FARMERS' KNOWLEDGE OF ADAPTATION TO CLIMATE CHANGE IN SOUTHWEST NIGERIA: A GENDERED APPROACH.

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ABSTRACT

Analysis of farmers' knowledge of adaptation to climate change is not complete until it is gender-sensitive which is necessary to capture the adaptation needs of male and female farmers. This study investigated farmers' knowledge of adaptation to climate change in Ogun and Ekiti States in southwest Nigeria. A multi-stage sampling procedure was employed to randomly select 358 male and 222 female farmers. A pre-tested questionnaire was used to obtain data and analysed with frequency counts, means, percentages, Chi-square, Pearson's Product Moment Correlation, t-test and regression analysis. Results show that 29.6% of male and female farmers (41.9%) were within the age range of 41-50 years while 13.5% of male and female farmers (24.2%) had no formal education. Significant relationships ($p<0.00$) were found between male and female farmers' knowledge of adaptation to climate change and marital status (male χ^2=736.42, female χ^2=432.17), membership of associations (male χ^2=92.20, female χ^2=97.25),traditional knowledge(male χ^2= 366.34, femaleχ^2=331.82), experience of climate change(male χ^2=373.22,female χ^2= 318.82), extension agents(male χ^2= 370.71,female χ^2=318.40), newspaper(male χ^2=294.70,female χ^2=261.95), television(male χ^2= 241.16,female χ^2=278.28), radio (male χ^2= 257.11, female χ^2=267.54) and observation of climatic variables (male χ^2=281.59,female χ^2=237.46).Furthermore, the dominant determinants of knowledge of adaptation by male farmers were education ($t=-4.630$, $p<0.01$) traditional knowledge $t=-2.375$, $p<0.05$), experience of climate change ($t=3.461$, $p<0.01$) and extension agents ($t=2.701$, $p<0.01$) while education ($t=2.523$, $p<0.01$), membership of associations ($t= 3.283$, $p<0.01$), radio ($t= 2.448$, $p<0.05$) and observation of climatic indicators ($t= 2.513$, $p<0.05$) were the dominant determinants of female farmers' knowledge of adaptation to climate change. There is a need for strategies at improving female farmers' knowledge of climate change using a gender sensitive strategy for better adaptation to climate change effects.

Keywords: Knowledge; adaptation; climate change; effects; experience.

INTRODUCTION

Agriculture is crucial to Nigeria's economic security because of its indispensable roles played in food and raw materials provision, employment generation and foreign exchange earnings. Despite these roles, agriculture is threatened and challenge by climate change/variability. Agriculture is the most vulnerable of all sectors, as the majority of rural rely on rain-fed agriculture (Tarfa *et al*. 2019). Agriculture accounts for about 24.18 percent of Nigeria's Gross Domestic Product, whereas rural agriculture supports 70% of the economy's informal jobs sector (Onwutuebe, 2019). The earth's average surface temperature has increased markedly between 0.650C and 1.06C over the last 100 years, according to empirical evidence (Intergovernmental Panel on Climate Change-IPCC, 2014). Earth warming is real and significant, but it fluctuates with time and space, with greenhouse gases generated by anthropogenic activities being the contributory factors (IPCC, 2014). Africa will bear the brunt of the effects of climate change because it is the most vulnerable and has the weakest capacity to adapt in all world's regions (Niang *et al*., 2014). Nigeria's climate is changing, as evident in rising global temperatures, inconsistent rainfall, sea-level rise, flooding, drought, desertification, land degradation, and more frequent extreme weather events wreaking havoc on forests, water supplies, and biodiversity (Olaniyi *et al*. 2013; Ebele and Emodi, 2016, Elisha *et al*. 2017). Rainfall is the most important aspect of climate change in Nigeria, and the country's water resources potential (Osasogie and Omorogbe, 2018). Climate change's adverse consequences have been widely recognized and documented, particularly by policymakers and researchers, like the IPCC, who are interested in a global future that would be sustainable (Adzawl *et al.*, 2019). It is causing severe and difficult dangers to global food security (Amir *et al*., 2020). Because of its effects on the natural environment and human existence, it is a multi-faceted challenge for today's societies (Ghulum, 2018).

Farmers' understanding of climate change is significant because it determines the techniques they use to avoid the adverse effects of climate change (Ochienje *et al*., 2016; Chah *et al*., 2016). Even though changes have been occurring over generations, rural farmers have been adapting to these changes throughout their life using local environmental knowledge (Mafongoya and Ajayi, 2017). Knowledge of adaptation to climate

change can be acquired through education and experience. Knowledge about adaptation strategies is a vital content of adaptive capacity. Adaptive capacity depends on sufficient education, assets, information and income (Madu, 2012). Level of knowledge of adaptation to climate change can influence how an individual perceives a particular strategy and at the same influences whether he will utilize it or not. Farmers should have regular access to new knowledge as a result of climate change and associated uncertainties (Chah *et al.,* 2016**).** Lack or inadequate knowledge of adaptation measures can hinder farmers from fully utilizing adaptation strategies, thereby rendering them more vulnerable to the effects of climate change.

In order to integrate climate change into every aspect of national life, Nigerians must have awareness and knowledge-access to knowledge –of what climate change is, how is impacting them and how they can adapt (Building Nigerian's Responses to Climate Change -BNRCC, 2011). They also need to be equipped with specialised skills to implement adaptation (Haider, 2019). The study's objectives were to (a) determine the influence of male and female farmers' socio-demographic characteristics on their knowledge of adaptation to climate change (b) ascertain farmers' knowledge of climate change adaptation, and (c) investigate the determinants of farmers' knowledge of climate change adaptation. The study hypothesized that (i) there is no significant difference in male and female farmers' understanding of adaptation to climate change, and ii) there is no significant difference in male and female farmers' socio-demographic variables.

MATERIALS AND METHODS

Study Area:

The research was carried in Ekiti and Ogun States Nigeria. Geographically, the State is located in the Southwest of Nigeria between longitudes 4^{o} 51` to $5^{o}$ 45` east of Greenwich meridian and on latitudes 7^{o} 15^{1} to 8^{o} $^{s}5^{1}$N of equator. Ekiti State is bounded to the north by Kwara and Kogi States, to the west by Osun State, to the east by Edo State and to the south by Ondo State. The State occupies an area of 6,353kmsq and enjoys generally tropical climate with two distinct seasons. The annual temperature of Ekiti State ranges from 21^{o} – 28^{o}C (Oluwasusi and Tijani, 2013) with a mean annual humidity of 75% (Olujobi, 2015). The State is an upland zone and experiences a mean annual rainfall ranges between 1200mm and 1800 (Ugwuja *et al*., 2011). The major vegetation being rain forest, deciduous forest and semi-grasslands. Tropical forest exists in the south of the State while guinea savannah occupies the northern peripheries of the State.

Ogun State lies within latitudes 6^{o} 12^{1}N and 7^{o} 47^{1}N in the tropics and longitudes 3^{o} 0^{1}E and $5^{o}0^{1}$ East of Greenwich meridian (Adeleke *et al*., 2015). The State covers 16,409.26 kilometres and shares an international boundary with the republic of Benin to the West and interstate boundaries with Oyo State to the north, Lagos and the Atlantic Ocean to the South and Ondo State to the east. The State is located in moderately hot, humid tropical climatic zone of southwest, Nigeria. The climate of Ogun State follows a tropical pattern with two distinct seasons (the rainy season which lasts from March/ April to October/ November till March/ April). The annual rainfall of the State value ranges between 1,400mm and 1500mm with an average temperature of 30^{o}C. The humidity is lowest at the peak of the dry season in February, usually at 37-54% and highest between June and September with a value of 78-85% (Adeleke, 2015). Ogun State has two main vegetation, namely, tropical rain forest and guinea savannah.

DATA COLLECTION AND ANALYSIS

Two third of the six States (6) in southwest Nigeria were randomly selected (Ekiti and Ogun States). Secondly, two (2) out of the three zones in Ekiti State Agricultural Development Programme were randomly selected while two zones were randomly selected from the four zones in Ogun State Agricultural Development Programme. Thirdly, three (3) blocks were randomly chosen from the selected zones in Ekiti State (making six blocks) while eight (8) blocks were randomly selected in Ogun State. Finally, using Krejcie and Morgan (1970) method for determination of sample size, a sample size of 302 respondents (175 males and 128 females) was randomly selected for the study in Ekiti State while 278 respondents (184 males and 94 females) were randomly selected in Ogun State from the list obtained from the National Agricultural Cooperative headquarters of the two States and interviewed (Table 1).

TABLE 1: SELECTION PROCEDURE FOR SAMPLE SIZE IN EKITI AND OGUN STATES

ADP Zones	Blocks	Selected blocks	NACOP members	Male farmers selected	Female farmers selected	Total
Ekiti State						
Aramoko	5	3	500	57	31	88
Ikere	5	3	900	117	97	214
Total	10	6	1400	174	128	302
%				57.8	42.2	
Ogun State						
Abeokuta	12	6	574	86	44	130
Ilaro	4	2	428	98	50	148
Total	16	8	1002	184	94	278
%				66.2	33.8	

The study employed a quantitative method (questionnaire) of data collection. A questionnaire is a research instrument consisting of a set of questions (items) intended to capture responses from respondents in a standardized manner (Bhattacherjee, 2012). The questionnaire was designed in phases to capture questions on farmers' socio-demographic characteristics and knowledge of adaptation to climate change. The instrument for data collection was pre-tested using the test-retest method at two weeks interval to measure the degree of its consistency and obtained reliability coefficients of 0.85 for knowledge adaptation to climate change. Farmers' knowledge of adaptation to climate change was measured with agreements of farmers with a list of options provided and aggregate scores determined. The data obtained were analysed by using Statistical Package for Social Sciences window version 23. The analytical tools employed in this study were descriptive (tables, percentages, frequencies and means) and inferential statistics (Chi-square, Pearson's Product Moment Correlation, t-test and regression analysis).

Results and Discussion

Descriptive analysis shows that male and female respondents were 49 and 45 years old, respectively. The findings could indicate that the respondents were active and knowledgeable climate change adaptation. This finding is in the similar pattern with the report of Angwa *et al*. (2020) who obtained an average of 47 years for male and 44 years for female farmers in a study conducted on climate change. The majority of male (82%) and female (85%) farmers were married, with an average of six people per household. This could indicate that knowledge about adaptation to climate change could be easily communicated and shared among farm families in order to mitigate the adverse effects of climate change. This report is similar to finding of Okunlola *et al*. (2018) and Adetoro (2021) who reported an average of 6 person per household, but not conform to the finding of Idoma *et al*. (2017) who observed a mean of 12 persons per household in a similar study. The probable reason could be that the male farmers in the latter study had multiple wives and were able to have a large family. In addition, the study reveals that 24% of female farmers had no formal education in contrast to 13.5% of male farmers. This could hint that the majority of the respondents possessed one form of formal education but the male farmers were more literate than the female farmers. This could indicate that education can assist to enhance male farmers' understanding of climate change as well as the knowledge of adaptation to climate change. This finding is similar to the report of Obi-Egbedi *et al* (2017) who noted that years spent in school by their females respondents was lesser when compared to that of male respondents. The study also shows that 53.2% of male and 58.1% of female farmers were members of crop farmers' association. This could suggest that more than half of the respondents engaged in crop production and are assumed to have more knowledge of adaptation to climate change in crop-related agricultural enterprises. The result is in tandem with the reports of Kolapo *et al* (2022) who noted 69.3% of their male and 78.8% of female farmers belong to farmers' association. In addition, the study further shows that male respondents had an average of 23years of farming experience as against 19years of farming experience for females. Consequently, it is assumed that farmers in this study generally were equipped with knowledge of adaptation to climate change as a result of the long-term years of farming experience. This result is in favour of the report of Oluwatayo and Ojo (2016) who observed a similar finding in their study on adaptation to climate change in Nigeria. In addition, the majority of female farmers (76.2%) cultivate between 0-2 hectares of land compared to male farmers (67.1%) that cultivate 3-5ha. This could indicate that male farmers had more access to land, as result, they expected to be involved in more agricultural enterprises than female farmers and

could have diverse knowledge of adaptation to climate change in different agricultural enterprises. This result is consistent with the observation of Ugwuja et *al.* (2012) who reported that male farmers had more access to land than the females in a similar study conducted in southwest Nigeria. In addition, the study reveals that more than half of male (57.8%) and female farmers (57.2%) earned less than 40,000 naira per annum. This could indicated that the respondents are subsistent farmers. The result is inconsistent with the observations of Obi-Egbedi *et al*. (2017) who reported that the majority (86.91% of male and 85.7% of female) of their respondents earned less than 40,000 thousand naira per annum from farming. The probable reason could be that their respondents had low knowledge of adaptation to climate change.

TABLE 2: SOCIO ECONOMIC CHARACTERISTICS OF RESPONDENTS

Socio-economic variables	**Male farmers**		**Female farmers**	
	Freq.	**%**	**Freq.**	**%**
Age (years)- mean	$\bar{x}$ =49		$\bar{x}$ =45	
Below 20	1	0.03	1	0.05
21-30	48	13.4	33	14.9
31-40	54	15.1	45	20.3
41-50	106	29.5	93	41.9
51-60	64	19.8	29	13.1
Above 60	86	24.9	21	9.5
Marital status				
Single	42	11.5	14	6.3
Married	304	85.0	182	82.0
Widow (er)	10	2.8	19	8.6
Divorced/ separated	3	0.8	7	3.2
Household size (mean)	$\bar{x}$ =6		$\bar{x}$ =6	
0-5	63	17.6	102	45.9
6-10	263	73.5	116	52.3
11-15	27	7.5	4	1.8
16-20	5	1.4	0	0.0
>20	0	0.0	0	0.0
Education				
No- formal education	48	13.5	87	24.2
Formal Education	311	86.5	135	75.8
Farming experience (years)- mean	$\bar{x}$ =23		$\bar{x}$ =19	
0-5	47	13.1	44	19.8
6-10	65	18.2	41	18.5
11-15	49	13.7	20	9.0
16-20	42	11.7	31	14.0
Above 20	155	43.3	86	38.7
Farm size (hectares)- mean	$\bar{x}$ =4.2		$\bar{x}$ =1.7	
0-2	61	17.0	167	75.2
3-5	241	67.1	21	9.5
6-8	30	8.4	16	7.2
Above 8	25	7.0	18	0.1
Average annual income(₦)				
Less than 40,000	200	57.8	127	57.2
41,000-80,000	94	26.2	59	26.6
81,000-100,000	16	5.0	13	5.9
Greater than 120,000	46	12.8	23	10.4

Respondents' Knowledge of Adaptation to Climate Change

Table 3 shows that the means of male farmers' knowledge of adaptation to climate change range from 1.89 to 1.03 while that of female farmers range from 1.78 to 1.03. Also, differences were noticed in the means of male and female farmers' knowledge of adaptation to climate change. This study shows that male and female farmers respectively had higher means in nineteen (19) and twelve (12) knowledge items, and three (3) equal means. Statistically, significant differences were observed in nineteen (19) items with male farmers having twelve (12) and female farmers having seven (7) significant means (Table 4). This result reveals that the respondents generally had array of knowledge about climate change adaptation. In addition, the study shows that male farmers were more equipped with the knowledge of adaptation to climate change and consequently assumed to have had a higher capacity to adapt to the effects of climate change than the female farmers. Although, the result could suggest that the respondents are adapting to climate change. These results are similar to the reports obtained by Ozor *et al*. (2015) who observed that their respondents had knowledge of adaptation to climate change in livestock enterprise. This mean that knowledge of adaptation of farmers to climate change is directly related to the farming enterprise engaged-in. In addition, Assan *et al*. (2018) reported that 95% and 75% of male and female farmers implemented adaptation strategies to improve their resilience to adverse effect of climate and climatic events. The result of this study is inconsistent with the report of Ogunbode *et al*. (2019) who noted that their respondents had low knowledge of climate change. The likely reason could be that 45.5% of the respondents had no formal education. Education favours knowledge acquisition (Kisuazi *et al*., 2012).

TABLE 3: MALE AND FEMALE FARMERS' KNOWLEDGE OF ADAPTATION TO CLIMATE CHANGE

Knowledge of adaptation to climate change	**Male-** $\bar{x}$	**Female-** $\bar{x}$	**t- value**
Timely harvest of crops	1.08	1.04	1.39
Crop processing	1.22	1.17	1.42
Irrigation	1.15	1.18	0.33
Planting of drought-resistant crops	1.07	1.09	0.59
Reduction of farm size	1.65	1.48	2.56*
Changing from crop to livestock production or vice versa	1.47	1.38	1.99*
Use of weather forecasts	1.10	1.03	2.55**
Construction of stronger homestead	1.18	1.18	-0.03
Fertilizer application	1.16	1.08	2.84**
Prayers	1.11	1.11	0.48
Abandon farmlands	1.48	1.64	3.57**
Proper storage of grains	1.16	1.06	2.90*
Planting of short maturing crop varieties	1.11	1.10	0.47
Ritual	1.41	1.56	1.64
Support of laws against deforestation	1.03	1.09	2.00*
Integration of crop and livestock production	1.25	1.24	0.29
Home gardening	1.19	1.21	0.53
Mulching	1.06	1.05	0.05
Diversification of livelihood activities	1.14	1.24	2.63**
Making of ridges along the slope	1.11	1.23	3.62**
Construction of contour bunds	1.07	1.07	0.07
Lengthened fallow	1.08	1.10	0.32
Construction of drainage channels	1,05	1.12	2.17*
Control and prevention of pests and diseases	1.23	1.37	3.22**
Digging of well for irrigation	1.20	1.34	3.56**
Mixed cropping	1.31	1.30	0.40
Planting of drought resistance	1.13	1.10	0.96
Conservation, preservation, and domestication of wild edible plants seeds and food crops	1.48	1.26	2.90**
Provision of shield for livestock and nursery bed	1.47	1.31	2.50*

Prompt weeding	1.57	1.42	2.16*
Changing of livelihood activity	1.67	1.45	3.15**
Diversification of livelihood activities	1.68	1.54	2.04*
Distress migration	1.89	1.78	1.67*
Water harvesting	1.58	1.42	2.37*

Association between Respondents' Knowledge of Adaptation to Climate Change and Independent Variables

Results show that there is a significant relationship (P<0.01) between male farmers' knowledge of adaptation to climate change and marital status (χ^2-376.42), membership of associations (χ^2- 92.20), traditional knowledge (χ^2-366.34), the experience of climate change (χ^2-373.22), extension agent (χ^2-370.71), newspaper (χ^2-294.70), television (χ^2-241.16), radio (χ^2-257.11), and observation of climatic indicators (χ^2-281.59). Also, there is a significant association (P<0.01) between female farmers' knowledge of adaptation to climate change and marital status (χ^2-432.17), membership of association (χ^2-97.25), traditional knowledge (χ^2-331.82), the experience of climate change (χ^2- 318.82), extension agent (χ^2-331.40), newspaper (χ^2-261.95), television (χ^2-278.28), radio (χ^2-267.54), and observation of climatic indicators (χ^2-237.46). The result could suggest that all the independent variables reviewed in this study are essential for the improvement male and female farmers' knowledge of adaptation to climate change.

TABLE 4: RESULTS OF CHI-SQUARE ANALYSIS BETWEEN RESPONDENTS' KNOWLEDGE OF ADAPTATION TO CLIMATE CHANGE AND INDEPENDENT VARIABLES

	Male farmers		Female farmers	
Independent Variables	**χ^2 value**	**P value**	**χ^2 value**	**P value**
Marital status	736.42	0.000	432.17	0.000
Membership of associations	92.20	0.000	97.25	0.000
Traditional knowledge	366.34	0.000	331.82	0.000
Experience of climate change	373.22	0.000	318.82	0.000
Extension agents	370.71	0.000	331.40	0.000
Newspaper	294.70	0.000	261.95	0.000
Television	241.16	0.000	278.28	0.000
Radio	257.11	0.000	267.54	0.000
Observation of climatic indicators	281.59	0.000	237.46	0.000

**P<0.01

Correlation Analysis between Respondents' Knowledge of Adaptation to Climate Change and Demographic Characteristics of the Respondents

The result shows that there is no significant relationship (P>0.05) between male farmers' knowledge of adaptation to climate change and, age (r=0.069) and farming experience (r=0.041). In the same vein, no significant relationship existed between female farmers' knowledge of adaptation to climate change and age (r=0.010) and farming experience (r=-0.043). This could suggest that increased age and experience in farming do not likely to translate to increased farmers' knowledge of adaptation to climate change and thus there is no direct relationship between them.

TABLE 5: RESULTS OF CORRELATION ANALYSIS BETWEEN RESPONDENTS' KNOWLEDGE OF ADAPTATION TO CLIMATE CHANGE AND DEMOGRAPHIC FACTORS.

	Male farmers		Female farmers	
Demographic factors	**r value**	**P value**	**r value**	**P value**
Age	0.069	0.194	0.010	0.888
Farming experience	0.041	0.437	-0.043	0.521

Determinants of Male and Female Farmers' knowledge of Adaptation to Climate Change

Results of each process of regression analysis are reported in Table 6 with standardized regression coefficients, t- statistical values, values of constant, R square and, adjusted R^2 values. The coefficients of determination (Adjusted R^2 and R^2) for male farmers were 0.30 and 0.33 respectively and, 0.47and 0.50 for

female farmers respectively. It was observed that four (4) independent variables had statistic significant beta coefficients for male farmers, these include education (t=-4.630, p<0.01) traditional knowledge t=-2.375, p<0.05), experience of climate change (t=3.461, p<0.01) and extension agents (t=2.701, p<0.01). The result shows that these variables exerted the strongest influence on male farmers' knowledge of adaptation to climate change. This result could suggest that education, traditional knowledge, experience of climate change and extension agent have a positive and direct relationship on the male farmers' knowledge of adaptation to climate change.

The findings of this study further show that four (4) independent variables had statistic significant beta coefficients for female farmers, these include education (t=2.523, p<0.01), membership of associations (t= 3.283, p<0.01), radio (t= 2.448, p<0.05) and observation of climatic indicators (t= 2.513, p<0.05). These results could indicate that education, membership of associations, radio and observation of climatic indicators were the predictors of female farmers' knowledge of adaptation to climate change. Findings from this study is inconsistent with the report of Kisuazi *et al*. (2012) who informed that sex was the sole determinant of the knowledge of climate change among others.

TABLE 6: DETERMINANTS OF RESPONDENTS' KNOWLEDGE OF ADAPTATION OF CLIMATE CHANGE

	Male farmers		**Female farmers**	
Independent variables	**β-value**	**t value**	**β-value**	**t value**
Age	-0.029	-0.722	0.069	1.547
Education	-1.646	-4.630**	0.864	2.523**
Farming Experience	-0.060	-1.626	-0.021	-0.475
Membership of associations	0.452	-0.451	3.439	3.283**
Traditional knowledge	-2.375	-1.901*	1.424	1.059
Experience of climate change	3.461	2.664**	2.092	1.543
Extension agents	2.701	2.535**	1.708	1.570
Newspaper	0.656	0.544	1.928	1.482
Television	0.984	0.849	2.513	2.048
Radio	-0.296	-0.242	3.197	2.448*
Observation of climatic indicators	2.936	1.883	-1.608	-1.129*
Constant	49.094		30.479	
R	0.570		0.707	
R^2	0.325		0.500	
Adjusted R^2	0.304		0.474	
Standard Error	7.512		5.345	
F change	15.182		19.09	
Significant F change	0.000		0.000	

*P<0.05 **P<0.01

Conclusion and recommendations

Findings from this study shows that male farmers had more knowledge of adaptation to climate change than the female farmers. The gender gap could be due to differences between male and female farmers in educational level, farm size, income, and farming experience. The study shows that positive and direct relationships existed between the respondents' knowledge of adaptation to climate change and marital status, membership of association, traditional knowledge, experience of climate change, extension agents, newspaper, television, radio and observation of climatic indicators. This is an implication that these correlated variables had strong and positive effects on knowledge of adaptation to climate change. In addition, regression analysis shows that education, membership of associations, radio and observation of climatic indicators exert the greatest influence on male farmers' knowledge of adaptation to climate change while education, traditional knowledge, the experience of climate change and extension agents exert influence on female farmers' knowledge of adaptation to climate change. The findings recommends a strong case for gender concern in climate change discourse noting that disparity is inevitable among male and female farmers' gender sensitive indicators like knowledge of adaptation to climate change. On this note, gender sensitive approach is essential to address the needs of

both categories of farmers while designing climate change adaptation policies and programmes. Also, enhancing farmers' knowledge of adaptation to climate change through agricultural extension agency and other potential stakeholders is essential in the form of adult literacy on adaptation to climate change. In addition, the predictors of male and female farmers' knowledge of adaptation should be well considered for meaningful interventions by stakeholders. Therefore disaggregated data on farmers' knowledge of adaptation become essential to know the capacity of male and female farmers and their vulnerability to climate change effects.

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