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Climate Hazards, Water Risks and Sorghum Farmers' Adaptation Strategies in the Semi-Arid Zone of Cameroon

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Abstract: This article deals with the problem of sorghum farmers' adaptation to climate hazards and water risks engendered by climate variability in Diamaré division in the semi-arid zone of Cameroon. The overall objective is to analyze the perceived main climate hazards and water risks as well as their consequences, then to evaluate the adaptation strategies adopted by the sorghum farmers, in order to propose ways for improving their resilience. The stratified random sampling method was used to select the sites, which consist of twenty (20) villages, and the sample, which consists of six hundred (600) farm household heads. After conducting focus-groups in ten villages and interviews with resource persons, the primary data were collected using a semi-open survey questionnaire. This study shows that the poor spatiotemporal rainfall distribution and the drought are respectively the main climate hazard and the main water risk faced by sorghum farmers in the area, with environmental, social and socio-economic consequences; It also comes out that these sorghum farmers are simply coping with the climate variability, but they do not really adapt to it; then, the lack of access to information and training about adaptation strategies, and the poverty, constitute the main constraints to the adoption of efficient adaptation strategies. In this case, improving the resilience of these sorghum farmers to climate variability must absolutely go through improving their access to agricultural innovations (especially agro-meteorological forecasting) and to training, and their socio-economic (poverty), environmental, and infrastructural conditions.
Keywords: climate variability, climate hazards, climate risks, adaptation strategies, sorghum farmers, semi-arid zone.

INTRODUCTION

This article deals with the problem of sorghum farmers' adaptation to climate hazards and water risks caused by climate variability. Almost all of the scientific works on adaptation to climate variability impacts in Africa have shown that farmers have adopted adaptation strategies [1, 2], but these adaptation strategies vary widely according to the regions and the socio-economic, environmental, and infrastructural characteristics of the farmers [3, 4]. Moreover, while it has been shown that some farmers truly adapt to this climate variability with visible and measurable impacts on the ground [5, 6], others simply cope with it [2, 7, 4, 8]. But, contrary to most of the research works which have been limited to a critical analysis of the farmers' adaptation strategies, we have analyzed these adaptation strategies in a linear relationship between the main climate hazards, the main water-induced risks, and the adaptation strategies adopted by sorghum producers; in addition, this study sought to identify the real reasons for not adopting the scientifically recognized efficient adaptation strategies. Finally, the overall objective of this research work is to analyze the main climate hazards and induced-water risks, then to assess the adaptation level of sorghum farmers to climate variability, and finally to identify the reasons for not adopting certain scientifically recognized efficient strategies, in order to make some recommendations to policy makers for the improvement of farmers' resilience.

MATERIALS AND METHODS

Choice of study area, sites and sample

The choice of the Diamaré division (Figure 1) as study area was guided mainly by the fact that it constitutes one of the largest basins (if not the largest basin) of sorghum (rainfed, dry season) production in the Far North region of Cameroon.

The selection of the sample, which was initiated from the beginning of the sites' choice, was made following the "stratified random sampling method", because of the heterogeneity of the survey universe containing the target population [9].

The identification of the mainly cultivated cereals, and the choice of the main production sites of these cereals, constitute the first stratification, while the random selection of the study sites among the identified potential ones, materializes the second stratification in the process of the sample choice. In the third phase of the process, which is the selection of the sample itself, for each of the sites, and depending on the speculation of interest (rainfed or dry season sorghum), we have drawn up an exhaustive list of all the farms' households heads that are producing in priority the speculation, with the help of the villages and neighborhoods' chiefs, assisted by the agricultural posts' heads. In each list we randomly drew thirty farms' households' heads to whom we submitted the survey questionnaire. This gives a total of three hundred (300) farms' households' heads per speculation, and a total sample of six hundred (600) farms' households' heads for the two speculations.

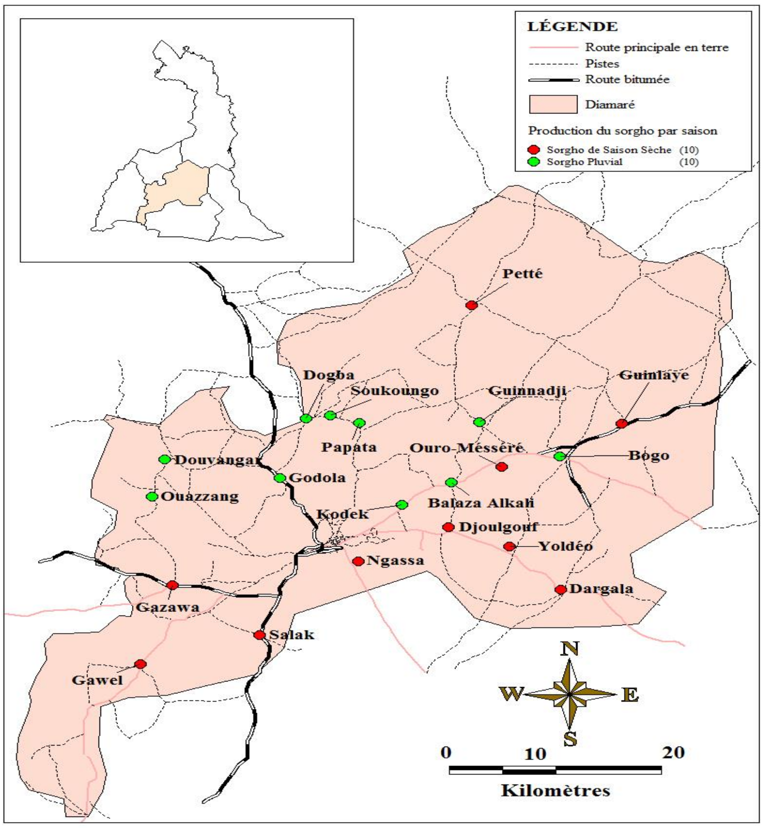

Fig-1: Study zone and sites (dry season sorghum sites in red, rainfed sorghum sites in green)

Data collection and analysis

After some interviews with a few resource persons and focus-groups in ten villages, five of them by speculation, a mixed survey questionnaire, both semi-closed and closed, was submitted to the six hundred (600) farms' households' heads.

SPSS statistical software was used to analyze the collected data. The analysis of climate hazards was focused on the analysis of their nature, their frequencies (percentages) of perception by the sorghum farmers, then their comparison with the existing three modes of action (excess, deficit, bad distribution). For the water risks, we simply identify the corresponding water risk of each listed climate hazard and then counted these risks in order to identify the main risk. The various consequences generated were implicitly deduced from the different climate hazards listed by sorghum farmers, and then analyzed on the basis of their frequencies (percentages). The adaptation strategies used were also analyzed on the basis of their endogenous or exogenous nature, their rate of adoption (frequencies, percentages), and then compared to some strategies that are universally recognized as efficient. The order of importance of the reasons for not adopting these efficient adaptation strategies was obtained using Kendall's W test of agreement.

RESULTTS AND DISCUSIONS

Climate hazards dominated by the poor spatiotemporal distribution of rains

The main climate hazards identified by rainfed and dry season sorghum farmers are summarized in Table 1 below.

Overall, Table 1 shows that sorghum production in the Diamaré division is hampered by some climate hazards that are mainly related to the characteristics and dynamics of rainfall, temperature and wind. Similarly, this table shows that sorghum production in the Diamaré division is also hampered by some extreme events such as high temperatures, hot and dry winds, and torrential and stormy rains. This result corroborates those obtained by [10, 2, 11] and then [12], which find that, overall, rainfall, thermometric, anemometric and edaphic parameters are the most used among climatic hazards listed by the peasants.

Table-1: Main climate hazards identified by sorghum farmers

Climate hazards	Rainfed sorghum		Dry season sorghum	
	Number	%	Number	%
Late or early onset of rains	235	78,33	109	36,33
Early or late cessation of rains	207	69	293	97,67
Poor spatial distribution of rainfall	178	59,33	212	70,67
More longer and frequent dry spells	255	85	220	73,33
Heavy rains (torrential rains)	102	34	253	84,33
Stormy rains	98	32,67	27	09
Overall decrease in the total amount of rainfall	240	80	296	98,67
High temperatures (rapid drying up of ponds and other water sources, rapid drying up and induration of soils)	-	-	295	98,33
Hot and dry winds (rapid drying of ponds and other water sources, rapid drying and induration of soils)	-	-	265	88,33
Light rains at the beginning of the rainy season	-	-	284	94,67
Absence of heavy rains at the end of the rainy season	-	-	278	92,67
Absence of haze during the dry and cool season	-	-	106	35,33

The analysis of these enumerated climate hazards according to their nature, indicates that they are essentially related to rainfall hazards, that means they are directly related to the dynamics of precipitations, apart from the rapid drying up of ponds and other water sources (wells, boreholes), the absence of haze during the dry and cool season, and the rapid drying up and induration of soils (which is a hazard partly related to precipitations). This result corroborates that one obtained by [13], which finds that a comprehensive enumeration of farmers' indicators shows that rainfall parameters are more numerous ; and [13], then [14], consider that it is because precipitations represent the first climate factor that conditions the realization of agricultural production, and all the different ecological and socioeconomic systems in dry zone.

Nevertheless, concerning the farmers' main climate variability indicators, while [15] have identified the dry spells, the harmattan (dry wind), the excess of heat (high temperatures), and the drying up of rivers, as key indicators, [12] identified rather the late onset of rains, the decreasing rainfall, and the floods, as the main farmers' indicators of climate variability; that means these main farmers' indicators of climate variability vary with locality, probably under the influence of the surveyed farmers' environmental, social, and socioeconomic characteristics.

The grouping of these rainfall hazards according to their three (3) scientifically known modes of action [14], namely the absence or the decrease of the precipitations, the excess of the precipitations, and their poor spatiotemporal distribution, allowed us to obtain the results mentioned in the following Table 2.

Table-2: Rainfall hazards and their corresponding modes of action

Climate hazards	Corresponding modes of action
Late or early onset of rains	Poor spatiotemporal distribution of rainfall
Early or late cessation of rains	Poor spatiotemporal distribution of rainfall
Poor spatial distribution of rains	Poor spatiotemporal distribution of rainfall
More longer and frequent dry spells	Poor spatiotemporal distribution of rainfall
Heavy rains (torrential rains)	Excessive rainfall
Stormy rains	Excessive rainfall
Overall decrease in the total amount of rainfall	Absence or decrease of precipitation
Light rains at the beginning of the rainy season	Poor spatiotemporal distribution of rainfall
Absence of heavy rains at the end of the rainy season	Poor spatiotemporal distribution of rainfall
Absence of haze during the dry and cool season	Poor spatiotemporal distribution of rainfall

The grouping of these rainfall hazards according to the previous listed three (3) modes of action indicates that:

- There is only one rainfall hazard that relates to the decrease of precipitation (general decrease in the amount of rainfall);
- There are two rainfall hazards that relate to the excessive rainfall (torrential rains, stormy rains);
- All the remaining seven (7) rainfall hazards are linked to the poor spatiotemporal distribution of the rains.
- That means a critical majority of climate hazards enumerated by sorghum farmers is synonymous with "the poor spatiotemporal distribution of rainfall", which constitutes therefore the main climate hazard they face.

The analysis of all the climate hazards according to their frequencies (percentages) of perception indicated in table 1, shows that "the late or early onset of the rains, the late or early departure of the rains, and the more frequent and longer dry spells, "which are all rainfall hazards related to ‘’the poor spatiotemporal distribution of rains", seem to be more perceived by a large number of both rainfed and dry season sorghum farmers; which means once more that "the poor spatiotemporal distribution of rains" is the main climate hazard faced by both rainfed and dry season sorghum farmers.

A synthesis of all these results indicates that the sorghum farmers of Diamaré division perceive the poor spatiotemporal distribution of the rains as being the main climate hazard that they face, and this in accordance with the scientific characterization of the climate and the results obtained from different works carried out on farmers' perception by [1, 10, 2, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25]. Moreover, the analysis of the scientific characterization of climate variability based on climate hazards carried out by [10] effectively confirms this result, since of the four (4) principal climate hazards identified, three (late onset of the rains, shortening of the rainy season, and dry spells) reflect a poor spatiotemporal distribution of rains.

Concerning the values of this spatiotemporal rainfall distribution, the estimates made by [26] show that in the Sahelian zone, these values are very high: dry spells of more than 15 days in the rainy season, differences in total annual rainfalls of more than 100 mm between two stations separated by only a few kilometers, and a variation in total inter-annual rainfalls of about 100 mm in the north and about 200 mm in the south within the same locality of the Sahel, were observed.

However, in the specific case of sorghums [27], estimates that, while the success of rainfed sorghum is conditioned by a better spatiotemporal distribution of rains throughout the rainy season, that of dry season sorghum, in addition to a good spatiotemporal distribution of rainfall throughout the rainy season requires good rainfall at the beginning and at the end of the rainy season; this result is in conformity with the last two rainfall hazards mentioned by sorghum farmers in table 2.

In conclusion to this paragraph on the farmers' perception of the main climate hazards, it appears that

The nature of the climate hazards listed by the sorghum farmers indicates that they are essentially related to rains (rainfall hazards);

The analysis of the rainfall hazards' dynamics (the most numerous) according to their three known modes of action (absence or decline, excess, poor spatiotemporal distribution), indicates that in terms of numbers, those linked to the poor spatiotemporal distribution of the rains are the most numerous;

The analysis of the whole climate hazards according to their frequencies and percentages of perception by sorghum farmers, indicates that the most perceived by both rainfed and dry season sorghum farmers are those related to the poor spatiotemporal distribution of the rains ;

On the basis of all these results, we could conclude that the sorghum farmers of the Diamaré division perceive that "the poor spatiotemporal distribution of the rains" constitutes the main climate hazard they are facing.

Water risks dominated by drought, mostly of natural origin and of meteorological nature

The search for water risks induced by the different climate hazards listed by the sorghum farmers gave the results mentioned in the following table 3.

The analysis of the "immediate impacts" induced by the set of climate hazards listed by the sorghum farmers indicates that they lead either to water deficits that are synonymous with drought or to water excesses that are synonymous with floods. That means the main water risks that are facing these sorghum farmers are mainly droughts and floods; and that in conformity with the results obtained by [28, 29, 1, 30, 5, 26, 31, 32].

Table-3: Climate hazards identified by sorghum farmers and corresponding water risks

Climate hazards	Corresponding water risks
Late or early onset of rains	Drought
Early or late cessation of rains	Drought
Poor spatial distribution of rainfall	Drought /Floods
More frequent and longer dry spells	Drought
Heavy rains (torrential rains)	Floods
Stormy rains	Floods
Overall decrease in the total amount of rainfall	Drought
High temperatures	Drought
Hot and dry winds	Drought
Light rains at the beginning of the rainy season	Drought
Absence of heavy rains at the end of the rainy season	Drought
Absence of haze during the cool season	Drought

The counting of climate hazards according to the number of water risks generated, indicates that out of twelve (12) hazards, nine (9) are likely to cause droughts (late or early onset of rains, early or late cessation of rainfall, more frequent and long dry spells, rapid drying up of ponds and other water sources, rapid drying up and induration of soils, general decrease in the total amount of rains, light rains at the beginning of the rainy season, absence of heavy rains at the end of the rainy season, absence of haze during the dry and cool season), one hazard generates both droughts and floods (poor spatial distribution of rainfall), and only two (2) (torrential rains, stormy rains) are potential factors of flooding.

That means sorghum farmers perceive through these climate hazards that "drought is the main water risk" they face in the Diamaré division; and this in accordance with the results obtained by [1, 33, 34, 35, 1] even consider that all the sahelian farmers' problems correspond to a group of "five (5) sahelian orthodoxy crises", to which they try to provide solutions, and whose main one is represented by the drought [36]. Explains this by the fact that water is the resource that limits mostly agricultural yields and this because agriculture is mainly rain-fed, and therefore dependent on rainfall conditions.

A comparison between the work of [15] on farmers' perception of the main indicators of climate variability, and those of [10] on the scientific characterization of climate variability, indicates that droughts and rising temperatures, which constitute the two indicators common to both types of perceptions, all lead to drought. That means, in terms of both farmers' perception and scientific characterization of climate variability, drought is the main water risk that sahelian farmers are facing. Likewise, according to [7], the creation of a sub-regional organization called the Inter-State Committee for Drought Control in the Sahel (CILSS) by the Sahel countries as an institutional response to the environmental crisis in the zone, constitutes a real proof that drought has until then been the main water risk for sahelian farmers.

Nevertheless, according to [7], it will be necessary to make a difference between the different regions of the Sahel, because when in the Sudano-Sahelian zone, water deficits that is to say droughts, attributable to dry sequences caused mainly by the decline and the poor spatiotemporal distribution of rains during the development of the crop, constitute the main water risk, in the Sudanian zone on the other hand, it is at the same time the combined effects of the excesses of water related to heavy rains (floods) and the succession of dry episodes (droughts) which constitute the main water risk.

The careful analysis of climate hazards that reflect the droughts, indicates that according to the typology made by [7], concerning the origin of the droughts, sorghum farmers mainly suffer from "natural drought" caused mainly by the rainfall hazards. Nevertheless, the existence of climate hazards such as "rapid drying up of ponds and other water sources" and "rapid drying up and induration of soils" indicates that it is highly likely that these sorghum farmers suffer also from drought of structural or anthropic origin.

With regard to the nature of droughts, according to the typology made by [35] and then [31], the analysis of the climate hazards listed by the sorghum farmers indicates that the main drought of which they suffer is to firstly, "a meteorological drought", since the majority of these hazards are made up of rainfall hazards. In addition to this meteorological drought, they also face a "hydrological drought" (rapid drying up of ponds and other water sources), and an "edaphic drought" (rapid drying up and induration of the soil surface).

In conclusion to this paragraph on the main water risks faced by sorghum farmers in the Diamaré division, we could say that:

- The main water risks these sorghum farmers are facing are mainly droughts and floods;
- The sorghum farmers perceive through these climate hazards that "drought is the main water risk" they face;

- and sorghum farmers suffer mainly from natural and meteorological drought;
- While rainfed sorghum farmers face meteorological and edaphic droughts, dry season sorghum farmers face meteorological, edaphic, and hydrological droughts;
- Based on all these results, we could conclude that sorghum farmers in the Diamaré division perceive that "drought" is the main water risk they face, in accordance with climate variability the scientific characterization and the results obtained by other researchers in the Sahel.

Perceived consequences of climate variability are social, socio-economic and environmental

An analysis of the climate variability consequences enumerated implicitly by sorghum farmers during the identification of the climate variability indicators gave the results mentioned in the following table 4.

Table-4: Consequences of climate variability perceived by sorghum farmers

Consequences	Frequency	%
Frequent failures of agricultural campaigns	425	70,83
Gradual extinction of old crops and crop varieties for the benefit of new ones	234	39,00
Proliferation of crop pests	354	59,00
Frequent attacks and destruction of crops by pests	329	54,83
Degradation of agricultural lands	456	76,00
Declining of agricultural yields and production	524	87,33
Decrease in the multiplication of the livestock	257	42,83
Increased frequency of famine episodes	185	30,83
Migration of farmers to other cities or villages	358	59,67

The analysis of the results in Table 4 shows that the consequences perceived by sorghum farmers include:

- Environmental consequences, such as the degradation of agricultural lands, the frequent failures of agricultural campaigns, the progressive extinction of old crops and crop varieties for the benefit of new ones, the proliferation of crop pests, the frequent attacks and destructions of crops by pest;
- Socioeconomic consequences, such as declining of agricultural yields and production, and the decline in livestock multiplication ;
- Social consequences, such as increasing frequency of famine episodes, and migration of farmers to other cities or villages.

The diversity and the severity of these consequences indicate as [38] and [39] have pointed out, that climate change through the decline and the poor spatiotemporal distribution of rains, the rise of temperatures and the consequent increase of evaporation (climatic hazards), then droughts and floods generated (water hazards), represents a serious threat to the agricultural development of the globe, especially that of the Sahelian African countries, and may jeopardize the efforts made by these countries for achieving food security; for example, in order to highlight the dreaded and fearful nature of the drought consequences [35], says that the history of drought in Western Asia reveals that Persian King Darius Scroll (522-485 BC) was praying for protection of Persia against three main things: enemies, drought, and lies.

Similarly, the consequences that are mostly perceived by these sorghum farmers are constituted respectively of the decline in agricultural production and yields (87.33%), the degradation of agricultural lands (76%), and the frequent failures of agricultural campaigns (70.83%), which are in fact logically related climate variability consequences; and this because it is scientifically proven that climate variability through land degradation, then the failure of agricultural campaigns (following poor rainfall distribution and drought) that it generates, results in the decline of agricultural production and yields, which in turn has social and socio-economic corollaries (famine, poverty, migration), according to the results obtained by [35, 31, 40].

In principle, according to [35], the social and socioeconomic consequences of climate variability correspond to the socio-economic drought, which occurs when the combined effects of all other forms of drought (meteorological, hydrological, and edaphic) lead to disastrous consequences on the population and the regional economy. That said, sorghum farmers implicitly perceive that climate variability has had direct consequences that are environmental, and indirect consequences that are social and socio-economic, synonymous with socio-economic droughts.

To summarize the overall impacts and consequences of climate variability on agriculture [41], believes that climate variability is becoming one of the major ecological challenges of the 21st century. At the African level [4], predicted that about 50-250 million Africans will be exposed to water stress by 2020, and that rainfed yields would fall by about 50% in some countries; while according to [42], Africa would host most of the malnourished population (about 75% by 2080), and in this situation, developing countries would increase their cereal imports by 10-40% in horizon 2080.

Sorghum farmers from Diamaré division cope with climate variability but do not really adapt to it

The summary of adaptation strategies used by sorghum farmers to combat climate hazards and water risks indicates that they are constituted by those indicated in the following Table 5.

The analysis of the nature of sorghum farmers' adaptation strategies to combat climate hazards and water risks in the Diamaré division permits us to make the following remarks:

- Apart from the "diversification of income-generating activities", all the other adaptation strategies used by the sorghum farmers aim to offset either the poor rainfall distribution or the meteorological, edaphic, and hydrological droughts, either to offset both the two types of constraints;
- An overwhelming majority of these adaptation strategies have been adopted to deal with meteorological drought, which is the main form of drought faced by sorghum farmers; it is followed by edaphic drought, then finally by hydrological drought;
- Despite the identification of floods as another major water risk by sorghum farmers, no adaptation strategy was apparently adopted by these ones to cope with them.

Table-5: Nature and frequency (percentage) of adaptation strategies' adoption by sorghum farmers

Adaptation strategies	Rainfed sorghum		Dry season sorghum	
	Frequency	%	Frequency	%
Sowing of early maturing ecotypes or varieties	131	43,67	175	58,33
Early sowing or transplanting	178	59,33	139	46,33
Sowing of drought resistant ecotypes or varieties	178	59,33	194	64,67
Diversification of crops' varieties	94	31,33	182	60,67
Diversification of crops	268	89,33	272	90,67
Changing of crops or crops' varieties	105	35	25	08,33
Plowing plots and / or ridging of plants	234	78	96	32
Temporary or permanent relocation of crops	170	56,67	30	10
Making of lockers or bunds	103	34,33	203	67,67
Use of soils and water conservation techniques (agroforestry, organic manure, mineral fertilization, stone bunds, crops' associations, crops' rotations, mulching)	271	90,33	82	27,33
Multiplication of weeding	123	41	20	06,67
Re-sowing /transplanting of melted or dried seedlings	166	55,33	05	01,67
Diversification of income-generating activities	195	65	141	47
Late transplanting	-	-	125	41,67
Variation of pile depth according to soil moisture	-	-	129	43
Nursery staggering	-	-	203	67,67
Organic or mineral fertilization of nurseries	-	-	107	35,67
Cleaning out of water sources (ponds, rivers)	-	-	131	43,67
Finding water over great distances	-	-	95	31,67
Fertilization of the transplanting water or the seedlings' roots	-	-	06	02

That means the overall goal of sorghum farmers' adaptation strategies is mainly to cope with the poor spatiotemporal distribution of rainfall and the droughts. Indeed, almost all the research works carried out in the African drylands on farmers' adaptation to climate variability, in particular those of [1, 2, 15, [38, 11, 5, 21, 25], directly or indirectly revealed the importance given by sahelian farmers to the poor spatiotemporal distribution of rainfall as the main climate hazard.

In this case, it could be said that the objective of these adopted adaptation strategies is noble since they were adopted mainly to cope with the poor spatiotemporal distribution of rainfall and the droughts, which constitute respectively the main climate hazard and the main water risk faced by sorghum farmers. But the question is whether these sorghum farmers really adapt to the climate variability, or they just cope with it.

An analysis of some particular characteristics of these adaptation strategies (endogenous or exogenous, adoption rate of the adaptation strategies used, rate of adoption of some adaptation strategies scientifically recognized as efficient), permits us to make the following main remarks:

- The majority of adaptation strategies used by the sorghum farmers is endogenous; exogenous strategies, especially those derived from agricultural research, are almost non-existent;

- For the majority of adaptation strategies used, adoption rates are generally low either for both the two types of sorghum, or for one type of sorghum;
- An almost complete absence of adaptation strategies that are recognized as efficient by the scientific community (modern weather forecast, community-based climate and early warning prediction, use of supplementary irrigation, collection of rainwater for irrigation during dry season, use of improved sorghum varieties, use of greenhouses, integrated adaptation approach).

In this case, with all these shortcomings observed in sorghum farmers' adaptation strategies, it could be said that they do simply cope with climate variability, but do not really adapt to it. In order to differentiate between farmers who truly adapt and those who do not adapt [1, 3] differentiate adaptation strategies between climate change coping strategies or survival mechanisms ("coping strategies"), usually on a short term, and the real "adaptation strategies", which constitute a deep change in response to the changing climate parameters. Indeed, authors such as [7, 43, 4] and then [8] found that sahelian farmers do not adapt to the climate variability but simply cope with it. This is simply because the adaptation strategies described as the best for the current and future climate variability by scientists are not used massively by these farmers. Moreover, even for the adaptation strategies that have been adopted by them, the overall adoption rates remain low; this is why [8, 4] believe that there is a lack of adaptation, because adaptation is limited and seems insufficient for the future climate change. Similarly [44, 7] also argue that sahelian farmers do not really adapt to the climate variability because they have for a long time favored the least risky and less productive agricultural practices, to the detriment of more productive but risky techniques; and therefore, these authors believe that while these adaptation strategies are effective in ensuring their survival, they severely limit development by maintaining a low production potential, even when rainfall conditions are good, which keeps these rural populations in poverty.

The analysis of statistics related to certain socioeconomic characteristics of the populations of the zone provided by [45-47], confirm these results : for example, after the 1999-2000 and 2000-2001 agricultural campaigns, 47% to 60% of households were unable to meet their food needs from their own production; similarly, according to [46], rural populations in the far-north region of Cameroon experienced between 2001 and 2007 an increase in the poverty index of 65.90%; and in view of these results, the MDG/SDG aimed at reducing extreme poverty and hunger cannot be achieved in this area. In addition, the proportion of the population living below the poverty line increased by 10 percentage points between 2001 and 2007, while in the same period, at the national level, there was a decrease of 0.3 point; the poverty gap index increased from 18.8 to 24.6 between 2001 and 2007.

Nevertheless, some authors such as [5, 6] found that, in fact, there are some sahelian farmers who truly adapt to climate variability [6] found that some communities have already proven that they can sustainably manage their natural resources and prevent degradation; and in some areas of northeastern Kenya, local adaptations have shown that they can both improve people's living conditions and at the same time protect natural resources. [5] also considered that in the Sahel, climate risk is one the most severe constraints faced by the farmers, but some communities have been able to develop empirically cultural practices and to adopt effective strategies to adapt to them.

Finally, this synthetic analysis of the adaptation strategies used by sorghum farmers leads us to two important conclusions:

- The general objective of the sorghum farmers' adaptation strategies is noble, because these adaptation strategies are aimed at adapting to the poor spatiotemporal rainfall distribution and to the drought;
- Nonetheless, because of all the shortcomings observed in these adaptation strategies, it could be said that the sorghum farmers in the Diamaré division simply cope with the climate variability, but they do not really adapt to it; and the results of the socioeconomic characteristics' analysis of these sorghum farmers constitute an irrefutable proof of this maladaptation.

The search for the real reasons for the non-adoption by the sorghum producers of the adaptation strategies scientifically recognized as efficient, gave the results mentioned in the following table 6.

Table-6: Order of importance of the reasons for the non-adoption of efficient adaptation strategies by sorghum farmers

Reasons for not adopting adaptation strategies	Rainfed sorghum		Dry season sorghum	
	Average Rank	Rank	Average Rank	Rank
Strategies not adapted to the area	2,18	1	2,41	1
Constraining strategies	3,73	2	3,56	3
Expensive strategies	4,01	3	2,96	2
High manpower demanding strategies	4,14	4	5,11	6
Unprofitable or inefficient strategies	4,37	5	4,08	4
Strategies with damaging consequences	4,58	6	5,24	7
Unknown strategies	5,00	7	4,65	5
	N	300	N	300
	W of Kendall[a]	,213	W of Kendall[a]	,306
	Khi-square	384,007	Khi-square	550,354
	Ddl	6	Ddl	6
	Sig.	,000	Sig.	,000

From Table 6 it can be seen that the three main reasons for the non-adoption of the efficient adaptation strategies by the rainfed and dry season sorghum farmers are almost the same, and are constituted mainly by the fact that the adaptation strategies disseminated are not adapted to the area (agro-ecological zone), they are restrictive (difficult to implement), and they are costly expensive.

The fact that sorghum farmers find that the adaptation strategies proposed to them are not adapted to the area and that they are constraining means simply either that they are under-informed about these adaptation strategies, or that they do not practically master them; this poses a problem of access to information about and training on the use of these adaptation strategies. The fact that they are qualified as expensive also means that they are financially unable to adopt them, which poses a problem of poverty. Indeed [5, 48] think that farmers have difficulty in adopting medium and long-term adaptation strategies because of the lack of information and knowledge about the effects of future climate change, as well as financial and material means; which, according to [49], exposes the various forms of vulnerability that characterize these sorghum farmers and thus hinder their sustainable development; because future sustainable development is linked to their ability to adapt to the impacts of climate change.

In this case, in order to improve the resilience to climate variability of these sorghum farmers, certain policy measures must be taken, introduced in sectoral development policies, and implemented in the short or medium terms:

- The regular access of farmers to short and long terms agro-meteorological forecasting, because the poor spatiotemporal distribution of rainfall and the drought constitute respectively the main climate hazard and the main water risk;
- The integration of farmers' innovations and formal agricultural innovations, and the practice of an integrated management of socio-economic activities and natural resources, in order to facilitate the adoption of disseminated innovations;
- The improvement of farmers' access to agricultural innovations through increased use of ICTs alongside with traditional interpersonal channels;
- The dissemination of agricultural innovations through innovation systems and platforms (integrated extension), and pluralistic (public, private) and demand-driven extension;
- The improvement of farmers' adoption of agricultural innovations through multifaceted and increased support for agricultural research and extension, and improvement of the socio-economic (especially poverty), environmental and infrastructural conditions of the populations.

CONCLUSION

In conclusion to this work, we could say that as in the rest of the Sahel, and according to the majority of the previous results, the poor spatiotemporal rainfall distribution and the drought constitute respectively the main climate hazard and the main water risk sahelian sorghum farmers are facing. But, confronted with these climatic constraints, they are simply coping, but they do not really adapt to them. In this case, a significant improvement of their resilience depends mostly on their regular access to agro-meteorological forecasting, the improvement of their access to agricultural innovations and training, the diffusion of these innovations through ICTs and interpersonal communication channels based both on innovation systems and on a pluralistic and demand-driven extension, the integrated management of socio-economic activities and natural resources; the integration of farmers agricultural innovations and formal agricultural innovations, and the improvement of their socio-economic (especially poverty), environmental and infrastructural conditions.

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