.29		2.31	0.56	***
Growing grounuts	-.40	.35		0.41	0.13	***
Growing millet	.80	.40	**	1.85	0.65	*
Growing sorghum	-2.56	.44	***	0.70	0.33	
Growing cowpea	-.03	.43		0.52	0.18	*
Constant	1.38	.62	**	1.04	0.55	
Mean dependent var		1.589	SD dependent var		1.226	
Pseudo r-squared		0.204	Number of obs		545	
Chi-square		257.70	Prob > chi2		0.000	
Akaike crit. (AIC)		1091.57	Bayesian crit. (BIC)		1272.20	

***Notes**: *** p<.01, ** p<.05, * p<.1*

Econometric Estimates of the Types of Anticipation Adopted by Producers

The regression of the independent variable "anticipation" is done with a multinimal logit model. The "no anticipation" group is taken as a reference. The other groups or models such as "naive anticipation", "adaptive anticipation" and "rational anticipation" are interpreted according to the reference group.

Estimation of coefficients: For naive expectations, only the tolerable production loss variable is negatively significant at 8.5%. This reflects the fact that producers who make a "naive expectation" are less willing to lose production than producers who make "no expectation".

The estimation of the 'adaptive anticipation' versus 'no anticipation' equation shows that being a victim of climate change, the level of tolerable production losses, ownership of small ruminants and sorghum cultivation practice are negatively significant. In other words, these variables tend to encourage the adoption of 'adaptive expectations' more than 'no expectations'. On the other hand, the amount of pre-campaign expenditure, the presence of a village within one kilometre and the presence of a market within one kilometre of his field are positively significant. This shows that producers who do not 'anticipate' are more remote and isolated. They devote less budget to preparing for the wintering season than producers who make an 'adaptive anticipation'.

The estimation of the 'rational anticipation' model compared to those who do not 'anticipate' reveals that being a victim of climate change, the level of tolerable production losses, the distance between the village and the farmer's field and the practice of sorghum cultivation are significantly negative. In other words, farmers who 'anticipate rationally' are those who are less affected by climate change, tolerate production losses less, live in villages close to their fields and grow sorghum less. Furthermore, the results show that membership of a producer group, pre-campaign expenditure, the presence of a village within 1 kilometre and the practice of millet cultivation are positively significant. These results imply that those who do not 'anticipate' are less involved in producer organisations, spend less on winter season preparation, are in isolated villages and practice less millet cultivation than those who 'adaptively anticipate'.

The coefficient estimates show that the characteristics, location and cropping system practiced by the producer contribute to improving expectations. However, the coefficient test does not provide any information on the level of contribution of the explanatory variables.

Estimation of the Relative Risk Ratio (RRR): The contribution of the variables is given by the Relative Risk Ratio (RRR). This ratio indicates the variation of one unit of factor for a given type of anticipation (j ranging from 1 to 3) compared to the "no anticipation" model (j=0) given that the other factors in the model are held constant. The RRR is interpreted in relation to 1 which means that there are no effects. To know if the RRR is different from 1, we refer to its probability. The estimates of the relative risk ratio show that if the producer sets a tolerable unit of output loss his chances of making an "adaptive anticipation" increase by 1.03. It is noted that the RRR does not have much effect on 'adaptive anticipations' compared to the 'no anticipation' model. On the other hand, group membership and millet cultivation increase the farmer's chances of making a 'rational anticipation' by 1.58 and 1.85 respectively.

Conclusion

i. In the choice of anticipation types, the consideration of tolerable losses plays an important role. Producers who try to minimise their production losses tend to use more climate information services to improve their decision-making. This producer characteristic, combined with the amount of money spent in the pre-campaign, membership of a producer group and being a victim of climate change, tends to increase producers' use of climate information. On the other hand, the distance from the field is a handicap for the producer, reducing the time he spends canvassing for better climatic information, but also reducing access to agricultural services. In addition, the possession of small ruminants, which are more mobile and adapt better to climatic variations, does not allow the producer to improve his level of climatic information. On the other hand, the production of millet and sorghum increases the level of climatic information used by the producer. Indeed, these two crops are most often used as human or animal food by rural households. As such, farmers prefer to ensure a secure food supply by using climatic information to define the plot and variety that provide this level of food security. The results confirm our hypothesis that group membership gives the farmer a better chance of accessing climate information and improving his or her anticipations. Based on the results of this work, policy implications can be considered to increase the use of climate information in the decision-making process of farmers:Improved financial inclusion of producers should enable them to increase their preseason expenditure, adopt climate change resilient strategies and at the same time reduce their level of tolerable loss. This financial inclusion is most effective when the loan is provided to members of a producer organisation.

ii. Local services or agricultural relays responsible for disseminating climatic information help to improve the anticipations made by producers. These means reduce the time producers spend prospecting by providing them with quality information on time and at a lower cost.

Like any human work, this work is not perfect. Taking into account the dynamics of climate expectations and the strategies implemented can provide a better understanding of farmers' behaviour. However, this work could help improve climate information dissemination strategies and agricultural insurance policy in Senegal by better profiling producers.

References

1. Agrhymet. Vulnérabilité de l'agriculture face à la variabilité et aux changements climatiques [workshop]. Accra, Ghana. 2013; 46.
2. ANACIM. Bull Agro-Météorologique Décadaire Situation Météorologique. 2015; 4.
3. ANSD. Recensement Général de la Population, de l'habitat, de l'agriculture et de l'Elevage. 2013; 2014. 19.
4. Cagan P. The monetary dynamics of hyperinflation. In: Friedman M, editor. Studies in the quantity theory of money. University of Chicago Press. 1956; 25117.
5. Cayatte J-L. Microéconomie de l'incertitude, Ouvertures economiques, De Boeck. 2ème ed. 2009; 254.
6. CGIAR. Agriculture intelligente face au climat au Sénégal, Considérations relatives à l'agriculture intelligente face au climat. Feed Future. 2016; 20.
7. Chavas J-P. On the economic rationality of market participants: the case of expectations in the U.S. pork market. J Agric Resour Econ. 1999; 19-37.
8. Cramer JS, Ridder G. Regroupement des états dans le modèle logit multinomial. J Économétrie. 1991; 47: 267-72.
9. Devoluy M. Théories macroéconomiques, Fondements et controverses. Paris: Armand Colin: Hal. archives-ouvertes. 1998; 24.
10. Diop M. A propos de la durée de la saison des pluies au Sénégal, Sciences et changements planétaires. Sécheresse. 1996; 1: 7-15.
11. FAO. Un système intégré d'enquêtes agricoles, Volume 1. Programme mondial du recensement de l'agriculture 2010, Développement statistiques, 11 p. Rome: Food and Agriculture Organization. GIEC. 2007.
12. Guido Z, Zimmer A, Lopus S, Hannah C, Gower D, Waldman K et al. Farmer forecasts: impacts of seasonal rainfall expectations on agricultural decision-making in Sub-Saharan Africa. Clim Risk Manag. 2020; 30: 100247.
13. Hansen JW, Marx SM, Weber EU. The role of climate perceptions, expectations, and forecasts in farmer decision making: the Argentine Pampas and South Florida: final Report of an IRI Seed Grant Project; 2004.
14. Kast R. La théorie de la décision, Nouvelle Edition. Repères. 2002; 120.
15. Lucas RE. Expectations and the neutrality of money. J Econ Theor. 1972; 4: 103-24.
16. Metzler LA. The nature and stability of inventory cycles. Rev Econ Stat. 1941; 23: 113-29.
17. Myrdal G. L'Equilibre monétaire, Paris: editions Mth. [Génin, 1950, première édition anglaise]. 1931; 1939.
18. Nerlove M, Fornari I. Quasi-rational expectations, an alternative to fully rational expectations: an application to US beef cattle supply. J Econ. 1998; 83: 129-61.
19. Ouédraogo M, Barry S, Zougmoré RB, Partey ST, Somé L, Baki G. Farmers' willingness to pay for climate information services: evidence from cowpea and sesame producers in Northern Burkina Faso. Sustainability. 2018; 10: 611.
20. PARM. Managing risk at farm level: a farmers' workbook. Rome. 2017; 35.
21. République du Sénégal. Sénégal: Evaluation des risques du secteur agricole (ASRA-II): évaluation des solutions, Ministère de l'Agriculture et de l'Equipement Rural: Document de travail. 2015a; 181.
22. République du Sénégal. Contribution Prévue Déterminée au Niveau National (CPDN), Ministère de l'environnement et du développement durable. 2015b; 19.
23. Ryley T, McKune S. Climate change and social networks in Senegal's peanut basin, CCAFS. 2014.