ANALYSIS OF FACTORS INFLUENCING THE ADOPTION OF CLIMATE CHANGE MITIGATING MEASURES BY SMALLHOLDER FARMERS IN IMO STATE, NIGERIA

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Abstract

Due to its significant reliance on weather patterns, as well as other environmental factors, agricultural production is particularly vulnerable to changes in climate. Adoption of climate change mitigating strategies are key to coping and building resilience against the vagaries of climate change and hence, increasing agricultural poverty, and lifting rural smallholder farmers out of poverty and food insecurity. This study analyzed the factors influencing the adoption of climate change mitigating measures by smallholder farmers in Imo State, Nigeria. Multi-stage sampling technique was used is selecting 60 respondents were used for the study. Primary data, collected using structured questionnaire, were analyzed using descriptive and inferential statistical tools such as frequency counts and percentages, mean, likert scale type analysis and probit regression. Results showed that unusual early rains followed by weeks of dryness, high temperature, incidence of diseases, heavy rainfall, decrease in soil fertility, increase in pest problems, erratic rainfall pattern, loss of forest resources, reduced harmattan, flooding, soil erosion, heavy winds, thunderstorms, heavy and long period of rainfall, weed infestation, overflowing of rivers and streams, and extinction of some crop species were some of the major effects or manifestations of climate change and they have severe effect on crop production. Also, climate change mitigation measures mostly adopted by the farmers were drainage/flood barrier construction, multiple cropping, mulching, use of improved varieties of crops, change of planting date, irrigation of crops, planting of cover crops, and tree planting. The probit regression showed that the significant variables influencing adoption of climate change mitigation measures were age of the farmer, farming experience, tenancy status, years of education, extension contact, income, access to credit and membership of farmers' association. Education and training of farmers especially as it pertains adoption of good agricultural practices was recommended, as well as the provision of credit to enable them adopt mitigation measures to climate change.

Key words: *adoption, change, climate, farmers, mitigation*

INTRODUCTION

The natural environment comprises the entire basis for food production through water, nutrients, soils, climate, weather and insects for pollination and controlling infestations. [13] noted that most adverse climatic and environmental impacts that occur today are manifestations of man's inadvertent modification to climate on a local and to a limited extent, regional scale in some activities of the distant past. [2] reported that agriculture places heavy burden on the environment in the process of providing humanity with food and fibre, while climate is the primary determinant of agricultural productivity.

Due to its significant reliance on weather patterns, as well as other environmental factors, agricultural production is particularly vulnerable to changes in climate. Some 40 percent of the Earth's land surface is under cropland and pasture, while natural forests cover another 30 percent.4 Emissions from agricultural activities represent [16]. Climate change has direct impact on agricultural production, because of the climate-dependent nature of agricultural systems. Global food insecurity remains a serious problem and more than 900 million people are still hungry in 2010 [5]. Poverty and malnutrition continue to be major problems in Sub-Saharan Africa. In most countries, future sustainable agricultural growth will require a greater emphasis on productivity growth, as suitable area for new cultivation declines, particularly given growing concerns about deforestation and climate change.

According to [13], climate and environmental change processes lead to changes in the biophysical life support system including land surface (vegetation), water resources, soil, and atmosphere which constitute the elements that support the long-term sustainability of life on earth. Projected changes in the frequecy and severity of extreme climatic events are prdicted to have serious consequences for food and food security than changes in projected mean temperatures and precipitation [16].

Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production [17]. [18] classified the patterns of impact of climate change on agriculture into biophysical and socio-economic impact. The biophysical impacts include; physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise and changes to ocean salinity and sea temperature rise causing fish to inhabit in different ranges. The socio-economic impacts result in decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, changes in geographical distribution of trade regime, increased number of people at risk of hunger and food insecurity, migration and civil unrest. According to [3], climate change is further exacerbating people's vulnerability with its negative impacts on public health, food security, water availability or livelihoods, and its consequences in terms of human mobility. In general terms, the most vulnerable groups such as the children, the elderly, and the extreme poor tend to bear the brunt of environmental impacts.

Africa's climate change challenges are enormous [34] as it is arguably the most vulnerable region in the world to the impacts of climate change**.** For instance, a 2011 report from the National Adaptation, Strategies and Plan of Action on Climate Change for Nigeria (NASPA-CCN) stated that climate change is already having significant impacts in Nigeria, and these impacts are expected to increase in the future. Recent estimates suggest that, in the absence of adaptation, climate change could result in a loss of between 2% and 11% of Nigeria's GDP by 2020, rising to between 6% and 30% by the year 2050. This loss is equivalent to between ₦15 trillion and ₦69 trillion.

[36] noted that the vulnerability of agriculture is not determined by the nature and magnitude of environmental stress like climate change per se, but by the combination of the societal capacity to cope with and/or recover from environmental change. The awareness of climate problems and the potential benefits of taking action is important determinant of adoption of climate change mitigating measures [8]. [22] argued that farmer awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. Innovation adoption is key to increasing farm productivity. Adoption of climate change mitigating strategies are key to coping and building resilience against the vagaries of climate change. This study there examined the factors influencing the adoption of climate change mitigating measures by smallholder farmers in Imo State, Nigeria.

MATERIALS AND METHODS

This study was conducted in Imo State of Nigeria. Imo State lies within latitudes 4^o 45^I and $7^0 15^1$ North of the Equator and longitudes $6^o 50^I$ and $7^0 25^I$ East of the Greenwich Meridian. It occupies a land area of 5,530Km^2 (2,140 m^2) and comprises of 27 local government areas, divided into three agricultural zones, namely Owerri, Okigwe and Orlu. Imo has a total population of 3,934,899 [24] and has an average population density of 710/km^2 (1,800/m^2). The effects of population pressure in the area have been recognized in a broad spectrum of livelihood activities such as intensive agriculture, engagement in non-farm activities and migration. The State is part of the southeast

Nigeria, which is particularly vulnerable to ecological problems, especially soil erosion in all forms [28, 30].

Multi-stage sampling technique was used is selecting the samples used for the study. One Agricultural Zone, Owerri Agricultural Zone, out of the 3 in the State was randomly selected in the first stage. In the second stage, 2 Local Government Areas (LGA) were selected randomly. The third stage involved the random selection 2 farming communities from the list of farming communities in each selected LGA. In the final stage, 15 crop farmers were randomly selected from the list of crop farmers in each chosen community. In all, 60 respondents were used for the study.

Primary data was used for the study. Data collection was through the use of structured questionnaire designed to elicit information on status of awareness of climate change and its link with agriculture, crops grown, land use practices that could exacerbate climate change, effects of climate change on the farmers' farm activities, their coping strategies, estimated costs and returns of these strategies, problems encountered in coping with climate change, etc.

Data collected were analyzed using descriptive statistical tools such as frequency counts, percentages, means, etc. and inferential statistical tools. The probit model was estimated for the factors influencing the adoption of climate change mitigation strategies and is specified as follows:

$$P(Yi = 1/\chi) = \Phi (\chi' \beta) = exp(-z2/2)dz \quad (1)$$

Where P is the probability that the ith household used the new technology, and 0 otherwise.

The probit model is generated by a simple latent model of the form,

$$Y^* = \chi' \beta + \varepsilon \quad (2)$$

Where $x|\varepsilon$ is a normally distributed error term; Y is the index of use of technologies/innovation measured as Y = (U/V)*100, where U is the participatory score of the respondent household on the number of technologies/innovations adopted and V is the overall score of all the innovations available. (NB: households with adoption index $< 50\%$ are regarded as non-adopters, and households with index $\geq 50\%$ are regarded as adopters).

X is a vector of explanatory variables such as age of farmer (years); gender (dummy: male = 1, female = 0), farming experience (years); tenancy status (dummy: owner occupier = 1, tenant farmer = 0); years of educational attainment; extension contact (dummy: 1 if the farmer was visited by extension agents in the last cropping season, and 0 if otherwise); farm size (hectare); income (naira); access to credit (amount of credit obtained (naira), and membership to an agricultural association/cooperative society (dummy: member = 1; non-member = 0).

RESULTS AND DISCUSSIONS

Perceived patterns of effect of climate change on weather elements and the environment

The perceived patterns of effect on climate change on weather elements and the environment is presented in Table 1.

The result in Table 1 showed that unusual early rains followed by weeks of dryness, high temperature, incidence of diseases, heavy rainfall, decrease in soil fertility, increase in pest problems, erratic rainfall pattern, loss of forest resources, reduced harmattan, flooding, soil erosion, heavy winds, thunderstorms, heavy and long period of rainfall, weed infestation, overflowing of rivers and streams, and extinction of some crop species are some of the major effects or manifestations of climate change.

Agricultural production is highly sensitive to climate variability and weather extremes as stated in Table 1.

As noted by [31], climate variability is one of the major challenges facing agricultural production systems and has become one of the critical determinants of agricultural output especially in developing countries where rain fed agriculture is predominantly practiced with heavy dependence on climatic resources and labour.

[23] observed that seasonal changes in rainfall

and temperature, which are features of climate change could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations.

[32] noted that agricultural production is particularly vulnerable to irregular or extreme conditions of climate such as more frequent droughts and deviations from "normal" growing season conditions.

Variability in climate variables, as noted by [35], will also interact with other forms of stress associated with agricultural production and affect crop yield and productivity in different ways, depending on the type of agricultural practices and systems in place.

Variations in climatic factors are directly linked with reduced soil productivity and to a higher incidence of pests and diseases. According to [14], poor yield and drought are brought about as a result of delayed onset of rainy season as the vegetative cover of soils withers and the soil become exposed to the vagaries of weather.

With heavy rains and the associated heavy leaching, the soil become eroded and rendered infertile leading to low productivity.

Using a five point Likert scale, the severity of the effects of these changes on the elements of weather and climate and the environment was tested.

The critical mean was 3 and any mean score that was greater than or equal to 3 is regarded as being severe and otherwise if less than 3. The result showed a grand mean of 3.72 indicating that the observed changes in climate variables had severe effect on agricultural production based on the perception of the farmers.

[4], noted the usual features of climate change as affect the volume, quality, quantity, stability of food production and the natural environment in which agriculture takes place.

[18] also noted that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop.

Table 1. Perceived patterns of effect of climate change on weather elements and the environment

Climate change phenomena	"Yes" response		"No" response		Mean score	SOE
	Freq.	%	Freq.	%		
Unusual early rains that are followed by weeks of dryness	60	100.0	0	0.0	4.75	S
Erratic rainfall pattern	55	91.7	5	8.3	4.38	S
Delay in the onset of rain	39	65.0	21	35.0	3.55	S
Long period of dry season	40	66.7	20	33.3	3.55	S
Heavy and long period of rainfall	45	75.0	15	25.0	3.93	S
Less rainfall	20	33.3	60	66.7	2.67	NS
No harmattan	25	41.7	35	58.3	2.70	NS
Reduced harmattan	47	78.3	13	21.7	3.70	S
Long period of harmattan	28	46.7	32	53.3	2.98	NS
Higher temperature	57	95.0	3	5.0	4.90	S
Thunderstorms	42	70.0	18	30.0	3.85	S
Heavy winds	47	78.3	13	21.7	4.02	S
Flooding	50	83.3	10	16.7	4.13	S
Drought	24	40.0	36	60.0	2.90	S
Loss of forest resources	48	80.0	12	20.0	3.85	NS
Heat waves/high temperature	40	66.7	20	33.3	3.48	S
Heavy rainfall	54	90.0	6	10.0	4.10	S
Desertification	18	30.0	42	70.0	2.50	S
Soil erosion	51	85.0	9	15.0	4.05	S
Decrease in soil moisture	34	56.7	26	43.3	3.05	S
Increase in pest problems	48	80.0	12	20.0	4.15	S
Disease incidence	57	95.0	3	5.0	4.40	S
Decrease in soil fertility	51	85.0	9	15.0	4.10	S
Weed infestation	46	76.7	14	23.3	4.00	S
Drying up of streams	33	55.0	27	45.0	3.20	S
Overflowing of streams/rivers	42	70.0	18	30.0	3.65	S
Extinction of some crop species	42	70.0	18	30.0	3.90	S
Grand Mean					3.72	S

Source: Field Survey, 2015.
SOE = severity of effect, S = severe, NS = not severe

Climate change mitigation measures adopted by the farmers

The distribution of the respondents based on climate change mitigation measures adopted is presented in Table 2. Multiple responses were recorded. The result showed that the climate change mitigation measures mostly adopted by the farmers were drainage/flood barrier construction, multiple cropping, mulching, use of improved varieties of crops, change of planting date, irrigation of crops, planting of cover crops, and tree planting. Agroforestry and planting of vertiver grass were the least adopted measures.

Drainage construction/flood barrier (contour ploughing) help in erosion control by controlling run off resulting from rainfall. Multiple cropping which was adopted by all the farmers protect the farms from risk of total crop failure due to the vagaries of climate change. That explained it adoption as a climate change mitigation measure by all the respondents. The result is consistent with the report of [1].

The use of mulching as a mitigation measure against the effect of climate change help decrease water requirements and increase water retention (reduced evapotranspiration); lower emissions due to reduced herbicide use for weed removal; increased capture and sequestering of CO2 and carbon into soils; reduced herbicide input costs; reduced soil-borne pathogen infection of plants, with resultant increased yields and quality; and reduced "drudgery" of hand weeding [6].

According to [6] and [37], the use of zero/minimum tillage has the beneficial effect of reducing soil erosion during severe rainfall; improved water absorption capacity; reduced release of carbon and organic matter stored in soils; reduced use of fossil fuels for plowing; improved profit margins due to reduction or elimination of tilling and plowing expenses.

It has been noted worldwide that farmers have already experienced an increase in the frequency and severity of droughts, floods, and other extreme weather events, and they have shown that adoption of basic agronomic techniques can reduce losses from these events (particularly short-duration events such as flash flooding). For drought conditions, these include mulching and contouring to retain and increase soil moisture, and more efficient irrigation methods that conserve water. For floods and heavy flash rains, mitigation measures include raised beds or contouring to divert heavy flows from plants and reduce soil erosion.

Table 2. Climate change mitigation measures adopted by the farmers

Mitigation measure	Frequency*	Percentage
Drainage construction/flood barriers	60	100.00
Planting of cover crops	37	61.67
Mulching	54	90.00
Crop rotation	28	46.67
Multiple cropping	60	100.00
Use of improved varieties of crops	52	86.67
Change of planting date	47	78.33
Irrigation	40	66.67
Tree planting/Afforestation	32	53.33
Planting of grasses (vertivar grass)	25	41.67
Zero/minimum tillage	29	48.33
Agroforestry	20	33.33

Source: Field Survey, 2015.
* Multiple responses

Factors influencing adoption of climate change mitigation measures

The probit regression estimates of the factors influencing the adoption of climate change mitigation measures is presented in Table 3. The coefficient of determination (R^2) was 0.8958 which implies that 89.58% of the variations in adoption of climate change mitigation measures were explained by the variables included in the estimated probit model. The likelihood ratio chi square was significant at 1% level of significance indicating the goodness-of-fit of the model. The significant variables influencing adoption of climate change mitigation measures were age of the farmer, farming experience, tenancy status, years of education, extension contact, income, access to credit and membership of farmers' association.

Table 3. Factors influencing adoption of climate change mitigation measures

Variable	Coefficient	Standard error	t-ratio
Intercept	3.865	1.002	3.86***
Age (X_1)	-1.943	0.905	-2.15**
Gender (X_2)	1.136	0.238	4.77***
Farming experience (X_3)	0.161	0.049	3.28***
Tenancy status (X_4)	5.122	1.048	4.89***
Years of education (X_5)	0.061	0.025	2.45**
Extension contact (X_6)	-0.005	0.001	-3.89***
Farm size (X_7)	0.002	0.002	1.16
Income (X_8)	0.1848	0.0766	2.41**
Access to credit (X_9)	0.050	0.014	3.67***
Membership of association (X_{10})	9.018	1.159	7.78***
R^2	0.8958		
Likelihood Ratio Chi^2	57.17		

Source: Field Survey (2015)
*** = significant at 1%, and ** = significant at 5%

The coefficient of age was significant at 1% level of probability and negatively related to adoption of climate change mitigation measures. This implies that the adoption of climate change mitigation measures strategies declines as the farmer gets older. This result is consistent with [12]. It has been noted that the older one becomes the more risk averse he/she is. This explains the negative relationship between adoption of new innovations and age.

The coefficient of gender was significant at 1% level of significant and positively related to adoption of climate change mitigation measures. This implies that adoption of climate change mitigation measures was higher for male farmers than their female counterparts. This result agree with those of [20], [12] and [27]. [12] opined that the higher rate of adoption by men has a bearing on the lopsidedness of extension services, the major means of innovation diffusion. [7] reported that few extension services are targeted at rural women, few of the world's extension agents are women and most of the extension services focus on commercial rather than subsistence crops-the primary concern of women. Also, [29] and [25] noted that gender affects technology adoption since the head of household is the primary decision maker and men have more access to and control over vital production resources than women due to socio-cultural values and norms.

The coefficient of farming experience was significant at 1% and positively related to adoption of climate change mitigation measures. The result has some positive implications for increased agricultural productivity because according to [26] and [12], as the number of years a farmer has spent in the farming business may give an indication of the practical knowledge he has acquired on how he can overcome certain inherent farm production problems, which include the vagaries of climate change effect.

The coefficient of tenancy status of the farmer was significant at 1% level of significance and positively related to adoption of climate change mitigation measures. This implies that adoption of mitigation measures increases if the farmer is the owner of the farm land rather than a tenant farmer. [11] and [21] noted that insecure property rights over land reduce sharply the level of activity on the land as it serves as disincentive to farmers from investing meaningfully on the land since the land goes back to the owner after the cropping season. According to [33], land tenure and property rights affect the application of technologies for agricultural and natural resource management.

The coefficients of level of education and extension contact were significant at 5% and 1% level of probability respectively and positively related to adoption of climate change mitigation measures. This implies that the higher the level of education attained and number of contacts with extension services, the higher the adoption of climate change mitigation measures. According to [10], education increases the ability of the farmers to adopt agricultural innovation and hence improve their productivity and efficiency. On the other hand, extension services provide informal training that helps to unlock the natural talents and inherent enterprising qualities of the farmer, enhancing his ability to understand and evaluate and adopt new production techniques leading to increased farm productivity [10, 12].

The coefficients of income and access to credit significant at 5% and 1% probability level respectively and positively related to adoption of climate change mitigation measures. This implies that adoption increases with enhanced access to credit and increase in income. As noted by [9], [15] and [19], lack of fund and access to credit prohibits smallholder farmers from assuming risks of financial leverage associated with the adoption of new technology. This result is consistent with the findings of [12].

The coefficient of membership of farmers' association was positively signed and significant at 1% level. This implies increase rate of adoption of mitigation measures with cooperative membership. Membership of farmers' association/cooperative serve as sources of good quality inputs, labour, credit, information and organized marketing of products. They are expected to help them to receive and synthesize new information and innovations within his locality and beyond. These explain their significant and positive relationship with adoption of climate change mitigation measures.

CONCLUSIONS

It could be concluded from this study that the farmers were ample aware of the pattern of effect of climate change. This informs their adoption of climate change mitigation measures to reduce their severe effects. The study therefore, recommend education and training of farmers especially as it pertains adoption of good agricultural practices, a package of techniques that increase productivity on a sustainable basis by improving soil composition, reducing erosion, raising soil fertility and water-holding capacity, and creating a balanced ecology of microflora and fauna within the soil and crop environment; and provision of credit to enable them adopt mitigation measures to climate change.

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