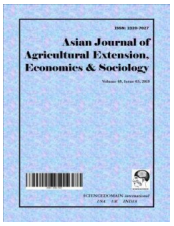

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Sorghum Farmers' Access to Agricultural Information Related to Water Stress Adaptation Strategies through ICTs in the Semi-arid Region of Cameroon

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Authors' contributions

This work was carried out in collaboration between all authors. Author SA designed the study, wrote the protocol, performed the statistical analysis, managed the literature searches and wrote the first draft. Authors AM, CN, AW, LM, FUE and TBTT corrected and approved the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This article addresses the problem of farmers' access to agricultural information through Information and Communication Technologies (radio, telephone, agricultural magazines). The purpose of this research work is to assess sorghum farmers' access to ICTs, and ICTs' contribution

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to the diffusion of agricultural information related to water stress adaptation strategies. The study was conducted in the Diamaré division from September 2011 to December 2014. The choice of the study area and sites was influenced by both ICTs' access and sorghum production basins. In all six hundred farms' household heads from twenty villages were randomly selected and submitted a questionnaire. The collected data were analyzed using descriptive and inferential statistics (W Kendall test of agreement, chi-square test). It appears that radio is the farmers' most used and most preferred ICT, while agricultural magazines are perceived as the most effective ICT in terms of dissemination of information related to water stress adaptation strategies. The phone is the ICT that has mostly contributed to the effective diffusion of the water stress adaptation strategies currently in use by farmers. The ICTs' features that attract farmers include diversity of broadcast languages, diversity of agricultural information disseminated, and ability to facilitate direct communication between actors. To promote broad dissemination of agricultural innovations through ICTs, agricultural stakeholders must consider all the above results, while integrating farmers and journalists in all phases of the process. The integration of the agricultural innovations' diffusion through ICTs in the agricultural policies and the ITCs' operators' agendas is a priority.

Keywords: Sorghum farmers; agricultural information; adaptation; water stress; ICTs; semi-arid region.

ABBREVIATIONS

FM : Frequency Modulation
INFOS : Informations (Information)
CNPC : Confédération Nationale des Producteurs de Coton du Cameroun (National Confederation of Cotton: Producers of Cameroon)
NDMC : National Drought Mitigation Centre
CDD : Comité Diocésain de Développement (Diocesan Development Committee)
CRTV : Cameroon Radio and Television
RR : Radio Rurale (Rural Radio)
Ydé : Yaoundé (Cameroon Capital City)
BA : Bulletin Agricole (Agricultural Magazine)
SODECOTON : Société de Développement du Coton (Cotton development Corporation)
CAMTEL : Cameron Telecommunications
MTN : Mobile Telephone Networks
ORANGE : Cameroonian Mobile telephone Operator
NEXTELL : Vietnamese Mobile Telephone Operator settled in Cameroon
SAILD : Service d'Appui aux Initiatives Locales de Développement (Local Development Support Service' Initiatives)
ICTWCC : Information and Communication Technologies, Water and Climate Change
IDRC : International Development and Research Centre
CODESRIA : Conseil pour le Développement de la Recherche en Sciences Sociales en Afrique (Council for the Development of Social Science Research in Africa).

1. INTRODUCTION

This article addresses the problem of sorghum farmers' access to agricultural information related to water stress adaptation strategies through ICTs, in particular radio, and telephone and agricultural magazines in Diamaré division.

Agriculture is the main activity of the populations, while sorghum is the basis of their diet [1-3]. With the advent of climate variability, the engendered agricultural water constraints (declining and poor distribution of rainfall in time and space, late arrival and early departure of rainfall, drying up of surface water) have had adverse effects on agricultural production and food needs' meeting of people [4]. Rapid population growth has aggravated the situation, and meeting the food needs absolutely requires diffusion and adoption of new and effective adaptation strategies. In the process of diffusion of these adaptation strategies, almost all research works confirm that traditional extension methods had very limited success [4-5]. According to L'Hôte [4], the Sahelian droughts of the 1970s were a climatic

catastrophe for the region. Thus Diamaré division has a food needs' coverage rate of only 58% and average rates of global acute malnutrition and severe acute malnutrition of 5.8% and 0.9% respectively [6]. The majority of scientists believe that the future meeting of these populations' food needs could only be reached through dissemination and adoption of new and effective coping strategies [7-8]. In the process of diffusion of these adaptation strategies, almost all research results confirm that traditional extension methods had very limited success [9-12]. This is because more research has shown that there is a strong correlation between the low adoption rate of coping strategies, and the weak farmers' access to information, mainly attributed to the traditional communication channels [9,10,13]. Yet, since some time, ICTs have proven to be powerful tools for diffusion and adoption of innovations with many advantages, as they are not only aimed to improve agricultural production and post-harvest activities, but also poverty reduction in general [9-11]. So it is in the aim of improving the diffusion of agricultural innovations related to farmers' adaption to water stresses adaptation strategies through ICTs in order to enhance their resilience that we decided to carry out this research work.

The major objective of this research work is to improve the diffusion of agricultural innovations related to farmers' adaption to water stress adaptation strategies through ICTs in order to enhance their resilience to climate change impacts on agricultural water.

The specific objectives of the research are to:

- Identify the sorghum farmers' most used and most preferred ICT;
- Appreciate farmers' perceptions of the contribution of the ICTs to the diffusion of agricultural information related to water stress adaptation strategies;
- Estimate the correlation between the number of accessible ICTs and the sorghum farmers' frequency of access to these ICTs on one hand, and the improvement of farmers' agricultural knowledge related to water stress adaptation strategies on the other hand;
- Evaluate the effective contribution of the ICTs to the diffusion of adaptation strategies in use by sorghum farmers.

In order to achieve the above objectives, we relied on the following research hypotheses:

H1: Radio is the sorghum farmers' most used and most preferred ICT;
H2: Radio is perceived by sorghum farmers as the ICT that has mostly contributed to the diffusion of agricultural information related to water stress adaptation strategies;
H3: The total number of accessible ICTs and the sorghum farmers' frequency of access to ICTs one hand, and the improvement of agricultural knowledge related to water stress adaptation strategies on the other hand, are correlated;
H4: Radio is the main ICT in the diffusion of water stress adaptation strategies used in the area by sorghum farmers.

2. METHODOLOGY

2.1 Study Area

Diamaré division (Fig. 1), which is our study area, is located in Cameroon Far North region, between the 10° and 11° north latitude (10° 30 '00' ') and the 14° and 15° east longitude (14° 30 '00' '). It is a semi-arid region with a long dry season (between seven and eight months) and a short rainy season, which is highly exposed to natural hazards (droughts, floods) [1,2,5,6].

2.2 Choice of the Study Area and Sites, and the Sample

The choice of Diamaré division as the study area could be explained by a good coverage of rural areas by ICTs (radio, mobile telephone, agricultural magazines), its central position which limits the influence of neighboring countries ICTs (Nigeria, Chad), and the possibility of obtaining climate data over a good period of time.

The choice of the study sites was mainly driven by the major cereal crops. After targeting the main cereal crops (dry and rainy seasons' sorghum), we have listed the 30 most suited production sites (villages) per crop, among which we selected ten; making in all twenty sites for the two sorghum crops (Fig. 1). The sample choice, which was initiated since the beginning of sitting, was done according to the "stratified sampling technique," because of the heterogeneity of the survey universe containing our target population. After site selection, we have listed all the names

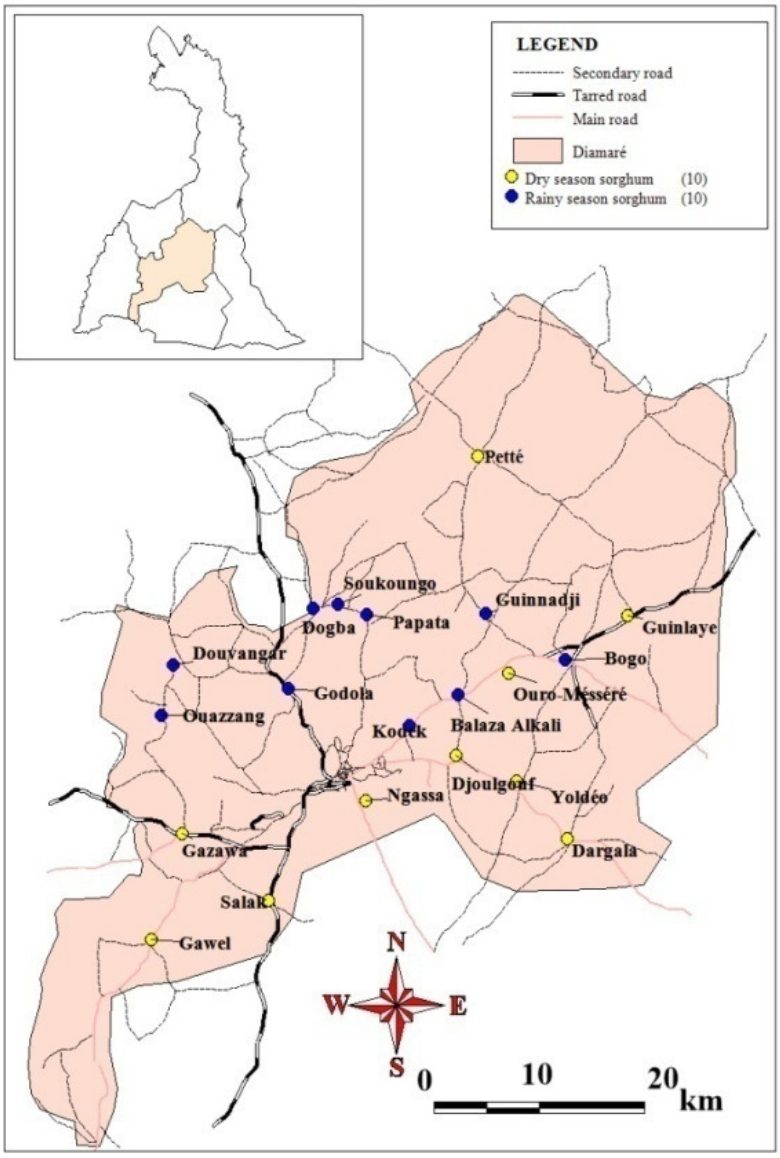

Fig. 1. Study area and sites

of the farms' household heads by site and then selected randomly thirty, giving a total of six hundred farms' household heads. After conducting focus groups in ten sites, including five per crop, we submitted a questionnaire survey to the household heads. The choice of radio, telephone and agricultural magazines as ICTs of interest is justified by the fact that they are the most used, but also the more accessible to farmers in rural areas.

The collected data were coded, counted and entered on Excel and analyzed using R and SPSS statistical software. Data analysis focused on descriptive and inferential statistics, i.e. frequencies, percentages, crosstabs, W Kendall test of agreement and the chi-square test. Some of the study results have been discussed on the basis of the theory of "Diffusion and adoption of innovations of Everett Rogers" and the theory of "Mere exposure of Zajonc".

3. RESULTS AND DISCUSSION

3.1 Sorghum Farmers' Socioeconomic Characteristics

The analysis of the collected data, coupled with the literary review have enabled us to synthesize the main socio-economic characteristics of the

sorghum farmers. In general, agriculture and animal husbandry are the main activities of the people, and Diamaré division is among the three most vulnerable divisions to food insecurity [3,6]. Priority is given to cereals in terms of land and labor mobilization [1], and sorghum (rainy and dry seasons' sorghum), is the staple diet of the people. The farms household heads are mostly men, mostly aged on average between 35 and 54 years [2-6], with an average age of 48 years in the Diamaré division. The average household size which is about 9 people is high (a regional average of 7 and a national average of 5.7). These are mostly small farmers (100% < 10 ha), and the average area planted for the rainy and dry seasons' sorghum is respectively of about 0.5 ha and 1 ha. These are farmers who use a small amount of agricultural inputs [2,3], and have limited access to agricultural extension services (51.50%) and loans (43.50%). Cotton, onion and rice are the only cash crops. To ensure their daily survival, they practiced polyculture (93.80%), increased income-generating activities (65.50%) and practiced subsistence agriculture (79%). The school enrollment rate is the lowest in the country (57%), with 39.30% who achieved the primary, 17% the secondary, and less than 1% (0.4%) the higher education. Health, road and school infrastructures are among the least-off of the country.

3.2 ICTs' General Characteristics and Sorghum Farmers' Access

3.2.1 ICTs' types, identities and general characteristics

Table 1 below shows the types of ICTs to which we are interested, in particular radio, telephone and agricultural magazines, and their respective identities.

In all six radio stations, four telephone networks and four agricultural magazines were identified. While rural radios, usually private or semi-public, with agropastoral aims, mainly diffuse agricultural information, public radio stations broadcast a very limited number of agropastoral emissions, often with the financial support of public, parastatal or private structures. The nature or content of information disseminated depends mainly on sponsors' targets. Agricultural magazines, in turn, generally belong to private structures, mainly diffuse agricultural information to the rural public, with a content emanating mostly from farmers' concerns. Contrary to the southern region of the country or other African regions (East, South, West) where farmers' organizations receive information relevant to their agricultural activities through SMS as following contracts with mobile phone networks' operators, dissemination of agricultural information through phone in Diamaré division is still a personal initiative.

3.2.2 Coverage of the study area by the different ICTs

Figs. 2, 3 and 4 below show the different coverage conditions of the study area by radio, mobile telephony and agricultural magazines.

All the study sites are covered by at least two radio stations, and a maximum of four radio stations. Peripheral sites, especially those in the southeast area appear to be better off than those in the immediate vicinity of the regional capital Maroua.FM Maroua and FM Yaoundé radio stations were the only ones to cover all sites.

The coverage map of the study area by mobile telephony presents a maximum of four telephone networks per site, and a minimum of three. Sites located in the immediate vicinity of the city of Maroua seem better off, unlike the distribution of radio stations. This disparity in the distribution of telephone networks has been caused by the absence of CAMTEL network in the sites away from the regional capital (rural area).

In terms of agricultural magazines, study sites have a coverage rate of between a minimum of one magazine per site (majority) and a maximum of four per site, with a trend towards concentration of sites better served in the western part of the division. The SODECOTON magazine (INFOS CNPC) is the only magazine that covers all the sites. This is due to the successful deployment of the structure that quadrilles the whole division through its various administrative and technical divisions.

3.2.3 The most used and most preferred ICT by sorghum farmers

The objective referred to in this part of the research work is to identify the most used and most preferred ICT by sorghum farmers. To identify the most used ICT by these farmers, we estimated farmers' global access to the various communication channels using frequencies. By global access to a channel, we mean here the total number of people with access to that channel. Subsequently, we have attempted to

estimate the order of preference of the various ICTs by these farmers using Kendall W test of agreement. The results were discussed on the basis of "the theory of mere exposure of Zajonc (1968)." This theory states that the more we are exposed to a stimulus (person, consumer product, location ... etc), the more likely we like it. The following Fig. 5 gives an idea of the farmers' global access rate to the various communication channels.

Table 1. ICTs' types and identities

Types of ICTs		
Radio stations	**Mobile phone networks**	**Agricultural magazines**
-FM Maroua	-CAMTEL (CT Phone)	-La voix du paysan
-FM Yaoundé	-MTN	-Infos CNPC
-FM Yagoua	-ORANGE	-Bulletin agricole du CDD
-Dana community Radio	-NEXTELL	-Bulletin d'informations agricoles
-Meskine community radio		INADES
-Mora community radio		

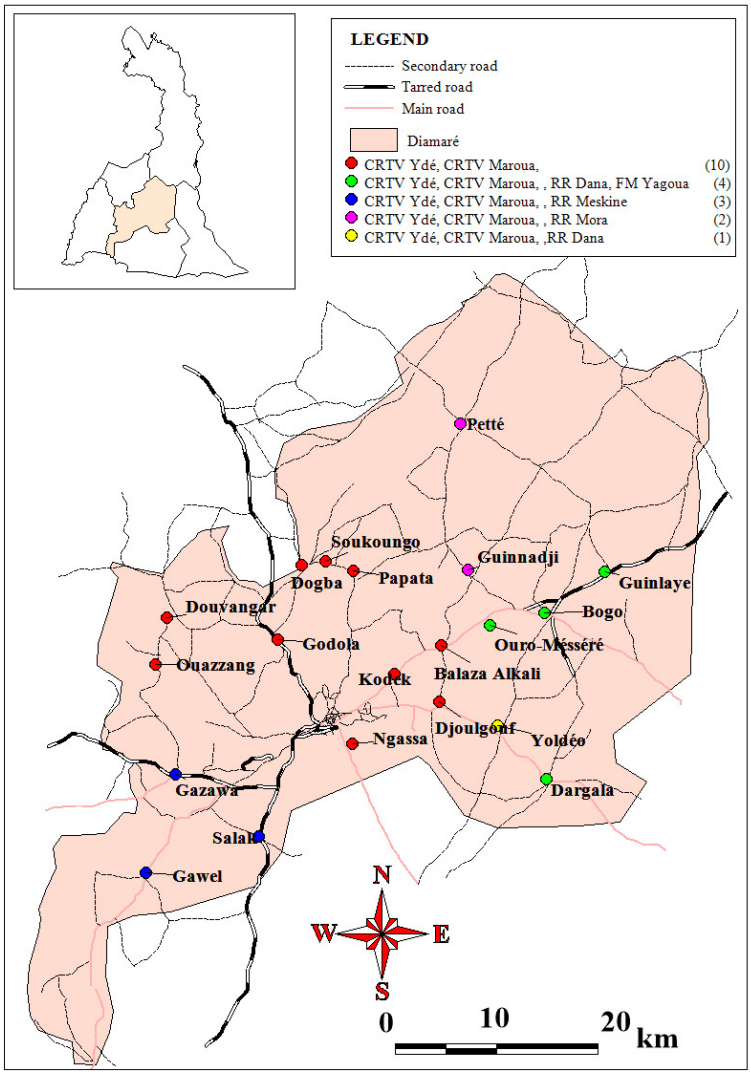

Fig. 2. Coverage of the study area by radio

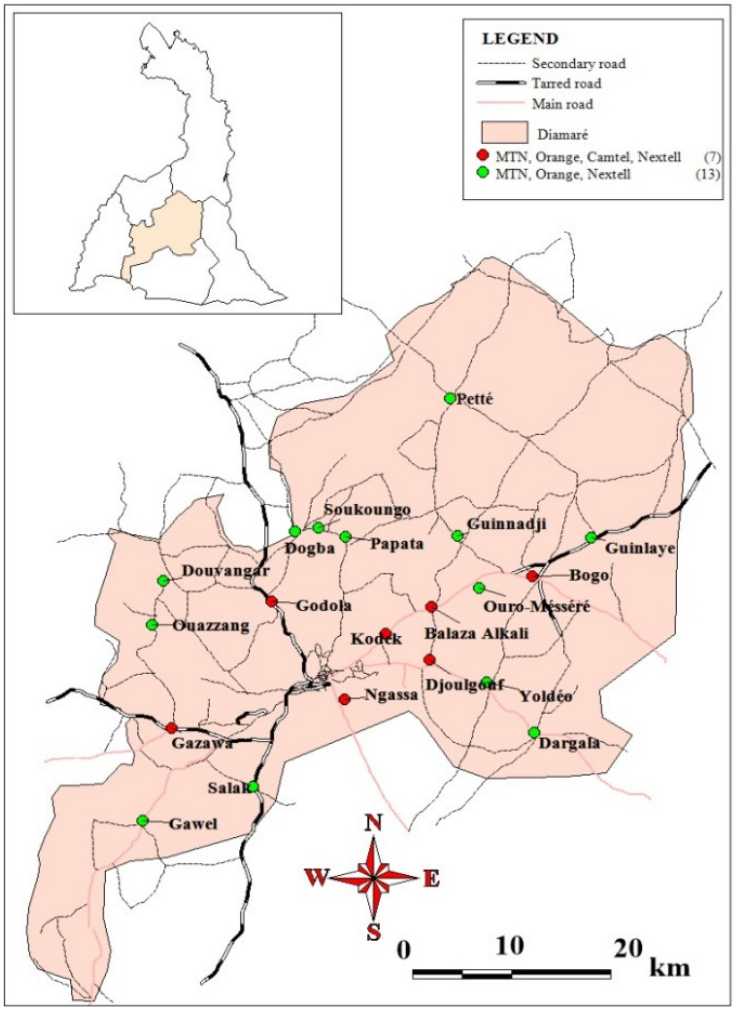

Fig. 3. Coverage of the study area by mobile telephony

Interpersonal channels remain the most used communication channel. Meinzen-Dick [15] has shown that among these interpersonal channels, public extension services through field visits remain the main channel for agricultural information diffusion, despite the important role played by private services and community networks.

Among the ICTs, radio appears as the main ICT in terms of farmers' global access to communication channels, followed by the phone. Fraser and Restrepo Estrada [16] believe that it is the first form of electronic communication for the poor because it allows them to cross the barriers of isolation and illiteracy. Indeed, according to Emenyeonu Nnamdi [17], in terms of access to ICTs in general, radio is the most accessible medium (82.10%), followed by agricultural journals (58.90%) and then television (29.20%), the phone has not been included in their study. This is quite logical since the radio is the first ICT to be used on-farm.

In terms of the order of preference of the various ICTs by sorghum farmers, the results are listed in Table 2.

Radio thus appears as the most used ICT (Fig. 5), but also the most favorite by sorghum farmers. This result is consistent with the theory of mere exposure of Zajonc. Thus, large access to ICTs is key for their adoption by sorghum farmers in Diamaré division, and constitutes an important step for improving their access to agricultural information; so decision makers and ICTs' operators should improve their rate of coverage in rural areas.

Since radio appears as the farmers' most used and most preferred ICT, we can say that our first hypothesis (H1) is verified and thus, accepted.

Since radio is the most preferred ICT by sorghum farmers, we tried to look for the three main reasons for this preference, and the results are listed in Table 3 below. The results were discussed on the basis of the theory of diffusion and adoption of innovations' of Everett Rogers (1995).

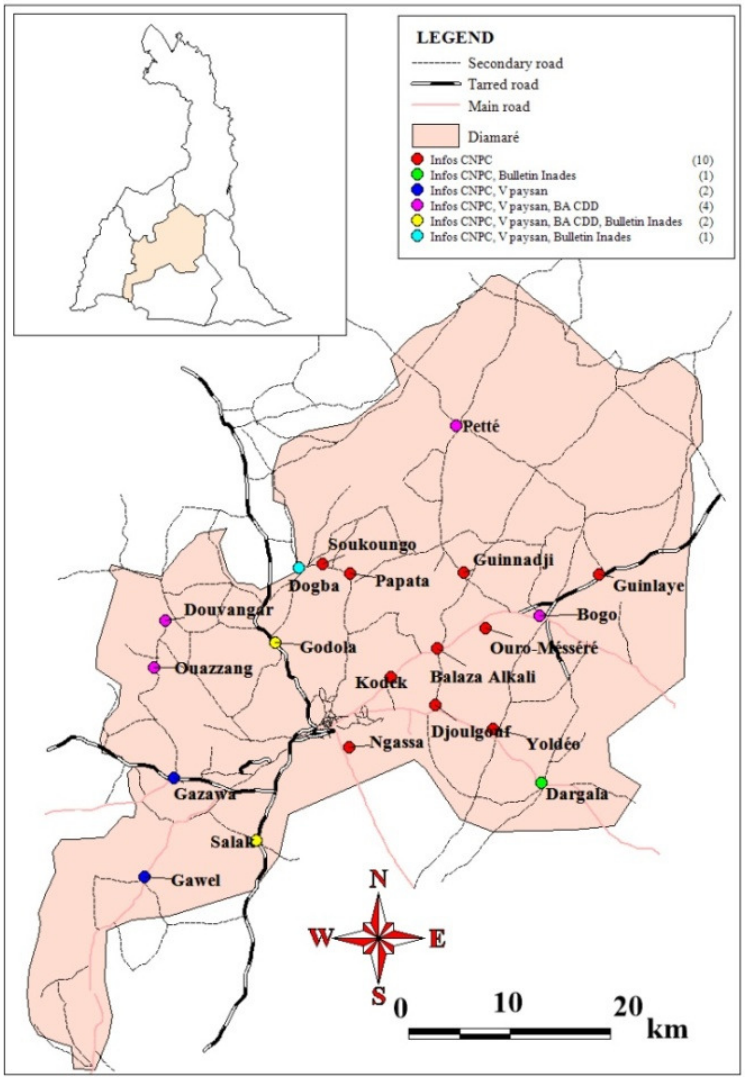

Fig. 4. Coverage of the study area by agricultural magazines

Table 2. Order of preference of ICTs given by sorghum farmers

ITC preference	Mean rank	Rank	Test results	
Prefer radio	1,65	1	N	600
Prefer phone	2,10	2	W of Kendall[a]	096
Prefer agricultural magazines	2,25	3	Khi-square	115,358
			Degree of freedom	2,000
			asymptotic significance	

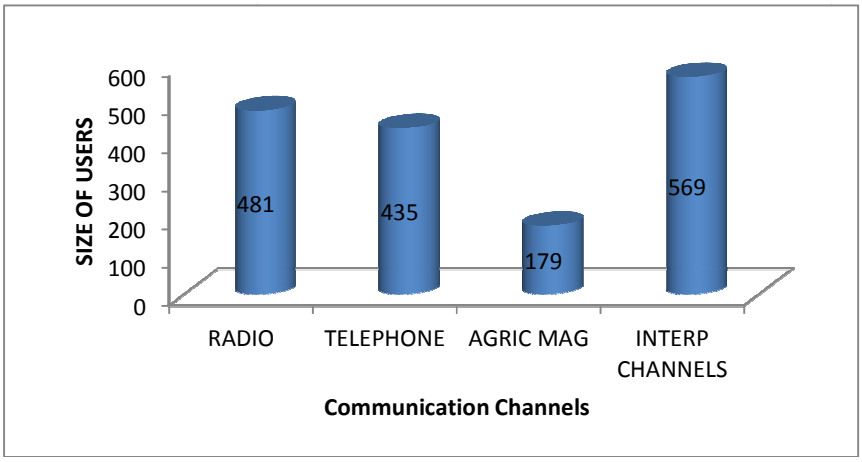

Fig. 5. Sorghum farmers' global access rate to the communication channels

The diversity of broadcast languages of agricultural information and diversity of agricultural information disseminated are the two main characteristics of agricultural information sought by the sorghum farmers and offered by radio. According to innovations' diffusion and adoption theory of Everett Rogers, there are three main groups of factors that explain the rate of diffusion and adoption of an innovation in a community over the time:

- the innovation's characteristics (relative advantage, compatibility, complexity, ability to test; and observability);
- the social system or users' characteristics (human, cognitive and material resources),
- the communication channels (ICTs or mass media, interpersonal channels) [18].

The diversity of broadcast languages of agricultural information and the diversity of information disseminated are the two main aspects of communication of agricultural information that is sought after by sorghum farmers. These two aspects can be attached either to the characteristics of innovations (if one is interested in the nature of agricultural information) or to the characteristics of the communication channels (if one is interested in the source of information). The diversity of broadcast languages allows literate and illiterate farmers and those speaking local languages, to access easily to the agricultural information disseminated. The diversity of agricultural information in turn allows farmers who have an access to radio, to access the different types of information they need. These results are consistent with diffusion and adoption of innovations' theory of Everett Rogers. Thus, to improve sorghum farmers' access to agricultural information through ICTs, we have to diversify the diffusion languages and the nature of agricultural information disseminated.

4. WATER STRESS AND SORGHUM FARMERS' ADAPTATION STRATEGIES

Despite the many similarities in terms of drought, each locality is a unique case, because the impacts of the drought vary depending on regional, local and national vulnerabilities and adaptation options available to reduce it [19].

Table 4 below summarizes the water constraints engendered by climate variability in the rainy season and dry seasons' sorghum production, and the coping strategies used by farmers.

Table 3. The three main reasons for the preference of the radio

Reasons for the preference	Total	Order of importance
Radio broadcasts information in different local languages	300	1
Radio broadcasts a variety of information	206	2
Radio broadcasts a variety of information in different local languages	94	3

Table 4. Water stresses engendered by climate variability in the production of rainy season and dry season sorghum

Water stress	Rainy season sorghum		Dry season sorghum	
	Total	Total percentage (%)	Total	Total percentage (%)
Late rains	300	100	297	99
Early cessation of rains	300	100	293	97,67
Poor spatial rainfall distribution	299	99,67	299	99,67
More frequent and long dry spells	300	100	300	100
Flooding of crops	300	100	294	98
General decline in the total amount of rainfall	299	99,67	296	98,67
Rapid drying of water sources (ponds, rivers, lakes, wells)	-	-	300	100
Rapid drying and hardening of soils	-	-	292	97,33
Light rains at the beginning of the rainy season	-	-	297	99
Absence of heavy rains at the end of the rainy season	-	-	297	99
No haze during cold season	-	-	299	99,67

Most of the water stresses mentioned here by farmers are drought-related, not excess water (flooding): drought is therefore the primary water stress limiting agricultural production in the area. All the three known forms of droughts are represented here:

- The meteorological drought (late rains, dry spells, reduced total amount of rainfall, early cessation of rains);
- The agricultural drought (fast drying and hardening of soils, no haze during cold season);
- The hydrological drought (rapid drying up of water sources).

According to the FAO and the NDMC [19], when all these three types of droughts occur anywhere, automatically, socioeconomic drought appears there as their logical consequence.

All water constraints affecting rainy season sorghum also affect dry season sorghum. This reflects the strong dependence of dry season sorghum on the meteoric waters (rains). The multiplicity of water stresses affecting dry season sorghum is due to the diversity of water resources (meteoric, surface water, ground water) necessary for its production. Similarly, the high rate of perception of water stress by farmers reflects both the breadth and depth of these constraints, but also the perfect understanding of phenomena by farmers who master their environment. This confirms once again that in general, farmers' communities that have close ties with their environment have a perfect knowledge of the climate, its manifestations and consequences. Moreover, these farmers are among the most vulnerable who are living in fragile ecosystems like Sudano-Sahelian area perceive more natural phenomena going on in their environment [15,16].

To continue to ensure their survival, farmers in this region have adopted or developed a variety of coping strategies, which are summarized in Table 5 below.

Observation of adaptation strategies in use by sorghum farmers raises three main points:

- The farmers in the area use a variety of coping strategies that are mostly traditional;
- Use of weather forecasting and irrigation techniques, which constitute effective coping strategies for both rainfed and dry season sorghum, is not part of farmers' adaptation options in this area, while drought is the main water stress [20,13].
- Adoption of adaptation strategies by farmers is relatively low, except for some two or three strategies; Obviously, according to Leary, Kulkarmi and Seipt [21], and then Yesuf et al. [13], all of the case studies conducted in developing countries have noted that there is a serious adaptation deficit.

5. ICTS' CONTRIBUTION TO THE DIFFUSION OF AGRICULTURAL INFORMATION RELATED TO WATER STRESS ADAPTATION STRATEGIES

The main diffusion mechanisms and strategies identified in the literature can be grouped into three levels of use: Reception, adoption, and implementation of innovation. In this case, diffusion is simply the reception, and can be defined as a process by which an innovation is communicated through certain channels, in varying periods, to the members of a social system; having said that, in any case, the disclosure of information about an innovation is no guarantee of its use, unless using means being aware of the existence of innovation [22].

5.1 Sorghum Farmers' Perception of ICTs' Contribution to their Access to Agricultural Information Related to Water Stress Adaptation Strategies

In general, it has been shown that farmers' access to new agricultural information plays an important role in improving adoption of agricultural innovations [23]. By agricultural information related to water stress adaptation strategies, we mean all the agricultural information diffused towards farmers for their adaptation to water stress; this agricultural information could fall within the area of meteorological predictions, farming techniques or post-harvest activities (food storage, outlets).

The objective in this part of the work is to assess farmers' perceptions of the contribution of ICTs to dissemination of agricultural information related to sorghum farmers' adaptation to water stress. This assessment was based on the estimation of two parameters:

- the sorghum farmers' perception of the overall contribution of ICTs to their access to agricultural information, using frequencies;
- the farmers' perception of the contribution of different ICTs to dissemination of agricultural information related to water stress adaptation strategies by order of importance, using W Kendall test of agreement.

The following fig 6 gives an idea of the farmers' perception of the overall ICTs' contribution to their access to agricultural information.

A significant majority of the sorghum farmers (507/600) recognizes that ICTs have contributed to their access to agricultural information. According to the results of a study conducted by Dingkuhn [24] in Kano state in Nigeria, the vast majority of farmers surveyed (72.20%) agree that ICTs globally contributed effectively to diffusion of agricultural information in their locality.

In terms of farmers' perception of the contribution of the different ICTs to dissemination of agricultural information related to water stress adaptation strategies by order of importance, the results obtained with the W Kendall test of agreement are mentioned in the following Table 6.

So as the research works' results obtained by Emenyeonu Nnamdi [17], interpersonal communication channels are known here as the main provider of agricultural information related to water stress adaptation strategies. In contrast to these results, according to Emenyeonu Nnamdi [17], another research work conducted with cocoa farmers in Nigeria, reveals that 75% of farmers had access to agricultural information through radio, 51% through interpersonal communication channels, and only 0.8% through television. Similarly, according to the research work of Ango, Illo, Abdullahi, Maikasuwa and Amina [25] in Kano state, most farmers had access to agricultural information through radio (97.80%). That is to say, therefore, that the importance of communication channels' contribution in general and ICTs in particular, to the dissemination of agricultural information varies according to region or locality.

It is true according to the above results that radio is both the most used (Fig. 5) and the most preferred ICT by farmers (Table 2), but in terms of contribution to the dissemination of agricultural information related to water stress adaptation strategies, it comes after agricultural magazines. Indeed, according to the results obtained by Mirza, Khalid and Sakhwat [11], the radio was recognized as being more used than television, but has been recognized at the same time as disseminating less useful agricultural innovations as television. This could have two main possible explanations: either the radio generally broadcasts less agricultural information than agricultural magazines (which is the case here); or radio broadcasts less than magazines, the agricultural information needed by farmers; or the broadcasting information format used by radio does not interest farmers, because according to

a study conducted by Ango, Illo, Abdullahi, Maikasuwa and Amina [25] in northern Nigeria, broadcast format is a very important aspect of information diffusion (debates are preferred to interviews and theaters). That means, access to an ICT by a significant amount of farmers do not automatically means that they have access to a large amount of agricultural information through it. Thus, in order to improve farmers' access to agricultural information in the area, radio which is the most used ICT should disseminate significant agricultural information, especially those they need.

Since radio is not perceived by sorghum farmers as the ICT that has mostly contributed to the diffusion of agricultural information related to water stress adaptation strategies, we can say that our second hypothesis is not verified and rejected.

Table 5. Sorghum farmers' adaptation strategies to water stress and their adoption rates

Adaptation strategies	Rainy season sorghum		Dry season sorghum	
	Total	Total percentage (%)	Total	Total percentage (%)
Sowing early matured varieties	131	43,67	175	**58,33**
Sowing or transplanting early	178	**59,33**	139	46,33
Sowing of drought resistant crops varieties	178	**59,33**	194	**64,67**
Diversification of crops varieties	94	31,33	182	**60,67**
Change of crops or crops varieties	105	35	25	08,33
Labor of plots and mounding of plants	234	**78**	96	32
Temporary or permanent transfer of crops	170	**56,67**	30	10
Making of racks or bunds	103	34,33	203	**67,67**
Organic or inorganic fertilizer input	271	**90,33**	82	27,33
Diversification of income-generating activities	195	65	141	47
Crops diversification	268	**89,33**	272	**90,67**
Multiplication of weeding	123	41	20	06,67
Sowing of molten seed holes or dried plants	166	**55,33**	05	01,67
Rocky bunds	05	01,67	-	-
Late sowing or transplanting	-	-	125	41,67
Deepening piles	-	-	129	43
Purchase or request of nurseries	-	-	104	34,67
Scaling of nurseries over the time	-	-	203	**67,67**
Organic or inorganic fertilization of nurseries	-	-	107	35,67
Cleaning and deepening of ponds	-	-	131	**60,33**
Water research over long distances	-	-	95	31,67
Fertilization of transplanting water	-	-	06	02

Table 6. Farmers' perception of the order of importance of ICTs' contribution to diffusion of agricultural information related to water stress adaptation strategies

Farmers' perception	Mean rank	Rank	Test results	
Radio as main source of diffusion	2,78	3	N	600
Telephone as main source of diffusion	3,49	4		
Agricultural magazine as main source of diffusion	2,13	2	W of Kendall[a]	403
Interpersonal communication channels as main source of diffusion	1,60	1	Khi-square Degree of freedom asymptotic significance	725,843 3, 000

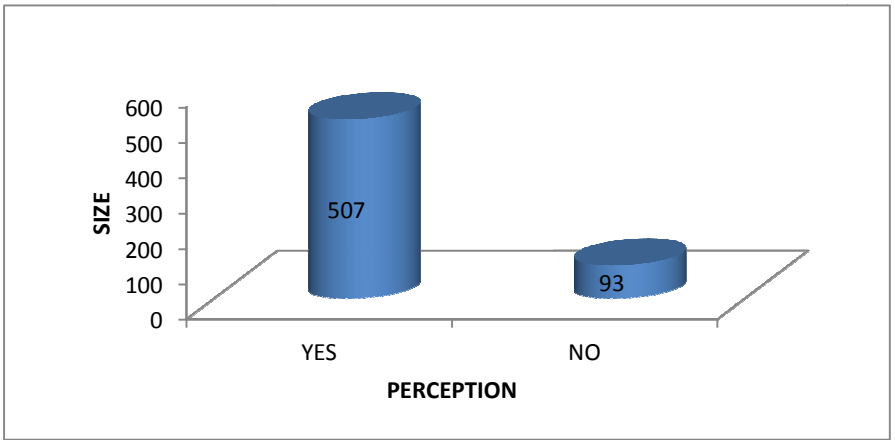

Fig. 6. Farmers' perception of the overall ICTs' contribution to their access to agricultural information

5.2 Relationship between the Total Number of Accessible ICTs, the Frequency of Access to ICTs and the Improvement of Agricultural Knowledge in Relation to Water Stress Adaptation Strategies

The aim here is to search the relationship between the total number of ICTs accessible to sorghum farmers and their access frequency to these ICTs on one hand, with their agricultural knowledge improvement on the other hand. This is to check with the chi-square test, if the total number of ICTs accessible to farmers and the frequency of farmers' access to ICTs, positively influence the amount of agricultural knowledge acquired by them. The results were discussed on the basis of the "theory of mere exposure of Zajonc (1968)", which states that the more we are exposed to a stimulus (person, consumer product, location ... etc), the more likely we like it.

Table 7 below gives the results of the correlation between the total number of accessible ICTs and sorghum farmers' agricultural knowledge improvement in relation to water stress adaptation strategies, using the chi-square test.

The high degree of significance between the total number of ICTs accessible to sorghum farmers and improvement of their agricultural knowledge in relation to adaptation to water stress, means that the more they have access to a large number of ICTs, the more they have the chance to learn and adopt a significant amount of agricultural innovations in connection with adaptation to water stress. This result is consistent with the theory of mere exposure of Zajonc.This result is consistent with that obtained by Arodokoun [26] in his work carried out with cotton farmers in rural areas of central Benin. It is assumed in this case that all the ICTs accessible to farmers in the area diffuse a large amount of agricultural information related to water stress adaptation strategies. So, the amount of agricultural information available to farmers can be improved by improving their access to the different ICTs, provided they disseminate agricultural information they need.

Table 8 below shows the estimate of the correlation between the access frequency of farmers to ICTs and the improvement of their agricultural knowledge related to water stress adaptation strategies using the chi-square test.

Since the frequency of access of sorghum farmers to the different ICTs is strongly correlated with the improvement of their agricultural knowledge related to water stress adaptation strategies, the more frequently a farmer accesses to these ICTs, the greater the amount of agricultural information related to water stress adaptation strategies he acquires. This result is consistent with the theory of mere exposure of Zajonc. So, the amount of agricultural information available to farmers through ICTs can also be improved by improving their frequency of access to these ICTs; this is only possible through improving the coverage of the area by the ICTs and the content of agricultural information disseminated.

Finally, we accept our third hypothesis (H3) because the total number of accessible ICTs and the farmers' frequency of access to these ICTs are highly correlated with farmers' improvement of agricultural knowledge related to water stress adaptation strategies.

Table 7. Results of the correlation between the total number of accessible ICTs and the improvement of sorghum farmers' agricultural knowledge

Variable	Khi-square	Degree of freedom	p-value
ACCOAACH (Improvement of agricultural knowledge in relation to water stress adaptation strategies)	468,490	3	,000

Table 8. Results of the correlation between the sorghum farmers' access frequency to ICTs and the improvement of their agricultural knowledge related to water stress adaptation strategies

Variables	Khi-square	Degree of freedom	p-value
Radio's access frequency	295,954	21	,000
Phone's access frequency	364,875	21	,000
Agricultural magazines' access frequency	541,176	18	,000

Table 9. Diffusion frequencies of each adaptation strategies used by sorghum farmers through each ICT

ICTs adaptation strategies	Radio	Telephone	Agricultural magazines	Interpersonal channels
Sowing early matured varieties	15	298	18	318
Sowing or transplanting early	11	318	13	306
Sowing of drought resistant crops varieties	23	375	22	275
Diversification of crops varieties	14	275	14	144
Change of crops or crops' varieties	1	130	2	542
Labor of plots and mounding of plants	21	328	8	130
Temporary or permanent transfer of crops	0	200	0	123
Making of racks or bunds	5	306	5	351
Organic or inorganic fertilizer input	9	347	3	339
Diversification of income-generating activities	0	340	2	377
Crops diversification	4	541	1	171
Multiplication of weeding	3	144	2	330
Sowing of molten seed holes or dried plants	1	167	1	460
Late sowing or transplanting	1	140	1	200
Deepening piles	0	123	0	102
Purchase or request of nurseries	1	103	1	203
Scaling of nurseries over the time	1	203	0	110
Organic or inorganic fertilization of nurseries	5	112	3	181
Cleaning and deepening of ponds	1	177	1	94
Water research over long distances	1	90	1	0
Fertilization of transplanting water	0	0	0	5
Rocky bunds	0	0	0	5

5.3 Effective ICTs' Contribution to the Diffusion of Water Stress Adaptation Strategies Used by the Sorghum Farmers

The estimate of the effective contribution of ICTs to the diffusion of water stress adaptation strategies in use in the area by the sorghum farmers consists of identifying the ICTs that have been used to diffuse each adaptation strategy, and the frequency of diffusion of each adaptation strategy through each of ICT, using crosstabs.

Table 9 above summarizes the diffusion frequencies of each adaptation strategies used by sorghum farmers through each ICT.

Interpersonal communication channels and telephone are the main diffusion channels of adaptation strategies that are currently used by farmers in the area. Although radio is the most accessible and most preferred ICT by farmers, and the agricultural magazines are perceived as the ICT that diffuses more agricultural information, the phone appears as the ICT which broadcasts really more agricultural information. One of the common denominators between the phone and the interpersonal channels is that they favor more than the other channels (radio, agricultural magazines), direct exchanges between actors. Indeed, according to Inter-Networks [27], farmers prefer communication channels that promote direct exchanges between actors. Since these direct exchanges between actors are generally facilitated through use of local languages because of illiteracy of the majority of farmers, it is clear that interpersonal channels and telephone are the only channels that can facilitate this kind of exchanges. Obviously, according to Ba Mbow [28], rural farmers are illiterate and do need communication channels that support both direct exchange and use of local languages.

Since radio is not the ICT that has contributed mostly to the diffusion of adaptation strategies currently used by sorghum farmers, we reject our fourth hypothesis.

6. CONCLUSIONS

According to this research, the following conclusions deserve special attention:

- Radio is the most used and most preferred ICT by farmers, agricultural magazines are perceived as the most effective ICT in dissemination of agricultural information, while phone is the ICT that really diffuses the adaptation strategies in use by farmers; then, rural people are mostly illiterate and need communication channels that support both direct exchange and use of local languages.
- It has been demonstrated consistently with the theory of "mere exposure of Zajonc (1968)" that the more sorghum farmers have access to a large number of ICTs, the more they have the chance to learn and adopt a significant amount of agricultural innovations in connection with adaptation to water stress;
- It has also been demonstrated consistently with the theory of "mere exposure of Zajonc (1968)" that the more frequently sorghum farmers have access to ICTs, the greater the amount of agricultural information related to water stress adaptation strategies they acquire;
- Some communication channels' characteristics such as the diversity of agricultural information broadcast languages, the diversity of agricultural information disseminated, and the ability to facilitate direct exchanges between actors, are key factors for ICTs' adoption by farmers; these results are consistent with the theory of "diffusion and adoption of innovations of Everett Rogers (1995)."

7. RECOMMENDATIONS

Since improvement of people's food security in the study area requires absolutely massive access of these sorghum farmers to ICTs, and intense diffusion of agricultural innovations towards and between farmers through ICTs, we recommend the following actions:

- Radio operators should focus their agropastoral broadcasts more on farmers' real information needs and conveniences (content, format, schedules);
- Agricultural magazines' operators, especially those of "La Voix du Paysan", should try to extend their coverage in the rural areas, and propose attractive measures to farmers;
- Mobile phone operators must work together with the other stakeholders (farmers, researchers, journalists, policy makers) to incorporate agricultural information's diffusion in their agenda and daily activities, as it is done in southern Cameroon and eastern Africa;
- Dissemination of agricultural information through ICTs (Radio, Telephone, agricultural magazines) must incorporate the aspect of language diversity and agricultural information's diversity, after having correctly identified farmers' real information needs and conveniences;
- The different stakeholders of the agricultural sector, particularly farmers and journalists, must be integrated into the wide agricultural innovations' dissemination process through ICTs, from the diagnostic phase to implementation through planning;
- The rural areas' rate of coverage by ICTs, so as the agricultural information diffusion

frequency through ICTs, must be improved;
- Agricultural information diffusion through ICTs should be integrated into the national agricultural policies and the ICTs' operators' agendas.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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