

Sorghum farmers’ access to agricultural information related to water stress adaptation strategies through ICTs in the semi-arid region of Cameroon

ABSTRACT

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

1. Introduction

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

Agriculture is the main activity of the populations, while sorghums are the basis of their diet [1]; [2]. With the advent of climate variability, the engendered agricultural water constraints have had adverse effects on agricultural production and food needs' meeting of people [3]. 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 confirms that traditional extension methods had very limited success [4]. 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 [2]. 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 [4]. It is in order to assess the access of sorghum farmers to ICTs, and the contribution of these ICTs to the diffusion of agricultural information related to water stress adaptation in the area, that we have decided to carry out this work.

The choice of the study area was influenced by access to ICTs, while that of study sites was influenced by both ICTs' access and main basins production of sorghum (rainy and dry season

49 sorghum). In all six hundred farms household heads from twenty villages were randomly selected and
50 submitted a questionnaire. The collected data were analyzed using R and SPSS statistical software
51 tools, namely the descriptive statistics, W Kendall test of agreement, and the chi-square test.

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1.1. Objectives of the study

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The overall objective of this research work is to assess sorghum farmers' access to ICTs, and
ICTs' contribution to the diffusion of agricultural information related to water stress adaptation in
Diamaré division.

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As specific goals, we want to:

-Identify the most used and preferred sorghum farmers' ICT;

-Evaluate farmers' perception of the contribution of the different ICTs to dissemination of

agricultural information related to water stress adaptation strategies;

-Estimate the correlation between on one hand, the number of accessible ICTs and the frequency

of access to ICTs, and on the other hand, the farmers' agricultural knowledge improvement in relation

to water stress adaptation strategies;

-Evaluate the effective contribution of the ICTs to the dissemination of sorghum farmers' currently

used adaptation strategies.

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1.2. Research Hypotheses

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To achieve the above objectives, we relied on the following research hypotheses:

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H1: Radio is the sorghum farmers' most used and most preferred ICT;

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H2: Radio is perceived by sorghum farmers as the ICT that has most contributed to the diffusion of
agricultural information related to water stress adaptation strategies;

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H3: The total number of accessible ICTs and the sorghum farmers' frequency access to ICTs on one
hand, and agricultural knowledge improvement in relation to water stress adaptation strategies on the
other hand, are correlated;

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H4: Radio is the main ICT in the diffusion of water stress adaptation strategies currently used in the
area by sorghum farmers.

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2. Methodology

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2.1. Study Area

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Diamaré division (Figure 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).

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Figure 1: Study area and sites

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2.2. Choice of the study area and sites, and the sample

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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, and the possibility of obtaining climate data over a good period of time.

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The choice of the study sites was mainly driven by the major cereal crops. After targeting the main cereal crops (sorghum dry and rainy seasons), 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 main sorghum crops (Figure 1). The sample choice, which was initiated since the beginning of sitting, was done

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93 according to the "probabilistic techniques", i.e. the "stratified sampling technique," because of the
94 heterogeneity of the survey universe containing our target population. After site selection, we have
95 listed all the names of the farms' household heads by site and then selected randomly thirty. Giving a
96 total of six hundred farms' household heads. After conducting focus groups in ten sites, including five
97 by crop, we submitted a questionnaire survey to the household heads. The choice of radio, telephone
98 and agricultural magazines as ICTs of interest is justified by the fact that they are the most used, but
99 also the more accessible to farmers in rural areas.

100 The collected data were coded, counted and entered on Excel and analyzed using R and SPSS
101 statistical software. Data analyzes focused on descriptive and inferential statistics, i.e. frequencies,
102 percentages, crosstabs, W Kendall test of agreement and the chi-square test.

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104 **3. Results and discussion**

105 **3.1. Sorghum farmers' socioeconomic characteristics**

106 The analysis of the collected data, coupled with the literary review, has enabled us to synthesize
107 the main socio-economic characteristics of the sorghum farmers in the area.
108 In general, agriculture and animal husbandry are the main activities of the people, and Diamaré
109 division is among the three most vulnerable divisions to food insecurity [2];[6]. Priority is given to
110 cereals in terms of land and labor mobilization [5], and sorghum (rainy and dry season sorghum), are
111 the staple diet of the people. The farms household heads are mostly men, mostly aged on average
112 between 35 and 54 years [7], with an average age of 48 years in the Diamaré division. The average
113 household size which is about 9 people is high (a regional average of 7 and a national average of 5.7).
114 These are mostly small farmers (100% < 10 ha), and the average area planted of the rainy season
115 and dry season sorghum is respectively of about 0.5 ha and 1 ha. These are farmers who use a small
116 amount of agricultural inputs (FAO 2009), and have limited access to agricultural extension services
117 (51.50%) and loans (43.50%). Cotton and onion are the only cash crops. To ensure their daily survival,
118 they practiced polyculture (93.80%), increased income-generating activities (65.50%) and practiced
119 subsistence agriculture (79%). The school enrollment rate is the lowest in the country (57%), with
120 39.30% who achieved the primary, 17% the secondary, and less than 1% (0.4%) the higher education.
121 Health, road and school infrastructure are among the least-off of the country.

122 **3.2. ICTs' general characteristics and sorghum farmers' access**

123 **3.2.1. ICTs' types, identities and general characteristics**

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

126 **Table 1:** ICTs' types and identities

Types of ICTs		
Radio stations	Mobile phone	Agricultural magazines
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		

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

138 **3.2.2. Coverage of the study area by the different ICTs**

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

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Figure 2: Coverage of the study area by radio

All 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 are the only to cover all sites.

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Figure 3: Coverage of the study area by mobile telephony

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 sites away from the regional capital (rural area).

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157 **Figure 4:** Coverage of the study area by agricultural magazines

158 In terms of agricultural magazines, study sites have coverage rates of between a minimum of one
159 magazine per site (majority) and a maximum of four per site, with a trend towards concentration of
160 sites better served in the western part of the division. The SODECOTON magazine (INFOS CNPC) is

161 the only magazine that covers all sites. This is due to the successful deployment of the structure that
162 quadrille the whole division through its various administrative and technical divisions.

163 **3.2.3. Sorghum farmers' access to the different ICTs**

164 In general, in order to understand farmers' access to the different ICTs, we relied primarily on two
165 types of analysis:

166 -The comparison of the global (overall) farmers' access to the various communication channels.
167 By global access to a channel, we mean here the total number of people with access to that channel.

168 -The comparison of these farmers' access to the different ICTs according to a certain number of
169 criteria, including the frequency of access to the ICTs, the number of accessible ICTs, the identity of
170 ICTs, and the broadcast languages of agricultural information.

171 The following Figure 5 gives an idea of the farmers' global access rate to the various communication
172 channels.

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174 **Figure 5:** Sorghum farmers' global access rate to the communication channels

175 Overall, interpersonal channels remain the most used communication channel. According to the
176 WB (World Bank) and IFPRI (International Food Policy Research Institute) cited by [Meinzen-Dick et al. \[8\]](#), recent studies
177 have shown that among these interpersonal channels, public extension services through field visits,
178 remain the main distribution channels for agricultural information, despite the important role played by
179 private services and community networks. This is quite logical in that this group of communication
180 channels begins its influence from the first moments of our existence.

181 Among the ICTs, radio appears as the main ICT in terms of use or farmers' global access to
182 communication channels, followed by the phone. [Meinzen-Dick et al. \[8\]](#) believe that it is the first form of electronic
183 communication for the poor because it allows them to cross the barriers of isolation and illiteracy.
184 Indeed, according to [Fraser and Restrepo Estrada \[9\]](#), 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
185 been included in their study.

186 In terms of farmers' overall access to ICTs therefore, radio appears as the most used ICT by
187 farmers.

188 The following tables 2, 3, 4 and 5 present successively the results of the comparison of different
189 farmers' access to ICTs according to the frequency of access, the number of accessible ICTs, the
190 identity of accessible ICTs, the broadcast languages of agricultural information.

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195 Table 2: Percentage of farmers' access to ICTs according to their frequency of access

Frequency of access to radio stations	Percentage (%)	Frequency of access to phone networks	Percentage (%)	Frequency of access to agricultural magazines	Percentage (%)
1 jr/semaine	14,35	1 jr/semaine	02,53	1 fois/an	52,51
2 jrs/semaine	16,01	2 jrs/semaine	05,98	2 fois/an	20,67
3 jrs/semaine	23,49	3 jrs/semaine	07,36	3 fois/an	12,29
4 jrs/semaine	18,10	4 jrs/semaine	09,88	4 fois/an	08,38
5 jrs/semaine	09,81	5 jrs/semaine	32,64	5 fois/an	06,15
6 jrs/semaine	10,60	6 jrs/semaine	24,37		
7 jrs/semaine	10,29	7 jrs/semaine	16,55		

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197 Both for radio, as for agricultural magazines, the majority of farmers belong to the lowest access
198 frequency bands. As for radio, it could be that farmers lack time to devote to listening, especially since
199 they do both various income-generating activities to survive. According to [Assigbley](#) [11] and [Emenyeonu Nnamdi](#) [10], the main
200 reasons for the talk radio access frequency are among others, broadcast schedules agricultural
201 information, the low involvement of farmers and journalists in the choice of themes and program
202 development, low purchasing power, lack of time to monitor the radio, the lack of interest, lack of
203 electricity, maintenance of the inability of the radios, but also the character informal broadcasting
204 contracts. According to the results obtained by [Fraser and Restrepo Estrada](#) [9], the main reasons explaining the low access
205 frequency to radio are among others in order of importance, the low purchasing power, the lack of time
206 to monitor radio, the lack of interest, the lack of electricity, and the radio maintenance disability. In
207 terms of agricultural magazines, the problem would be at several levels: the unavailability of
208 magazines over a good period of time during the year following delivery problems (roads, number of
209 subscribers), lack of financial means to acquire more frequently the magazines, language and
210 translation constraints, especially for SODECOTON agricultural newsletter (INFOS CNPC), which is
211 freely distributed yet. According to the results obtained by [Fraser and Restrepo Estrada](#) [9], the main reasons for the fable frequency
212 of access to agricultural magazines are among others in order of importance, illiteracy, lack of access,
213 and low power purchase.

214 Concerning telephone contrary, the access rates are higher for the higher frequency bands. That
215 means the time spent by farmers who have access to telephone, to access information is more
216 important than the one spent to access information through radio or agricultural magazines. Logically,
217 if there is a linear relationship between the time spent to access to agricultural information and the
218 amount of information received, the phone would override radio and agricultural magazines in the
219 dissemination of agricultural information. This could be explained by the facts that unlike radio and
220 agricultural magazines rather transmit information, the phone allows both transmitting and receiving
221 the information needed in a short period of time. It is used to solve all socio-economic activities
222 concerns, hence the high utilization rates.
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228 Tableau 3: Frequency of farmers' access to ICTs according to the number of ICTs

Number of radio stations	Access Frequency	Number of Phone networks	Access Frequency	Number of Agricultural magazine	Access Frequency
1	162	1	55	1	94
2	313	2	127	2	37
3	4	3	223	3	22
4	2	4	30	4	16
5	1			5	10

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 230 The percentage of farmers with access to a small number of radio and agricultural magazines is
 231 important. As for radio, it could be justified either by the nature of the information sought by farmers
 232 (which are broadcasted by these radio stations only) or information broadcast languages, or the ease
 233 of access to these radio stations. For the agricultural magazines also, this could be explained either by
 234 the nature of the information provided or by the ease of access to these magazines. Contrary, for the
 235 phone, the interest shown by the majority of farmers to a large number of telephone networks could be
 236 explained either by the coverage of the area by a large number of telephone networks or by the fact
 237 that they are looking for specific benefits offered by phone networks operators.

238 Tableau 4: Frequency of farmers' access to ICTs according to ICTs' identity

Radio stations	Frequency of access	Phone networks	Frequency of access	Agricultural magazines	Frequency of access
FM Maroua	480	MTN	397	La voix du paysan	87
FM Yaoundé	317	ORANGE	419	Infos CNPC	97
Mesquine community radio	02	NEXTELL	259	Bulletin du CDD	01
FM Yagoua	06	CAMTEL	31	Bulletin agricole	00
				INADES	
Mora community radio	6				
Dana community radio	01				

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 240 FM Maroua and FM Yaoundé appear as the most requested radio, probably because of their ease
 241 of access, as when referring to Figure 2 dealing with sites coverage by radio, it appears that they are
 242 the only radio stations that cover the entire study area. For the phone, apart from CAMTEL network, all
 243 the others are well solicited because they are accessible in the majority of sites. NEXTELL network

244 particularly, has been quickly adopted in a short period of time by a large number of farmers, probably
245 because of some of its advantages, but especially its accessibility even in the remotest areas. Among
246 agricultural magazines, “INFOS CNPC” of SODECOTON and “La Voix du Paysan” of SAILD are the
247 only real sources of farmers’ agricultural information. The magazine “La Voix du Paysan” is surely
248 imposed for its diversity and quality of agricultural information, well appreciated by most of the farmers,
249 while “INFOS CNPC”, which broadcasts mainly information related to the cotton cultivation, and to a
250 lesser measurement to cereal crops, has become more accessible due to its strong extension and its
251 free distribution by SODECOTON agents, crisscrossing the entire study area.

252 Tableau 5: Frequency of farmers' access to ICTs according to broadcast languages

Radio stations	Frequency of access	Phone networks	Frequency of access	Agricultural magazines	Frequency of access
French	1	French	5	French	74
Local languages	99	Local languages	162	Local languages	24
French and Local languages	381	French and Local languages	268	French and Local languages	138

253 Languages are another very important aspect of agricultural information dissemination through
254 ICTs towards farmers. Whether for radio, telephone or agricultural magazines, the majority of farmers
255 are more interested in ICTs that provide access to agricultural information both in French and local
256 languages. That means the more an ICT provide access to information through a variety of languages,
257 the more it will be sought. Between ICTs that disseminate information either in French or in local
258 languages, farmers prefer those broadcasting in local languages. This could be justified by the low
259 rate of school enrollment of people in the region. Indeed, [Meinzen-Dick et al. \[8\]](#) believed that local languages and
260 expressions are the raw material that feeds community radios; they are the cement of cultural
261 diversity, which is as important to the future survival of humankind as biodiversity.

263 **3.2.4. Order of preference of ICTs by sorghum farmers**

264 We sought here to know the order of preference granted by farmers to the various ICTs, in order
265 to understand their real motivation and the main ICTs’ features they need.

266 The results of the order of preference for the various ICTs by these farmers are listed in Table 6
267 below.

268 Table 6: Order of preference of ICT given by farmers

Codings	ITC Preference	Mean Rank	Rank	Test	
PRERADIO	Prefer Radio	1,65	1	N	600
PRETELEVI	Prefer Phone	2,10	2	W of Kendalla	,096
PREREVAG	Prefer	2,25	3	Khi-square	115,358
	Agricultural magazines			Degree of freedom	2
				Asymptotic Significance	,000

Radio appears as the farmers’ preferred ICT in the area, followed by phone, and agricultural magazines.
We tried to look for the three main reasons for preference of radio compared to the other ICTs, and the results are shown in Table 7 below.

Table 7: The three main reasons for the preference of the radio

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

An analysis of the reasons given by farmers identifies two main advantages offered by the radio compared to other ICT that are sought by these farmers: the diversity of information dissemination languages and the diversity of information disseminated. 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) [11].

The radio is considered here as a communication channel, and its main features interesting farmers include: the diversity of information dissemination languages and the diversity of information disseminated. The preference by farmers of ICTs that disseminate information both in French and local languages (Table 5) is quite justified. The phone appears particularly more solicited than the other ICTs by those farmers who favor information exchange in local languages. In addition to the variety of information dissemination languages, these farmers are also looking for ICTs that broadcast a variety of information.

Since radio appears as the most used (Figure 5) and the farmers’ most favorite ICT (Table 6), we can conclude that our hypothesis H1 holds, and is therefore accepted.

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 region, local and national vulnerabilities and adaptation options available to reduce it [13].
Table 8 below summarizes the water constraints engendered by climate variability in the rainy season and dry season sorghum production, and the coping strategies used by farmers.

306 Table 8. A: Water stress (constraints) engendered by climate variability in the production of rainy
307 season and dry season sorghum

Water stress	Rainy season sorghum		Dry season sorghum	
	Total	Percentage (%)	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

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309 Most of the water constraints mentioned here by farmers are drought-related, not excess water
310 (flooding): drought is therefore the primary water stress limiting agricultural production in the area.

311 All the three known forms of droughts are represented here:
312 -the meteorological drought (late rains, dry spells, reduced total amount of rainfall, early cessation
313 of rains);
314 -the agricultural drought (fast drying and hardening of soils, no haze during cold season);
315 - the hydrological drought (rapid drying of water sources).

316 According to the FAO and the National Drought Mitigation Center (NDMC), when all these three
317 types of droughts occur anywhere, automatically, socioeconomic drought appears there as their logical
318 consequence.

319 All water constraints affecting rainy season sorghum also affect dry season sorghums. This
320 reflects the strong dependence of dry season sorghum on the meteoric waters. The multiplicity of
321 water constraints affecting dry season sorghum is due to the diversity of water resources (meteoric,
322 surface water, ground water) necessary for their production.

323 Similarly, the high rate of perception of water stress by farmers reflects both the breadth and depth
324 of these constraints, but also the perfect understanding of phenomena by farmers who master their
325 environment. This confirms once again as stated by Arodokoun [14], that in general, farmers' communities that have
326 close ties with their environment have a perfect knowledge of the climate, its manifestations and

327 consequences. Moreover, these farmers are among the most vulnerable who are living in fragile
328 ecosystems like Sudano-Sahelian area perceive more natural phenomena going on in their
329 environment [15];[16].

330 To continue to ensure their survival, farmers in this region have adopted or developed a variety of
331 coping strategies, which are summarized in Table 9 below.

332 Table 9. A: Sorghum farmers' adaptation strategies to water stress and their adoption rates

Adaptation strategies	Rainy season sorghum Total Percentage (%)		Dry season sorghum Total Percentage (%)	
Sowing early matured varieties	13143,67		17558,33	
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	-	-	107	35,67

nurseries				
	Cleaning and deepening of ponds	-	-	13160,33
	Water research over long distances	-	-	9531,67
	Fertilization of transplanting water	-	-	0602
333	Observation of adaptation strategies in use by sorghum farmers raises three main points:			
334	-the farmers in the area use a variety of coping strategies that are mostly traditional;			
335	-use of irrigation, which is nevertheless an effective coping strategy for both rainfed crops and dry			
336	season crops, is not part of the farmers' coping strategies in the area, while droughts are the major			
337	water stress, far ahead of flooding [15]; [5].			
338	-adoption of adaptation strategies by farmers is relatively low, except for some two or three			
339	strategies; Obviously, according to Nhemachena and Hassan [17], and then Yesuf et al. [5], all of the case studies conducted in developing			
340	countries have noted that there is a serious adaptation deficit.			
341	Overall, we can classify these coping strategies both on the basis of farmers' practices and on that			
342	of agricultural research. Depending on the angle of farmers' practices, we will quote rankings done by			
343	[18], then by Bryant et al., André et al., Senna et al., Ouranaos, Adjamagbo et al., Rousseau et al.,			
344	and Dia Toure, cited by [19]. On contrary, depending on the angle of agricultural research, we have the			
345	grouping suggested by [20].			
346	On the basis of farmers' practices, Nhemachena and Hassan [18] estimated that there are basically two types of strategies in			
347	agricultural production systems:			
348	-the first is the increased diversification that corresponds to the adoption of production activities			
349	that are drought tolerant and resistant to thermal stress, who value the amount of water available and			
350	the ambient temperature and other factors, as well as activities related to their efficient management;			
351	-the second strategy focuses on management practices that include avoiding crops critical stages			
352	of plant growth not coincide with adverse weather conditions such as droughts offseason (modification			
353	of the crop cycle, change of planting and harvesting dates).			
354	Bryant et al., André et al., Senna et al., Ouranaos, Adjamagbo et al., Rousseau et al., and Dia			
355	Touré, cited by [19], Meanwhile , estimates that farmers adaptation strategies to climate variability can			
356	be divided into three main groups based on Fabre [19]:			
357	-the choice of crops (species, varieties);			
358	-the changing practices (irrigation and drainage, polyculture, changes in cropping calendar);			
359	-the modification of income generating-activities (crafts, farming, trade ... etc).			
360	According to Dingkuhn [20] the areas of agricultural research were grouped based on the adaptation			
361	strategies into four distinct types:			
362	-the genetic adaptation (drought resistant varieties, early maturing varieties);			
363	-the agricultural adaptation (all adaptation strategies related to crop management, which are the			
364	most numerous);			
365	-the geographical adaptation (temporary or permanent transfer of crops);			
366	-the temporal adaptation (early sowing, late planting, nursery timing);			
367	To this grouping proposed by Dingkuhn [20], we could add the socioeconomic adaptation (diversification of			
368	income-generating activities).			
369	Overall, it appears that all the coping strategies used by both dry season and rainy season			
370	sorghum farmers are found in at least one of the major coping strategies' groups described above.			
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373 **5. ICTs’ contribution to the diffusion of agricultural information related to water stress**
374 **adaptation strategies**

375 **5.1. Sorghum farmers’ perception of ICTs’ contribution to their access to agricultural**
376 **information related to water stress adaptation strategies**

377 In general, it has been shown that farmers' access to new agricultural information plays an
378 important role in improving the adoption of agricultural innovations (Kabuli 2014). By agricultural
379 information related to water stress adaptation strategies, we mean all the agricultural information
380 diffused towards farmers for their adaptation to water stress; this agricultural information could fall
381 within the area of climate predictions, coping strategies or post-harvest activities (food storage,
382 outlets).

383 The evaluation of ICTs’ contribution to diffusion of agricultural information related to water stress
384 adaptation was based on the estimation of the following two parameters:
385 -the sorghum farmers’ perception of the overall contribution of ICTs to their access to agricultural
386 information;
387 -the sorghum farmers’ perception of the order of importance of ICTs’ contribution to the diffusion of
388 agricultural information related to water constraints adaptation strategies.

389 The following figure 7 gives an idea of the farmers’ perception of the overall ICTs contribution to
390 their access to agricultural information.

391

392 **Figure 7:** Farmers’ perception of the overall ICTs’ contribution to their access to agricultural
393 information

394 A significant majority of the farmers (507/600) recognizes that ICTs have contributed to their
395 access to agricultural information. According to the results of a study conducted by [20] in Kano state
396 in Nigeria, the vast majority of farmers surveyed (72.20%) agree that ICTs contributed effectively to
397 diffusion of agricultural information in their locality.

398 In terms of farmers’ perception of the order of importance of ICTs’ contribution to diffusion of
399 agricultural information related to water stress adaptation strategies, the results obtained with the W
400 Kendall test of agreement, are shown in Table 8 below.

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Table 8. B: 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	
Radio as main source of diffusion	2,78	3	N	600
Telephone as main source of diffusion	3,49	4	W of Kendall ^a	,403
Agricultural magazine as main source of diffusion	2,13	2	Khi-square	725,843
Interpersonal communication channels as main source of diffusion	1,60	1	Degree of freedom	3
			Asymptotic	
			Significance	,000

Interpersonal communication channels, despite their many shortcomings, are recognized here as the main provider of agricultural information related to water stress adaptation strategies. Clarke and Akinbode cited by [10], after conducting a survey with farmers in southern Nigeria, found that interpersonal communication channels were the farmers' primary source of agricultural information. [4], in their work, went further by saying that within interpersonal communication channels, the circle formed by parents, brothers, friends, opinion leaders contributes more to farmers' access to agricultural information. In contrast to these results, according to a study conducted by Monu and Omole cited [10] with cocoa farmers in Nigeria, 75% of farmers said they had access to agricultural information through radio, 51% through interpersonal communication channels, and only 0.8% through television. Similarly, according to the work of Dingkuhn [20] in the Kano state (Nigeria), 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 (Figure 2) and the most preferred ICT by farmers (Table 6), 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 after a work with Indian farmers by Mirza [4], 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 broadcasts generally agricultural information less than agricultural magazines (which is the case now, because the magazines essentially broadcast agricultural information); or radio broadcasts less than magazines, the agricultural information needed by farmers; or the broadcasting information format used by the radio does not interest farmers, because according to the study conducted by Dingkuhn [20] in northern Nigeria, broadcast format is very important (threads 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.

Since it is rather the agricultural magazines that are perceived by farmers as the ICT which has contributed most to diffusion of agricultural information related to water stress adaptation strategies, we can say that our research hypothesis H2 is not verified, and is rejected.

441 **5.2. Relationship between the total number of accessible ICTs, the frequency of**
442 **access to ICTs and the improvement of agricultural knowledge in relation to water**
443 **stress adaptation strategies**

444 This is to find out whether there is a correlation between the total number of ICTs accessible to
445 sorghum farmers, and their access frequency to these ICTs one hand, and their agricultural
446 knowledge (related to water stress adaptation strategies) improvement.

447 Table 9 below gives the results of the correlation between the total number of accessible ICTs and
448 sorghum farmers' agricultural knowledge improvement (in relation to water stress adaptation
449 strategies) using the chi-square test.

450 Table 9. B: Results of the correlation between the total number of accessible ICTs and the
451 improvement of sorghum farmers' agricultural knowledge (related to water stress adaptation
452 strategies)

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

453 The total number of ICTs accessible to sorghum farmers in the area is highly correlated with the
454 improvement of their agricultural knowledge in relation to water stress adaptation strategies. In other
455 words, the more a farmer has access to a large number of ICTs, the greater the chance or opportunity
456 to improve his knowledge related to water stress adaptation strategies. This result is consistent with
457 that obtained by [Arodokoun \[14\]](#) in his work carried out with cotton farmers in rural areas of central Benin. It is
458 assumed in this case that all the ICTs accessible to farmers in the area diffuse a large amount of
459 agricultural information in connection with water stress adaptation strategies.

460 Table 10 below shows the estimate of the correlation between the access frequency of farmers to
461 ICTs and the improvement of their knowledge related to water stress adaptation strategies using the
462 chi-square test.

463 Table 10: Results of the correlation between the sorghum farmers' frequency of access to ICTs and
464 the improvement of their agricultural knowledge related to water stress adaptation strategies

Variables	Khi-deux	Degré de liberté	p-value
FRERADIO			
(Radio frequency access)	295,954	21	,000
FRETELEP			
(Access frequency the phone)	364,875	21	,000
FREREVAG			
(Frequency of access to agricultural	541,176	18	,000

journals)

The farmers' frequency of access to ICTs in this area is highly correlated to the improvement of their agricultural knowledge in relation to water stress adaptation strategies. That said, most frequently a farmer has access to ICTs, the greater the amount of agricultural information related water stress adaptation strategies he acquires.

Since the Chi-square test confirms that the total number of ICTs accessible to farmers, as well as their frequency of access to ICTs are highly correlated to the improve of their agricultural knowledge in relation to water stress adaptation strategies, we can say that our research hypothesis H3 is verified, and therefore accepted.

5.3. Effective ICTs’ contribution to the diffusion of water stress adaptation strategies used by the sorghum farmers

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

Table 11 below summarizes the diffusion frequencies of each adaptation strategies used by sorghum farmers through each ICT.

Tableau 11: Diffusion frequencies of each adaptation strategies used by sorghum farmers through each ICT

TIC Stratégies d’adaptation	Radio	Téléphone	Revues agricoles	Canaux interpersonnels
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-	0	340	2	377
generating activities				
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	1	103	1	203
nurseries				
Scaling of nurseries over the	1	203	0	110
time				
Organic or inorganic	5	112	3	181
fertilization of nurseries				
Cleaning and deepening of	1	177	1	94
ponds				
Water research over long	1	90	1	0
distances				
Fertilization of transplanting	0	0	0	5
water				
Rocky bunds	0	0	0	5

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Generally, interpersonal communication channels on one hand, and the telephone on the other hand, are the main diffusion channel of the adaptation strategies currently in use by sorghum farmers in the area. It is also important to note that one of the common link between the two main communication channels is that they both favor direct exchanges between agricultural actors, more than the others (radio, agricultural journals). Indeed, according to [Inter-Réseaux](#) [22], during an innovation diffusion symposium held from 22 to 26 March 2004 in Segou (Mali), all the participants particularly underlined the fact that both interpersonal communication channels and ICTs should favor direct exchanges between farmers, between innovation actors and between farmers' in order to facilitate dissemination of agricultural innovations. Since direct exchanges between actors are usually facilitated through the use of local languages because of the illiteracy of the majority of farmers, it is clear that interpersonal channels and telephone are the only channels that promote such direct exchanges between actors. Obviously, according to [Ba et al.](#)[23], rural farmers are illiterate and do need absolutely communication channels that take into account this aspect of direct exchanges.

For the interpersonal communication channels, it is quite logical they have contributed more than other communication channels to the dissemination of agricultural innovations. This is because, either for farmers' rates of access to communication channels, or for the contribution of communication channels to the dissemination of agricultural information in related to water stress adaptation strategies, they were ranked first by the farmers. According to [Inter-Réseaux](#) [22], it is usually in the case of farmers' agricultural innovations that interpersonal channels play an important role in the diffusion process. This seems to be the case as most of these coping strategies seem to emanate largely from farmers' initiatives.

We could say that interpersonal communication channels constitute with the phone, one of the most efficient in the dissemination of water stress adaptation strategies in use by sorghum farmers in the area.

Concerning the phone, a synthesis of all the previous results leads us to make the following remarks:

- depending on the overall rate of use of communication channels by farmers (Figure 5), the phone is the third communication channel, and the second ICT behind the radio;
- depending on the order of preference of ICTs given by farmers (Figure 6), the phone is the second ICT behind the radio;
- depending on the order of importance of ICTs' contribution to the dissemination of agricultural information related to water stress adaptation strategies (Table 8), the phone was ranked fourth, behind all the other channels.

The fact that the phone has contributed curiously more than the other ICTs to the dissemination of the adaptation strategies in use by farmers, could also be explained through the following elements from the results of these analyzes:

- the frequencies of access to agricultural information through the phone are higher for the higher frequency ranges (Table 2); meaning that the amount of agricultural information exchanged through the phone by those who have an access, is very important; which corroborates the results of the correlation between the frequency of access to ICTs and the improvement of agricultural knowledge in relation to water stress adaptation strategies (Table 10).
- the frequency of access to agricultural information is higher for large numbers of telephone networks (Table 3); which means that the possibilities of interconnections, and therefore the exchange of agricultural information between stakeholders in the agricultural sector (farmers, extension agents, researchers) are more important with the phone than with the other ICTs; which means once again that the amount of agricultural information exchanged through the phone by those who have an access, is very important; which further corroborates the results of the correlation between the total number of accessible ICTs and the improvement of agricultural knowledge in relation to water stress adaptation strategies (Table 9).
- the number of the most used telephone networks is three for the phone, when it was only two, both for radio and for agricultural magazines (Table 3); which further corroborates the results of the correlation between the total number of accessible ICTs and the improvement of farmers agricultural knowledge in relation to water stress adaptation strategies (Table 9).
- the most important use of local languages by phone users during agricultural information exchanges (Table 5), reflects the large amount of information exchanged, but also the ease (easy) of the exchanges through phone.

Based on these analyzes, we could say that the phone is the main ICT in the dissemination of water stress adaptation strategies in use by sorghum farmers. Thus, our research hypothesis H4 is not verified and is therefore rejected.

Conclusions

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

- radio is the most used and most preferred ICT by sorghum farmers, while agricultural magazines are perceived by sorghum farmers as the most effective ICT for dissemination of agricultural information in relation to water stress adaptation strategies;
- the total number of ICTs accessible to farmers and their frequency of access to these ICTs influence significantly and positively the improvement of farmers' agricultural knowledge in relation to water stress adaptation strategies;

550 -the phone is the most effective ICT in the dissemination of water stress adaptation strategies
 551 currently in use by sorghum farmers;
 552 -the main ITCs' characteristics (features) sought by sorghum farmers include the diversity of
 553 agricultural information broadcast languages, the diversity of agricultural information broadcasted, and
 554 the capacity of facilitating direct exchange between agricultural sector's actors.

555 Recommendations

556 Since improvement of people's food security in the study area requires absolutely massive access
 557 of these sorghum farmers to ICTs, and intense diffusion of agricultural innovations to and between
 558 farmers through ICTs, we recommend the following actions:
 559 -the radio operators should focus their agropastoral broadcasts more on farmers' real information
 560 needs and conveniences (content, format, schedules);
 561 -agricultural magazines operators, especially those of "La Voix du Paysan", should try to extend
 562 their coverage in the rural areas, and propose attractive measures to farmers;
 563 -mobile phone operators must work together with the other stakeholders (farmers, researchers,
 564 journalists, policy makers) to incorporate agricultural information's diffusion in their agenda and daily
 565 activities, as it is done in southern Cameroon and eastern Africa;
 566 -the dissemination of agricultural information through ICTs in general (Radio, Telephone,
 567 agricultural magazines) must incorporate the aspect of language diversity and diversity of agricultural
 568 information, after having correctly identified farmers' real information needs and conveniences;
 569 -the different stakeholders of the agricultural sector, particularly farmers and journalists, must be
 570 integrated into the wide agricultural innovations' dissemination process through ICTs, from the
 571 diagnostic phase to the implementation through planning;
 572 -the rural areas' rate of coverage by ICTs, so as the agricultural information diffusion frequency
 573 through ICTs, must be improved;
 574 -agricultural information diffusion through ICTs should be integrated into the national agricultural
 575 policies and the ICTs' operators' agendas.
 576

577 References

- 578 [1] CEDC 2010, Regional Plan Director of Planning and Territorial Development (SRADDT) MINDAT,
 579 Yaoundé
- 580 [2] WFP 2005, Assessment mission report food shortage in the province of the Far North Cameroon,
 581 WFP Garoua.
- 582 [3] L'Hôte, Y 2000, 'Climatologie', Seignobos, C et Iyébi-Mandjek, O (eds), Atlas de la province de
 583 l'Extrême-Nord Cameroun, Editions IRD, IRD, Paris, Pp :1-12.
- 584 [4] Mirza, J, Khalid, S et Sakhwat, A 2011, 'Role of communication in diffusion and adoption of
 585 agricultural innovations', Gomel University Journal of Research, 27 (1), Pp: 111-118.
- 586 [5] Yesuf, M, Di Falco, S, Deressa, T, Ringler, C and Kohlin, G 2008, The impact of Climate Change
 587 and Adaptation on Food Production in Low-income Countries: Evidence from the Nile Basin(Ethiopia),
 588 IFPRI discussion paper number 00828, IFPRI, Addis Ababa.
- 589 [6] SOCPA, A and Mballa, A 2004 Vulnerability to food insecurity in rural areas in the provinces of
 590 North and Far North of Cameroon, VAM Survey 2004, WFP, Yaounde
- 591 [7] FAO, 2009, Report I Panorama on food and agricultural statistics, FAO, Rome.
- 592 [8] Meinzen-Dick, R et al. 2011, Engendering Agricultural Research, Development, and Extension,
 593 IFPRI, Washington.
- 594 [9] Fraser, C. and Restrepo Estrada, S 1991, Community Radio Handbook, UNESCO, Paris.
- 595 [10] Emenyeonu Nnamdi, B 1987, 'Communication and adoption of agricultural innovations:
 596 quantifications and notes towards a conceptual model', Africa Media Review, Vol. 1, No. 2, 105-119.

- 597 [11], Y 1997 Project communication for rural areas in Cameroon: Impact Assessment, Case
598 Study, IDRC, Lomé.
- 599 [12] Vendramin, P. and Valenduc O 2002, 'The diffusion of innovations: the internet case' emerit letter,
600 Second Quarter 2002, Issue 32, pp: 1-8.
- 601 [13] FAO and NDMC 2008, A review of drought occurrence and monitoring and planning activities in
602 the Near East Region, FAO, Rome.
- 603 [14] Arodokoun, THE 2011 'Socio-economic impact of the use of ICTs in adaptation strategies to
604 climate change in rural areas: the case of cotton farmers in Benin Centre', Thesis for graduation of
605 Agronomist, University of Abomey, Abomey.
- 606 [15] Ouedraogo, M, Dembele, Y, and Soné Leopold 2010, 'perceptions and strategies to adapt to
607 changes in precipitation: the case of Burkina Faso farmers' Drought, Volume 21, Number 2, pp: 87-96
608 .
- 609 [16] Agossou, DSM, Tossou, CR, Vissoh, VP, Agbossou, KE, 2012, 'Perception of climate disruption,
610 local knowledge and coping strategies of Beninese farmers' African Crop Science Journal, Volume 20,
611 Number 2, pp: 565-588.
- 612 [17] Leary N, Kulkarmi J and Seipt C 2007, Assessments of impacts and adaptation to climate change:
613 Summary of the final report of the AIACC project, Editions START, Washington.
- 614 [18] Nhemachena C and Hassan, R 2007, Micro-level analysis of farmers' adaptation to climate change
615 in southern Africa, IFPRI discussion paper 00714, IFPRI, Washington.
- 616 [19] Fabre, C. 2011. Adaptation of subsistence farmers to climate variability ', Paper presented for
617 obtaining a Master's degree in Agronomy, USAD Dakar.
- 618 [20] Dingkuhn, M 2009, 'Adapting crops to climate change', Caron P (eds), Climate change and
619 agriculture: the environment and food safety at stake, CIRAD, Paris, pp: 6-7.
- 620 [21] Ango, AK, Illo, AI, Abdullahi, AN, Maikasuwa, MA, etAmina, A 2013, 'Role of Farm-radio
621 Agricultural Programmes in Disseminating Agricultural Technology to Rural Farmers for Agricultural
622 Development in Zaria, Kaduna State, Nigeria', Asian Journal of Agricultural Extension, Economics and
623 Sociology, Vol. 2, No. 1, Pp: 54-68.
- 624 [22] Inter-Réseaux, 2014, 'The sustainability of innovations' Grain of Salt, Special Issue, pp: 19-20.
- 625 [23] Ba, Mbow. AF et al, 2009, 'Climate change, between resilience and resistance', LEISA Magazine,
626 Volume 25, Number 4, pp. 4-5.

627 **Abbreviations**

628 FM: Frequency Modulation
629 INFOS: Informations (Information)
630 CNPC: Confédération Nationale des Producteurs de Coton du Cameroun (National Confederation of
631 Cotton Producers of Cameroon)
632 NDMC: National Drought Mitigation Centre
633 CDD: Comité Diocésain de Développement (Diocesan Development Committee)
634 CRTV: Cameroon Radio and Television
635 RR: Radio Rurale (Rural Radio)
636 Ydé: Yaoundé (Cameroon Capital City)
637 BA: Bulletin Agricole (Agricultural Magazine)
638 SODECOTON: Société de Développement du Coton (Cotton development Corporation)
639 CAMTEL: Cameroun Telecommunications
640 MTN: Mobile Telephone Networks
641 ORANGE: Cameroonian Mobile telephone Operator
642 NEXTELL: Vietnamese Mobile Telephone Operator settled in Cameroon

643 SAILD: Service d’Appui aux Initiatives Locales de Développement (Local Development Support
644 Service’ Initiatives)
645 ICTWCC: Information and Communication Technologies, Water and Climate Change
646 IDRC: International Development and Research Centre
647 CODESRIA: Conseil pour le Développement de la Recherche en Sciences Sociales en Afrique
648 (Council for the Development of Social Science Research in Africa)

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