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Farmers Awareness and Adaptation to Climate Change in Kaffrine Region of Senegal

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Abstract
Climate change is a global critical issue that threatens the livelihood of most farmers, particularly in the developing countries. This study investigates farmers' awareness and adaptation to climate change in Kaffrine Region of Senegal. The study involved a cross-sectional survey of 204 farmer household heads, selected from nine communities through a multi-stage sampling technique. Additional data was collected from 9 focus group discussions and 8 key informant interviews. The results of the study reveal that 64.7% of the respondents were aware of climatic change with an average awareness index of 0.5903 (59%). This indicates that farmers in the study area are fairly aware of the changing climate. Also, a large number of surveyed farmers representing (90%) responded to the changing climate by employing one or more adaptation strategies such as growing early maturing varieties, crop diversifications, using different planting dates, using chemical fertilizers, practicing crop rotation among others. The study suggests that the government of Senegal should develop more effective climatic change adaptation strategies as well as improve dissemination of information to farmers through extension officers in order to increase adoption of effective climatic change adaptation strategies. It would be crucial that farmers collaborate to form farmer organization to enable them have easy access to farm inputs and training on climate change in order to reduce their vulnerability and increase their resilience to the changing climate.
Keywords: Senegal, Climate Change, Climate Change Awareness Index, Adaptation

1. Introduction

Climatic change is one of the most critical challenges facing the global community today. According to the Intergovernmental Panel on Climate Change (IPCC) the average global temperature has increased with many unprecedented changes observed over decades to millennia (IPCC, 2013). Human activities such as deforestation, burning of fossil fuels, among others are the principal causes of the current changes in climate (IPCC, 2007c). As stated by IPCC (2007a), although the impact of climate change is global, Africa is one of the regions that are most affected by the changing climate due to the vulnerable nature of the continent in terms of climate variability and climate change.

Climate predictions for the African Sahel indicate increases in average rainfall, rising temperatures, higher frequency of extreme events, and greater evapotranspiration (IPCC, 2014). Agriculture is the most important source of livelihood for millions of people in Africa (Denkyirah *et al.*, 2017). The erratic rainfall, coupled with increase in temperature tend considerably affect agriculture, particularly in tropical regions where the reduction in low agricultural yields and land quality have been reported (IPCC, 2007a). The evidence that climate change will adversely affect agriculture in sub-Sahara Africa (SSA) has become a crucial challenge for sustainable development of the continent. Generally, losses in the agriculture sector due to climate change causes wide economic consequences such as loss in gross domestic output, a decline in the income or consumption of the most vulnerable population; hence, a general deterioration in households' welfare (Juana *et al.*, 2013). Africa is at the tip of the spear of climatic change impacts mainly due to the interactions of multiple stressors, including extreme poverty, over-dependence on rain-fed agriculture, insufficient public spending on rural infrastructure, poor data availability and quality, and knowledge gaps (IPCC, 2007 and UNEP, 2005).

Senegal is a lower middle income country with the agricultural sector accounting for 17.5% of the GDP in 2013 (FAO, 2015). The agricultural sector remained the primary means of livelihood for 69% of the workforce in 2013. Regarding agriculture, the sector has been facing major challenges that have weakened its proper development and vulnerability to climatic shocks, with high risks of drought (République du Sénégal/PSE, 2014). The Senegalese agricultural sector primarily comprised smallholder farmers practicing rain-fed agriculture.

Senegal suffers the consequences of climate change, characterized by an increase in temperatures, and reduction and increased variability in rainfall. For instance, average temperatures have increased by 0.9ºC (1.62º F) since 1975, and average rainfall in the 2000- 2009 period fell by 15% compared to 1920-1969 (Funk *et al*., 2012). These changes, combined with population growth, could decrease per capita cereal production by 30% by 2025 (Funk *et al*., 2012), if the government and its development partners do not take measures to ensure effective adaptation to the changing climate in agricultural development programs. Furthermore, climate change is undermining efforts to achieving the goals of the Accelerated Programme for Agriculture in Senegal (PRACAS) on food security and poverty reduction in the country at large by 2035. Globally, climate change may cause the loss of livelihoods, and the onset of food insecurity, and unemployment, thereby increasing Senegal's vulnerability to climate change. Therefore, the rural Senegalese population, mainly depending on rain-fed agriculture, needs to have adaptation skills and great coping strategies in order to survive negative trends, shocks and extreme events of the changing climate (Mertz *et al*., 2009).

To increase climate change awareness in Senegal, diverse climate change awareness programmes and campaigns have been launched by the government and its partners to enable farmers make informed decisions to respond to the changing climate phenomenon (McKune & Serra, 2016). However, there appears to be little empirical evidence on how this awareness is influencing farmers in their response to the changing climate as well as the factors influencing farmers' response to climatic change.

For farmers to respond sustainably to climate change impacts there is the need for them to be more aware of the phenomenon of the changing climate and its impacts on their lives and livelihoods. It is against this knowledge gap that this study seeks to evaluate farmers' awareness and response to climate change as well as the factors that influence their responses to the changing climate in Kaffrine Region of Senegal.

2. Methodology

2.1. Study Area

The study was carried out in three randomly selected districts in Kaffrine Region of Senegal which is located in the central part of the country as presented in Figure 1. The region lies between 14 ° 07 N latitude and 15 ° 32 W longitude, and covers an area of 11181 Km², or 5.6% of the national territory. Kaffrine Region also belongs to the southern groundnut basin of Senegal (agro-ecological zone) which largely contributes to the production of food in the country. Kaffrine Region falls within Sudano-Sahelian zone with an interannual variability of rainfall coupled with less vegetation cover, poor soil fertility and structure compared to the South of the country. The average annual rainfall is, for several years, less than 800 mm (ANSD, 2015). Temperatures in Kaffrine Region are generally high, with significant variations. They oscillate between 26 and 39 ° C with an average of 29 ° C. Over the entire period (from 1931 to 2003), the overall situation of Kaffrine Region is a reduction of water resources because of severe droughts experienced in the past (Mbow *et al*., 2008). Rainfall scarcity and unpredictable onset and intra-seasonal distribution of rains are major problems for rain-fed agriculture which is the main activity of the area and takes place during just 3–4 months per year. Water scarcity is a direct result of the overall decline in rainfall but also to other related hydrological stresses, such as a lowering of the groundwater table and an increase in evapotranspiration as a result of higher temperatures (Mbow *et al*., 2008).

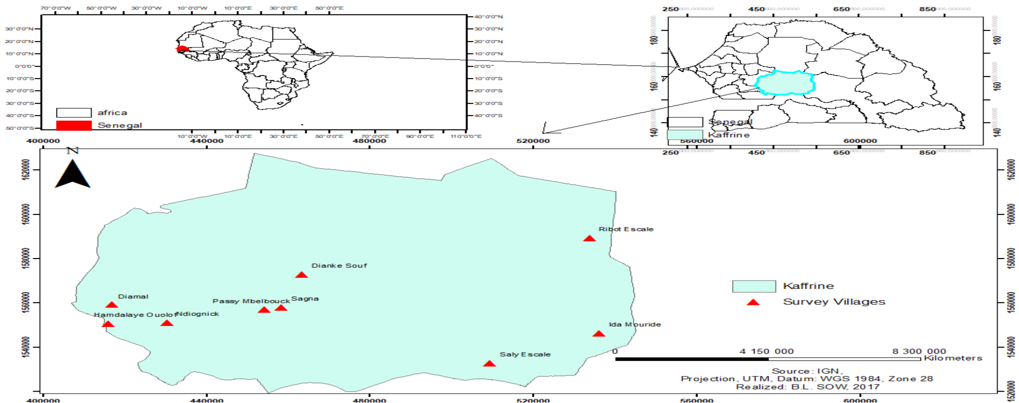

Figure 1: Map of the study area

2.2 . Sampling Techniques and Sample Size

To select respondents for the study a multistage cluster sampling technique was employed. The first stage was the selection of one region in the country. Senegal has fourteen (14) regions, but Kaffrine Region was purposively selected because it is one of the regions which are more affected by unpredictable rainfall, high temperatures and drought in the country, because of significant decline in rainfall during the rainy season since 1960 (Ndiaye *et al.,* 2013; Podestá *et al*., 2013). Also, livelihoods of people in Kaffrine Region are heavily dependent on rain-fed agriculture, Kaffrine's vulnerability to climate-related shock and extreme events is more evident (Ndiaye *et al.,* 2013; Podestá *et al*., 2013). For the second stage, simple random sampling technique was then used to select three districts from the four districts in the region. In the third stage, since communities in the various districts of Kaffrine Region share similar characteristics, three communities were randomly selected from each selected district in the region. For the last stage, simple random sampling technique was used to select households from each selected community as households serve as the sampling units for the entire study. In each selected house one household head was interviewed for the study but in the absence of the household head, any adult member (more than 18 years which is mostly considered as mature age) was interviewed. To compute the sample size for the study the sample size formula established by Krejcie & Morgan (1970) was used (Equation 1). For the entire study 204 household heads were interviewed.

S = X2NP (1-P) /d2 (N-1) + X2 P (1-P) …………………………………………… [1]

Where: S = required sample size

X2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841) that is 1.96 *1.96 = 3.841

N = the population size.

P = the population proportion (assumed to be 0.50 since this would provide the maximum Sample size)

d= the degree of accuracy expressed as a proportion (0.05)

Table 1 indicates the sample size for each selected community that is obtained by dividing the total number of households in each community by the total households for the study (432) and the result value multiplied by 204.

Table 1: Sample for the study

Region	*District*	Communities	Total households	Sampled households	Percentage (%)
Kaffrine Region	*Birkelane*	Keur Elhadji Mor Coumba	29	11	6
		Gama	74	31	15
		Hamdallaye Wolof	12	7	3
	Malèm Hoddar	Medina Dianke	59	26	13
		Mbarocounda	146	73	36
		Passy Mbelbouck	46	21	10
	Koungheul	Diokoul Wadene	10	8	4
		Taiba Nguebanene	12	7	3
		Tawfekh Saloum	44	20	10
Total	**3 districts**	**9 communities**	**432**	**204**	**100**

2.3 . Data Collection and Analysis

To seek information on farmers' awareness, source of climate change information and adaptation strategies, a semi-structured questionnaire was administered to the sampled farmers. To provide more detailed explanations on the data that was collected during farmers' individual interviews, a total of nine Focus Group Discussions (FGD) were conducted for the entire study, one in each village. The method also provided the opportunity to affirm and served as a cross check on the answers from the interview. Quantitative data collected through individual interviews was analyzed with the aid of Statistical Package for Social Sciences (SPSS) version 23.

Climate change awareness index was calculated using three indicators: i) conceptual awareness; ii) experiential awareness; and iii) engagement. According to Gbetibouo & Mills (2012) conceptual awareness is about the individual' knowledge on the human causes of climatic change and their impacts whiles experiential awareness refers to experiencing and knowing long term changes in climate and their impacts. The last indicator, engagement, is also defined by Gbetibouo & Mills (2012) as the frequency with which an individual talks or hears about climatic change.

The answers from the questions in the awareness section of the questionnaire were assigned a numerical score which were summed up for each respondent in order to compute the awareness index for each participant. To compute a climate change awareness index, the responses to the nine questions were used. Therefore, the index was calculated as follows: the scores from the nine questions were summed up and the minimum and maximum total scores a participant obtained was between 0 and 17 respectively to get an index between 0 and 1, and the total score that a participant got was then divided by 17. Climate change awareness scores were further normalised to range between 0 – 100% by dividing the scores with the highest possible score (17) and multiplying the quotient by 100 as shown in Equation 2.

Equation 2: Climate Change Awareness Index Formula……… [2]

*CCAI= AS/MS*100*

Where;

CCAI refers to Climate Change Awareness Index

AS means Awareness Score

MS refers to Maximum Score

3. Results and Discussion

3.1 Socio-economic characteristics of the farmers

A large part of respondents (74.5%) were males while the remaining 25.5% were females. The relative domination by male respondents among the farmers could be the result of males having greater access to farm land than females. This result is similar to the general *census* of Senegalese's population conducted by ANSD (2015) in which it has been stated that males are relatively more numerous than females in Malem Hodar and Koungheul districts. Figure 2 showed that the majority (96.5%) of the farmer household heads were married while 1.5% was observed to be single. It also showed that 0.5% of the respondents were divorced whilst 1.5% was reported to be widows. This means that most farmers who engage in farming in the study area are married and consequently it could have positive repercussions in crop production as married people are more likely to combine their efforts and energy in order to have good crop yields, hence to sustain the household's welfare.

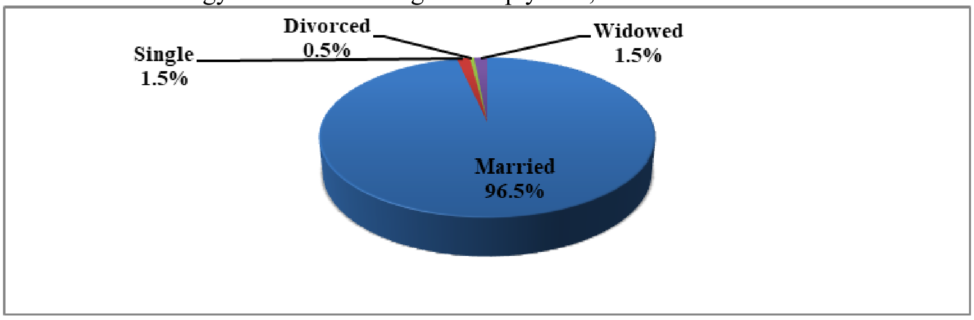

Figure 2: Marital status of farmer households heads

The others socio-economic characteristics of the respondents are also presented in Table 2. It is indicated that the proportion of farmers whose ages ranged between 18–30 years was 19.1%, 31–40 years was 24.0%, 41–50 years was 17.6%, 51–60 years was 19.6 and over 60 years was 19.6%. The youngest and oldest ages of farmer household heads were 18 and 81 years respectively with the mean age of 46 years. The majority (24.0%) of farmers were within the age bracket of 31-40 years old. This means that farmers in the study area are relatively young and that could play a considerable role in climate change adaptation since younger farmers are economically active and thus, can undergo stress and have the man-power to carry out labor intensive response strategies (Kutir, 2015). The majority (72.5%) of the farmers had household size of 10 or more persons. Proportion of farmers who had household size between 7 and 9 persons was 18.1%, household size between 4 and 6 persons was 7.8% and household size between 1 and 3 persons was 1.5%. The mean household size was 10 persons per household with the highest and lowest household size being 33 and 2 members respectively. This is an indication of large family size in the study area. This also means that farmers have a source of cheap labour from their large household size. This result is in line with the findings of Denkyirah *et al.* (2017) which reported that large sized rural households would be capable of supplying the labor necessary for their crop production due to abundance of own labor. This thus, could have a positive repercussion for crop production. Very few (2.0%) farmers had farming experience between 1 and 5 years while the majority (61.8%) of the farmers had farming experience 21 or more years with a mean of 18 years of experience. This means that majority of the farmers are experienced in farming in the study area and this is important in climate change adaptation. This result is in line with the findings of Danso-Abbeam *et al*. (2014) which stated that a good farming experience could help farmers in making good decisions and choices in their crop production process hence, has a positive implication for crop productivity. On farm land size the results indicated that majority representing 79.4% of the farmers had farm land size between 1 and 10 hectares with 6.9% having a land size equal or more than 31 hectares (Table 2). This means that farmers in the study area were relatively subsistence farmers making them vulnerable to the changing climate. These findings are in agreement with that of Idrisa *et al*. (2012) in which they found in their study area Borno State of Nigeria, that famers were generally vulnerable to climate change because of their subsistence farming activities which are probably linked to small land size.

In terms of education, 5.4% of farmers in the study area had education up to primary, 2.5% had education up to secondary, majority (88.2%) had Quaranic education and only 3.9% had no formal education. This shows that literacy level in the study area is very low, thus inhibiting farmers' understanding and use of crop technologies. This result agrees with the findings of Yegbemey *et al*. (2014) that educational level of farmers was low in their study area Northern Benin. Low educational level of farmers in the study area has implication for climate awareness and response to climatic change as well as the adoption of new agricultural innovations and technologies. In addition, Maddison (2007) asserted that educated and experienced farmers are expected to have information and knowledge about climatic change and adaptation measures to use in response to the changing climate. Also, Idrisa *et al*. (2012) argued that a minimum threshold in terms of educational qualification is necessary for understanding the technical and scientific nature of modern agriculture. It is suggested that educated farmers tend to be more efficient in production and readily accept new innovation when compared to uneducated ones that rely on their experience (Martey *et al*., 2013; Enete & Igbokwe, 2009). This means that adaptation to climate change would not be a major challenge in relation to education. Furthermore, farmers should be educated and trained on improved and sustainable response strategies for crop production due to its capacity to increase crop yields and food security (Tesfay, 2014).

Table 2: Age, Gender, and Years of farming experience, Household size, Farm land size, and Educational level of respondents

Variables	Description	Frequency	Percentage (%)
Age	between 18 and 30	39	19.1
	between 31 and 40	49	24.0
	between 41 and 50	36	17.6
	between 51 and 60	40	19.6
	over 60	40	19.6
	Total	204	100.0
Gender	Male	152	74.5
	Female	52	25.5
	Total	204	100.0
Years of farming experience	between 1and 5	4	2.0
	between 6 and 10	22	10.8
	between 11 and 15	19	9.3
	between 16 and 20	33	16.2
	21 or more	126	61.8
	Total	204	100.0
Household size	between 1 and 3	3	1.5
	between 4 and 6	16	7.8
	between 7 and 9	37	18.1
	10 or more	148	72.5
	Total	204	100.0
Farm land size	between 1 and 10	162	79.4
	between 11 and 20	24	11.8
	between 21 and 30	4	2.0
	31 or more	14	6.9
	Total	204	100.0
Educational level	primary education	11	5.4
	secondary education	5	2.5
	no formal education	8	3.9
	Quaranic education	180	88.2
	Total	204	100.0

3.2 Awareness of Climate Change in Kaffrine Region

Farmers' awareness of climate change is presented in Figure 3. Out of the 204 respondents, 154 (64.7%) indicated they have heard of climate change or have an idea of what climate change is, while 35.3% indicated they had never heard of climate change. This result indicates that farmers in the study area are fairly aware of climate change. This would help farmers to adapt to climate change mitigation measures and help create awareness among fellow farmers. Similar findings have been reported by researchers in parts of Africa (Fosu-Mensah *et al*., 2012; Gbetibouo, 2009; Mertz *et al*., 2009).

To further assess farmers' awareness on climate change, an awareness index was computed. The average awareness index for the study was 0.5903 (59.03%). The awareness index for this study implies that farmers in Kaffrine Region are aware of the changing climate. In addition, Gbetibouo (2009) reported that climate change awareness/perception is a crucial first step to effectively tackle this global challenge. Thus, this considerable average awareness index in the study has positive implications for food production since farmers have relatively adequate knowledge about the changing climate and can therefore respond sustainably to it.

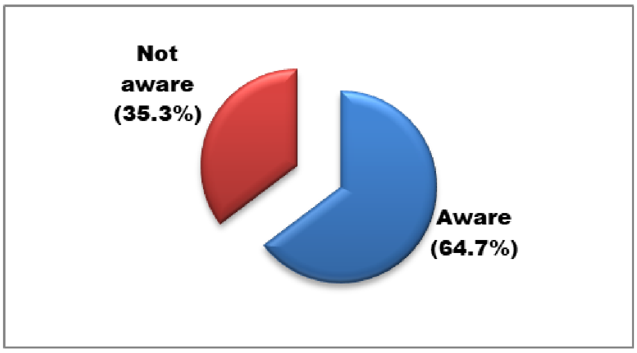

Figure 3: Farmers climate change awareness

Moreover, a comparison of farmers' awareness of climate change was done between the three selected districts for the study. Thus, Birkelane and Malem Hodar had an awareness index of 0.5601 (56.01%) and 0.562 (56.20%) respectively. This shows that the average awareness index computed among sampled farmers in Birkelane and Malem Hodar districts are relatively equal. Farmers in Koungheul district had the highest awareness index of 0.709 (70.90%) for the entire study. The finding also revealed that the least aware farmers were found in Birkelane and Malem Hodar whilst the most aware farmers were in Koungheul district.

3.3. Farmers' Preferences about the Sources of Climatic Change Information

As shown in Table 3, a considerable part (36.8%) of the respondents preferred radio broadcast as their source of climate change information, whilst 28.4% preferred extension services and 26.4% of them preferred researchers and project/NGOs as source of climate change information. The raisons behind of this preference of radio broadcast as farmers' source of climate change information was that farmers have trust and confidence in the climatic change information from the radio broadcast because radio broadcast was their only source of climate change information and for its capacity to reach uneducated farmers with matters associated to crop production in comprehensible language. Also, farmers indicated that they preferred radio broadcast as source of climate change information because experts in climate and agricultural field discuss on the radio and that could be a benefit for them in order to deal with climate change and agricultural issues. The results are similar to the findings of Churi *et al*. (2012) in which it has been revealed that majority of the farmers preferred radio broadcast as their source of climate and agricultural market information in Tanzania. In the study area, the justification of 28.4% preferred extension services and 26.4% preferred researchers and project/NGOs for sources of climate change information by farmers was that they consider extension workers and researchers among others have the knowledge and the responsibility to educate, train and advise farmers on farming and climate issues. This means that farmers in the study area would like to have an effective access to extension services and researchers and project/NGOs as sources of climate change information instead of relying only on their colleague farmers among others to be informed about the changing climate. Also, the Table 3 presented that 4.41% of the farmers indicated that neighbour farmers were their source of climate change information, claiming that it is easier to have information about agricultural issues and environmental changes from their neighbour than others sources. The least preferred source of climate change information for the study was farmer association representing 3.92% and could be linked to the fact that majority of the sampled farmers were not members of any farmer association. Furthermore, it has been suggested that the more number of contact farmers have with extension personnel and services the better their production, productivity, and the more efficient the farmers in the use of resources, and invariably the more the profits (Otitoju, 2013). Therefore, to tackle effectively climate change in the region it is crucial to more focus on those preferred sources of climate change information for farmers in the study area.

Table 3: Preferred source of climatic change information for farmers

Preferred source of climatic change information	Frequency	Percent
Radio broadcast	75	36.8
Extension services	58	28.4
Researchers	27	13.2
Project/NGOs	27	13.2
Neighbor farmers	9	4.4
Farmer association	8	3.9
Total	204	100

3.4. Adaptation Strategies to the Changing Climate

Out of the 204 respondents in the study area, 184 (90.2%) responded to the changing climate by adopting one or more adaptation strategies to increase their crop production and reduce vulnerability to climate change. These findings are in accordance with the results of Alam *et al.* (2017) in which majority of the respondents adapted to the changing climate in Bangladesh. However, despite the negative effects of climate change on their productivity, 9.8% of the respondents did not adopt any adaptation strategy to respond it. Indeed, these farmers argued that Allah (God) is the main responsible for the changing climate, hence decreased crop yields that they have experienced in the area. Thus, this could have a negative implication for crop production since such farmers would not response to the changing climate and therefore, increasing their vulnerability and reducing their adaptive capacity.

The response to the changing climate differs from farmer to farmer since the preference of adaptation strategies is based on a farmer's perception and willingness to respond to it. The results of this study on the response strategies employed by farmers to adapt to the changing climate indicated that farmers implement diverse response measures to cope with the changing climate and increase their crop production. As shown in Figure 4, majority of the respondents (69.7%) employed Strategy I as a response to climatic change for the past 3 years, whilst 12.35% of the farmers used Strategy IV as an adaptation strategy. In addition, 9.83% of the respondents also used Strategy II as response to the changing climate and 8.12% used Strategy III as an adaptation strategy to climatic change. However, 9.8% of the sampled farmers never responded to the changing climate. In fact, apart from performing prayer or ritual offerings they have never changed their farming activities or crop as a way of adapting to the changing climate. They claimed that God is the only one that can bring good rainy season, hence increase their productivity.

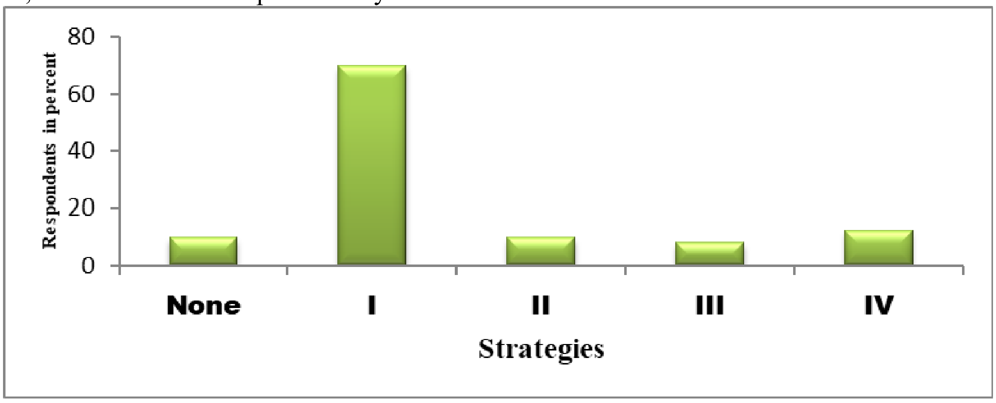

Figure 4: Farmers' adaptation strategies to climatic change

Note: None *means farmers who never responded to climatic change*

Strategy I: *Adaptation strategy that involved the using different planting dates, using drought resistant crops, practicing of crop diversification, practicing crop rotation, growing early maturing varieties, using chemical fertilizers, performing prayer/ritual offerings, and implementing soil and water conservation methods.*

Strategy II: *Response strategy that involved the changing area/size of farm land, practicing crop diversification, using drought resistant crops, using different planting dates, and practicing crop rotation.*

Strategy III: *Adaptation strategy that involved migrating to different locations, acquiring credit, growing early maturing crop varieties, practicing crop rotation, and applying chemical fertilizers.*

Section IV : *Response strategy that involved using early maturing crop varieties, using different planting dates, growing drought resistant crops, performing prayers/ ritual offerings, and applying chemical fertilizers.*

Furthermore, out of 184 respondents who responded to the changing climate in the study area, 154 (83.69%) claimed that the response strategies they used were effective whilst 16.31% of them argued that even though they adapted by implementing different adaptation strategies, but these strategies were not effective as they still have low crop yields due to the high variability of temperatures and rainfall patterns in the study area.

4 Conclusion

Majority of the farmers representing 64.7% were aware of the changing climate. The average awareness index for the study was (0.5903) 59.03%. This implies a relative low level of climate change awareness among farmers in Kaffrine Region of Senegal. This could be attributed to the diversity of sources of climate change information for farmers in the region. Indeed, 36.8% of farmers preferred radio broadcast as source of climate change information among all the others sources whiles 28.4% and 3.92% of the respondents preferred extension services and farmer associations as source of climatic change information respectively. Therefore, effective communication and programmes on climate change adaptation and mitigation for farmers should be established through preferred sources (radios, colleagues, and extension workers) to help increase their resilience and reduce their vulnerability.

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