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Examining Farmers' Resilience to Climate Change and Policy Ramifications In North-West Cameroon

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Abstract

Over half of the world's population depends on smallholder farms for their daily food needs. However, high levels of vulnerability and low levels of resilience to the adverse effects of climatic variations and changes constitute major threats to smallholder farms and farmers. It is within this context that this paper assessed the levels of resilience of smallholder farmers as well as the factors affecting smallholder farmers' resilience to climate change in north western Cameroon. A mixed research approach was adopted during data collection, and data analysis was done using descriptive and inferential statistics. It was found that climate extremes were the order of the day, and farmers perceived income level, practice of agroforestry and land accessibility as the main determinants of resilience. The main resilience option practiced by most smallholder farmers was agroforestry. Chi-square and t-test statistics showed the existence of a statistically significant difference ($p<0.05$) between smallholder farmers resilience to climate change and different environmental, institutional and socio-economic variables. Logistic regression coefficients showed the existence of a statistically significant cause-effect relationship ($p<0.05$) between farmers' resilience to climate change and different environmental, institutional and socio-economic variables such as income level, land accessibility, credit accessibility, information accessibility and number of farms. From the foregoing, income level, land accessibility, credit accessibility, information accessibility and number of farms play a significant role towards enhancing smallholder farmers' resilience to climate change. Policy makers therefore need to factor in these variables when crafting policies geared towards improving smallholder farmers' resilience to climate change.

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Introduction

The desire of the national, regional and international policy makers to combat global environmental challenges is unquestionable.[1] This is evidenced by the crafting and adoption of seventeen (17) Sustainable Development Goals (SDGs) – agenda 2030, wherein the fight against climate change features prominently as goal number thirteen.[2,3] The increasing concentration of greenhouse gases especially nitrous oxide, methane, carbon dioxide, chlorofluorocarbons and others in the atmosphere has led to unusual levels of global warming.[1,4] These unprecedented concentrations of greenhouse gases in the atmosphere result mainly from human activities like tropical forest degradation, burning of fossil fuels, and wanton deforestation.[5,6,7,8] Adaptation and/or mitigation are the two options mankind has to deal with the existential threats posed by climate change.[6] For the agricultural sector, adaptation to climate change is seemingly the short-term option while mitigation of climate change is the long-term option.[9,10,11,12,13] Thus, it is incumbent to promote climate-smart, environmentally friendly, and sustainable agricultural practices especially in the smallholder farming sector which is amongst the most vulnerable to the adverse effects of climate change.

Small holder farmers being amongst the most vulnerable to climate change adversities, their livelihood is seriously threatened[14. 15] indicated that the low level of resilience of smallholder farmers confronted with climate change makes them highly vulnerable. With smallholder farms contributing towards the feeding of a vast majority of the world's population, especially in the developing world, the limited resilience of smallholder farms and farmers in the face of climate change is a major call for concern. In sub-Saharan Africa and Asia in particular, and the developing world in general, estimates have shown that there are over 500 million smallholder farms, catering for the food needs of over 80% of the population – i.e. feeding over two billion persons.[16]. Studies have shown that smallholder farms have continued to increase across the world in general and the developing world in particular.[13,17,18,19] Thus, it is imperative to examine the levels of resilience of smallholder farms as well as the factors affecting smallholder farmers' resilience in the face of climatic variations and changes.

In Cameroon and more specifically north western Cameroon where this study was carried out, food-focused agricultural systems are the order of the day, with most (over 90%) owned by smallholder farmers.[20,21] These smallholder farms which are mainly rainfall dependent have been negatively affected by the adverse effects of climate variability and change.[22,23,24] It has been shown that placing financial, material, logistic and other vital resources at the disposal of smallholder farmers could play a crucial role towards enhancing their resilience to climate change.[21,25,26] It was within this backdrop that this study sought to examine the resilience levels of smallholder farmers and the factors affecting smallholder farmers resilience faced with the adversities of climate change.

Materials and Methods

Description of the Study Area

The study was carried out in north western Cameroon located latitudinally between 5°4'N to 7°15'N and longitudinally between 9°30'E to 11°15' E. North western Cameroon is among the most densely populated areas in Cameroon with a population density greater than 103 inhabitants/Km^2. It has a surface area of roughly 17,812 km^2 and a population of over 1,840,500 inhabitants. It is characterized by a tropical highland climate, a vegetation cover dominated by savannah grassland. It has a rolling topography with mountains like Mt Oku and Mt Lefo, and plains like the Ndop and Mbaw plains.

A vast majority of the population is mainly involved in agricultural activities with most being smallholders. Smallholders are farmers whose farm sizes are generally smaller than two hectares, using mainly family labour for cultivation; consume most of the food produced, with excess sold to generate income for the household. Crops generally grown include food crops (maize, beans, groundnuts, potato, sweet potato, plantains, cassava, cocoyams (Taro), yams and many other), cash crops (coffee), and market gardening crops (tomatoes, vegetables, spices and many others).

Selection of Study Site and Sampling Procedure

The study made use of the multiphase sampling procedure. Firstly, north western Cameroon (the study area) was purposively chosen because most of the farmers are smallholders as well as the high level of vulnerability of these smallholders to climatic variations and changes. Secondly, taking into consideration the environmental, agro-ecological and socio-economic characteristics of the study area, ten (10) villages were randomly selected from the different districts found in the study area. Owing to their mastery of the study area as well as the broad knowledge they possessed concerning smallholders, agricultural extension agents aided in the process of selection of the different villages. Thirdly, focus group discussions smallholder farmers and other stakeholders, as well as key informant interviews with resource persons were carried out. Focus group discussions and key informant interviews allowed for the collection of general information on the level of resilience of smallholder farmers which was triangulated with data collected from farmers during household surveys. Fourthly, using simple random sampling, household surveys were conducted with smallholder farmers in the ten (10) selected villages. A total of 350 smallholder farmer household heads were sampled in the ten (10) selected villages using semi-structured questionnaires.

Data Collection

Data for the study were sourced from primary and secondary sources. Review of relevant literature and climate data from weather stations in the study area were the main sources of secondary data. The collection of primary data was done through household survey wherein 350 smallholder farmer household heads were sampled. This was complemented with key informant interviews (30), focus group discussions (05), and direct observations which allowed for the triangulation of information.

The use of Likert scale style questions enabled farmers to rank their levels of resilience to climate change on the basis of their different livelihood assets. These livelihood assets were human, natural, physical, social and financial. The livelihood assets were the explanatory variables of the study (Table 1 and Table 2). Thus, based on the livelihood assets, farmers ranked their levels of resilience to climate change as high, low, or not resilient.

Direct field surveys on smallholder farmers' farm plots equally allowed for the collection of primary data. This was done in order to see firsthand the different resilience options of smallholder farmers confronted with climatic variations and changes.

Data Analysis

Collected data were coded and imputed into Microsoft Excel 2007 and SPSS 20.0 for descriptive and inferential statistical analyses. Percentage indices and charts were the main descriptive statistics computed while chi-square statistic, t-test statistic and logistic regression were the main inferential statistics computed.

To indicate the non-cause-effect relationship existing between explanatory variables and smallholder farmers' resilience to climate change, chi-square and t-test statistics were used. To show the cause-effect relationship existing between explanatory variables and smallholder farmers' resilience to climate change, the binomial logistic regression was used. The binomial logistic regression enables the analysis of decisions across two categories, and predicts the probability of making one decision or the other.[27,28]

Table 1: Dependent and explanatory variables of the study

Dependent variable	Explanatory variables
Resilience	Number of farms
	Household size
	Age of household head
	Income of household
	Educational level of household head
	Gender of household head
	Practice of agroforestry
	Vulnerability to climate change
	Information accessibility
	Credit accessibility
	Land accessibility
	Access to extension services

Source: Own survey; adapted from[29, 30]

Dependent and Explanatory Variables of the Study

The study had both dependent and explanatory variables. The explanatory variables which in most cases represented livelihood capital assets were income of household, number of farms, access to extension services, household size, educational level of household head, information accessibility, gender of household head, credit accessibility, practice of agroforestry, age of household head, vulnerability to climate change, and land accessibility (Table 1 and Table 2). The dependent variable on its part was resilience (Table 1 and Table 2).

From Table 1 and Table 2 above, it is noticed that the dependent and explanatory variables of the study were mostly qualitative in nature. This explains why most of the statistical analyses were done using non-parametric tests and the non-linear or discrete regression model (binomial logistic regression).

Table 2: Description of dependent and explanatory variables of the study

Dependent variable	Description
Resilience	Qualitative, takes value of 1 if resilient and, 0 if not resilient
Explanatory variables	**Description**
Number of farms	Quantitative
Household size	Quantitative
Age of household head	Quantitative
Income of household	Quantitative
Educational level of household head	Qualitative, takes value of 0 for no formal education, 1 for primary, 2 for secondary, 3 for high schools and 4 for tertiary
Gender of household head	Qualitative, takes value of 1 if male and, 0 if female
Practice of agroforestry	Qualitative, takes value of 1 if Yes and, 0 if No
Vulnerability to climate change	Qualitative, takes value of 1 if Yes and, 0 if No
Information accessibility	Qualitative, takes value of 1 if Yes and, 0 if No
Credit accessibility	Qualitative, takes value of 1 if Yes and, 0 if No
Land accessibility	Qualitative, takes value of 1 if Yes and, 0 if No
Access to extension services	Qualitative, takes value of 1 if Yes and, 0 if No

Source: Own Survey; adapted from[29,30]

Results

Climatic Variations and Changes

From the analysis of climate data, it was found that climatic elements especially temperature and rainfall have experienced significant fluctuations in the past five decades (Figure, 1, 2 and 3). Mean temperature was found to be much higher while quantity of rainfall and number of rainy days were decreasing and becoming fewer respectively. Thus, rainfall has been scanty and erratic within the past five decades.

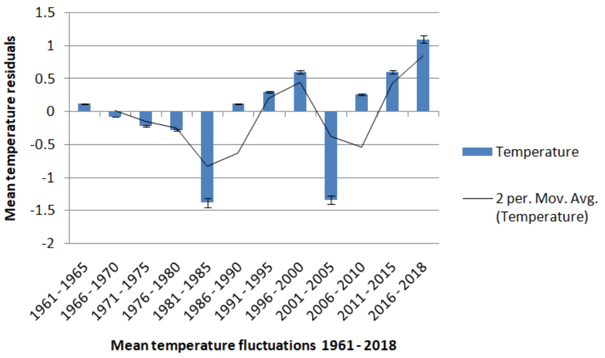

Fig. 1: Temperature variations

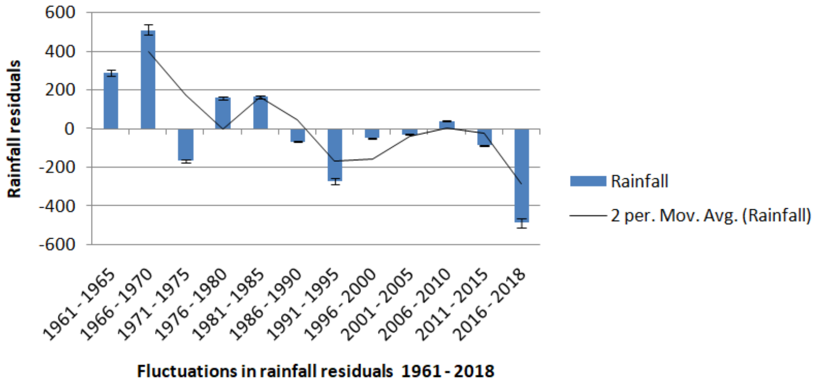

Fig. 2: Rainfall variations

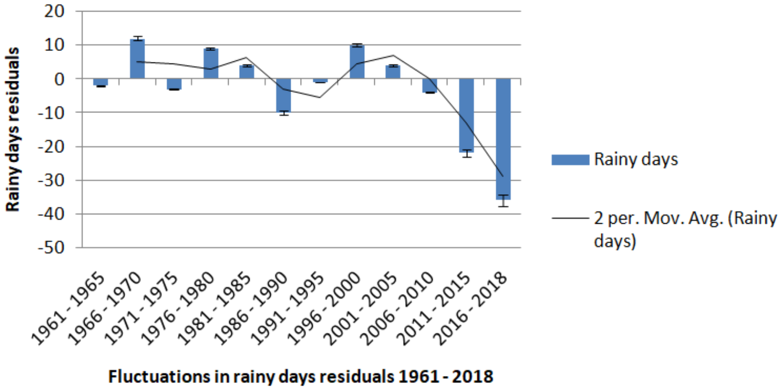

Fig. 3: Variations in rainy days

In the present dispensation of climatic variations and changes, findings showed that the relationship between different climatic elements was varied. From scatter plots, it was found that an insignificant negative correlation existed between rainfall and temperature, as well as rainy days and temperature. Meanwhile a relatively strong positive correlation existed between rainfall and rainy days.

Resilience Options of Smallholder Farmers Confronted with the Adverse Effects of Climate Change

From the analysis of empirical data, it was found that in the face of climate change adversities, agroforestry was a resilience option par excellence, practiced by most smallholder farmers (Table 3). It was equally found that confronted with climate extremes, some farmers practiced sole cropping and mono-livestock practices as a resilience option (Table 3). Common crops planted in sole cropping systems by smallholder farmers in the face of climate change were food crops (maize, cassava, plantains, yams, cocoyams, beans, and groundnuts), market gardening crops (tomatoes, vegetables, spices) and cash crops (coffee).

Perceptions of Smallholder Farmers as to the Factors Affecting Resilience to Climate Change

From empirical data analysis, it was found that the most common factors perceived by smallholder farmers as influencing resilience to climate change were household income, accessibility to land, market accessibility, the practice of agroforestry, accessibility to information, access to extension services, and access to credit (Figure 4). From all these factors perceived by smallholder farmers as influencing resilience to climate change, the three main factors were household income, accessibility to land, and the practice of agroforestry.

Table 3: Small-scale farmers' resilience options faced with the adverse effects of climate change

Farmers' resilience choice faced with climate change adversity	Frequency (n)	Percent (%)
A. Agroforestry practices		
a. trees on croplands	30	11
b. coffee-based plantation	25	9
c. Taungya	20	7
d. home garden with livestock	35	13
e. live fences/hedges	30	11
f. improved fallows	10	4
g. home garden	30	11
h. trees on pastureland	15	6
i. others (aquaforestry, entomoforestry)	5	2
Total	**200**	**74**
B. Sole cropping/livestock practices		
a. Livestock only	5	2
b. Cash crops only	20	7
c. Market gardening crops only	20	8
d. Food crops only	25	9
Total	**70**	**26**
N	270	100

Source: Own survey; adapted from.[50,51]

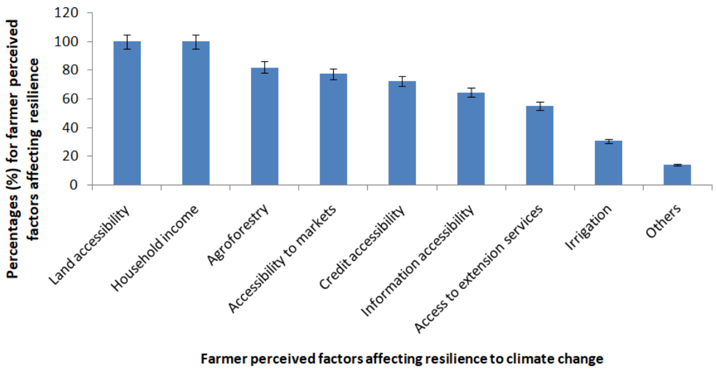

Fig. 4: Factors influencing resilience to climate change perceived by smallholder farmers

Smallholder Farmers' Ranking of their Level of Resilience to Climate Change

From the analysis of empirical data it was found that on the basis of livelihood assets, most smallholder farmers perceived that they were not resilient to climate change (Figure 5). Just few smallholder farmers perceived that they were highly resilient, or resilient to climate change. Thus, on the basis of smallholder farmers' perceptions, most of them were not resilient to climate change adversities (Figure 5).

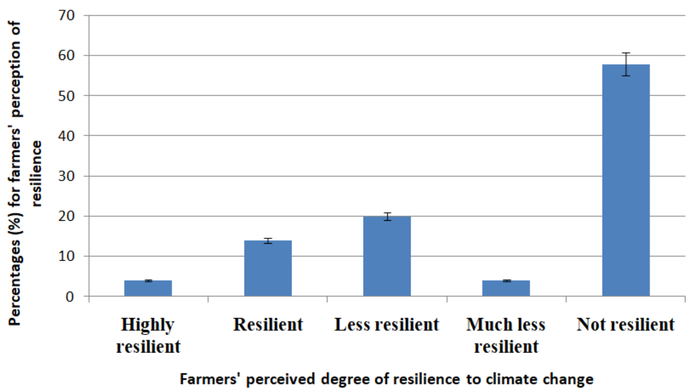

Fig. 5: Resilience to climate change perceived by smallholder farmers

Table 4: Non-cause-effect relationship between continuous explanatory variables and smallholder farmers' resilience to climatic variations and changes

		Levene's test for the equality of variance		t-test for equality of means			
Variable	**Assumption**	**F**	**p-level**	**t**	**df**	**p-level**	**Mean diff.**
Age of house -hold head	Equal variance assumed	83.806	0.000***				
	Equal variance not assumed			-8.224	209.441	0.000***	-5.192
Income of household (in FCFA)	Equal variance assumed	150.556	0.000***				
	Equal variance not assumed			-9.062	179.442	0.000***	-179415.9
Household size	Equal variance assumed	107.704	0.000***				
	Equal variance not assumed			-7.552	195.262	0.000***	-1.590
Number of farms	Equal variance assumed	502.094	0.000***				
	Equal variance not assumed			-10.776	170.493	0.000***	-2.940

*** Significant at 5% probability level

Factors Influencing Smallholder Farmers' Resilience to Climatic Variations and Changes

Influence of Continuous or Quantitative Explanatory Variables on Smallholder Farmers' Resilience to Climatic Variations and Changes

From the computation of the t-test statistic, a statistically significant non-cause-effect relationship ($p<0.05$) was found to exist between some continuous explanatory variables and smallholder farmers' resilience to climatic variations and changes (Table 4).

From Table 4, it is seen that all the four continuous explanatory variables i.e. age of household head, income of household, number of farms, and size of household, all had a statistically significant non-cause-effect relationship with smallholder farmers' resilience to climatic variations and changes. This shows that the aforementioned variables could play a great role in influencing smallholder farmers' resilience to climatic variations and changes.

Influence of Discontinuous or Qualitative Explanatory Variables on Smallholder Farmers' Resilience to Climatic Variations and Changes

Computation of chi-square test statistic revealed the existence of a statistically significant non-cause-effect relationship (0<0.05) between discontinuous explanatory variables and smallholder farmers' resilience to climate change (Table 5). Table 5 shows that the different discontinuous explanatory variables i.e. information accessibility, land accessibility, level of education of household head, access to agricultural extension services, practice of agroforestry, gender of household head, and credit accessibility, all had a statistically significant non-cause-effect relationship (p<0.05) with smallholder farmers' resilience to climatic variations and changes. This confirms that, these variables have a propensity to influence smallholder farmers' resilience to climate change.

Table 5: Non-cause-effect relationship between discontinuous explanatory variables smallholder farmers' resilience to climatic variations and changes

Discontinuous explanatory Variable	Description	Frequency (n)		Percentage (%)		Chi-square	L.R.	p-level
		R	N.R.	R.	N.R.			
Information accessibility	Yes	42	7	12	2			
	No	105	196	30	56	44.70	46.69	0.000***
Access to extension	Yes	45	22	12.86	6.29	21.54	21.41	0.000***
	No	102	181	29.14	51.71			
Practice of agroforestry	Yes	147	132	42	37.71	64.50	90.23	0.000***
	No	0	71	0	20.28			
Credit accessibility	Yes	64	5	18.28	1.43	90.88	99.25	0.000***
	No	83	198	23.71	56.57			
Educational level of house -hold head	No formal education	11	21	3.14	6	123.10	141.69	0.000***
	Primary	62	180	17.71	51.43			
	Secondary	10	0	2.86	0			
	High school	34	1	9.71	2.86			
	Tertiary	30	1	8.57	2.86			
Gender of household head	Male	104	89	29.71	25.43	24.95	25.47	0.000***
	Female	43	114	12.28	32.57			
Land accessibility	Yes	51	10	14.57	2.86	52.50	54.33	0.000***
	No	96	193	27.43	55.14			

*** Significant at 5% probability level; R. = Resilient; N.R. = Not Resilient; L.R. = Likelihood Ratio.

Table 6: Logistic regression predicting influence of explanatory variables on smallholder farmers' resilience to climate change

Explanatory variables	Coefficients (β)	p-level	df	Odds ratio (Exp β)
Land accessibility	1.029*	0.027	1	2.798
Information accessibility	0.937*	0.047	1	2.553
Number of farms	0.271*	0.003	1	1.311
Credit accessibility	1.596*	0.006	1	4.931
Income of household	1.821*	0.002	1	5.134
Intercept	- 1.961*	0.000	1	0.141
Likelihood ratio X^2	145.84*	0.000		
Log likelihood	330.37			
Number of cases correctly classified	80%			
Nagelkerke R^2	0.648			

*, significant at 5% probability level

Influence of Explanatory Variables on Smallholder Farmers' Resilience to Climatic Variations and Changes

From the coefficients of the binary logistic regression model, it was found that five explanatory variables had a statistically significant causal relationship ($p<0.05$) with smallholder farmers' resilience to climate change (Table 6).

Based on the coefficients of the logistic regression model, explanatory variables including credit accessibility, number of farms, land accessibility, income of household, and information accessibility, all had a statistically significant direct cause-effect relationship ($p<0.05$) with smallholder farmers' resilience to climate change. Thus, credit accessibility, land accessibility, number of farms, household income, and information accessibility, have a great role to play towards enhancing smallholder farmers' resilience to climate change.

It is worth mentioning that the parameter estimates of the binary logistic regression model were valid looking at the number of cases correctly classified, Likelihood Ratio X^2, and the Nagelkerke R^2. The model correctly classified up to 80% of the factors influencing smallholder farmers' resilience to climate change. Looking at the Nagelkerke R^2 (Pseudo R^2) of the model which stood at 0.648, it is found that up to 64.8% of the changes in smallholder farmers' resilience to climate change could be explained by changes in the continuous and discontinuous explanatory variables of the model. Likelihood Ratio X^2 (5, n = 350 = 145.835, $p<0.01$), indicated that the model was statistically significant and had a strong explanatory power. Hence, from statistics of the number of cases correctly classified, Likelihood Ratio X^2 and Nagelkerke R^2, it could be said that the predictions of the model were very much valid as far as determining the factors influencing smallholder farmers' resilience to climatic variations and changes were concerned.

Discussion

Climatic Variations and Changes

Recurrent extreme weather/climate events have been the order of the day in north western Cameroon as evidenced by the findings of this study. These extreme weather and climatic events could be attributed to climate change. Some studies carried out in north western Cameroon,[24,26,28,29,30] have shown that extreme variations in climate parameters is a reality in north western Cameroon. However, most of these studies used only a few years of climate data (less than 30 years) to make inferences. This study by making use of over five decades of climate data has filled this knowledge gap.

Through the use of correlation and regression analyses, it was equally proven that some sort of interdependent relationship exists between different climate parameters in the face of climatic variations and changes. Although, some studies undertaken across different parts of the world by[31,32,33,34,35,36,37,38] equally showed the existence of an interdependent relationship between climate parameters, little or no research has been done to assess the interdependent relationship existing between climate parameters in the present dispensation of climate variability and change. This study by shedding light on this has somehow filled the knowledge gap.

Resilience Options of Smallholder Farmers Confronted with the Adverse Effects of Climate Change

This study found that agroforestry is among the most used by smallholder farmers as a resilient option faced with the adversities of climate change. Most studies carried out across Africa have generally shown that smallholder farmers take to different indigenous and modern adaptation options in their drive to combat the adverse effects of climate change.[39,40,41,42,43,44,53] Few studies have identified agroforestry as a major resilience option used by smallholder farmers, with most studies[52,54] focusing on agroforestry as a sustainable farming practice good for farmers with limited research done to assess the role of agroforestry as a resilience option to climate change adversities. With this paper showing that a majority of smallholder farmers take to agro-ecological farming practices like agroforestry to mitigate the adverse effects of climatic changes, a key knowledge gap has been filled.

Perceived Factors Affecting Smallholder Farmers' Resilience to Climatic Variations and Changes

Smallholder farmers' perception is vital to understanding how they feel and react when faced with adversities like climate change. In this study, it was found that smallholder farmers perceived three main factors as the most important influencing their resilience to climate change i.e. income of household, practice of agroforestry and land accessibility. Studies have generally focused on the adaptation choices of smallholder farmers faced with climate change,[12,45,46,47] with little or nothing done to examine smallholder farmers' resilience to climate change. The few existing studies on resilience,[42,48,49] are mostly conceptual, descriptive and theoretical with little or no empirical backing. This study by employing inferential statistical tools and using empirical data breaks away from the norm, and therefore fills a major knowledge gap.

Influence of Explanatory Variables on Smallholder Farmers' Resilience to Climatic Variations and Changes

The existence of a statistically significant non-cause-effect and cause-effect relationship between explanatory variables and smallholder farmers' resilience to climate change could be attributed to the fact that most of the explanatory variables like information accessibility, income of household, credit accessibility, land accessibility, and number of farms are major livelihood assets which can play a great role in the enhancement of smallholder farmers' resilience.

Studies carried out across Africa and other parts of the world,[12,29,30,42,45,46,47,48,49] mostly focused on the non-causal and causal relationship existing between explanatory variables and smallholder farmers adaptation choices to climate change. This study has therefore filled a knowledge gap by examining the non-causal and causal relationship existing between explanatory variables and smallholder farmers' resilience to climatic variations and changes.

The existence of a statistically significant direct causal relationship between five explanatory variables (information accessibility, land accessibility, credit accessibility, income of household, and number of farms) and smallholder farmers' resilience to climate change in particular has many ramifications for these variables have a great role to play towards enhancing smallholder farmers' resilience faced with climate change:

For accessibility to land, the existence of a statistically significant direct causal relationship implies that smallholder farmers with more access to land have a better resilience to climate change than their counterparts with limited or no land which can be attributed to the fact that land is an indispensable asset to any farmer, for it is the most important fixed asset, and without it, no farming activity can take place.

Concerning information accessibility, the existence of a statistically significant direct causal relationship means that smallholder farmers with better information accessibility are more resilient to climate change than their counterparts with limited or no access which could be attributed to the fact that smallholder farmers with easy access to information are able to make plans into the future which helps them to adopt best practices.

With respect to credit accessibility, a statistically significant direct causal relationship indicates that smallholder farmers with more access to credit are more resilient to climate change adversities than their fellow farmers with limited or no access to credit. This could be due to the fact that smallholder farmers with easy access to credit facilities are able to buy better farm inputs and can easily switch to best practices which act as a buffer to the adverse effects of climate change. Meanwhile smallholder farmers with little or no access to credit facilities are unable to buy good farm inputs and cannot switch to best practices on time which renders them weak and vulnerable in the face of climatic extremes.

For number of farms, the existence of a statistically significant direct causal relationship implies that smallholder farmers with many farms are more resilient to climate change which could be attributed to more yields obtained from these many farms which nourishes the household and excess sold to buy farm inputs. It could equally be that these farmers have more access to social and financial resources and or better education which allows them to control more land and therefore enhanced resilience.

Most studies carried out across Africa and the world,[29,30,45,48,49,55] have shown the existence of a causal relationship between farmers' adaptation choices to climate change and different explanatory variables. This study by making use of inferential statistics and empirical data to examine the causal relationship between resilience and different explanatory variables fills a major knowledge gap.

Conclusion and Policy Implications

Smallholder farmers' resilience faced with the adversities of climate change is influenced by a plethora of factors with the main one being income of household, number of farms, credit accessibility, information accessibility, and land accessibility. This implies that these livelihood assets are key determinants of resilience and could play a major role towards enhancing smallholder farmers' resilience to climate change.

Policy makers therefore need to critically examine information accessibility, household income, credit accessibility, number of farms, and land accessibility when crafting policies geared towards enhancing smallholder farmers' resilience to climate change.

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Conflict of Interest

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