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Farm Size, Climate Variability and Arable Crop Production in Abia State, Nigeria

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Abstract: This study was on effect of farm size and climate variability on arable crop production in Abia state. The study was necessitated as a result of the increasing rate of food insecurity due to climatic variations and inappropriate adaptation decisions made by farmers. The study focused on analysis of the climate variability pattern in the study area, analyzing the major factors affecting arable crop output, identifying the activities of farmers that worsens the effect of climate change, ascertaining the problems associated with climate change experienced by the farmers as well as the analysis of socio-economic factors influencing the adoption of strategies aimed at curbing or reducing the effect of climate change. Data collections were from both primary and secondary sources. Analysis of data involved the use of trend analysis, regression analysis and the use of descriptive statistics. Results revealed temperature has been on a steady increase, with increasing amounts but changes in the timing of rains and that temperature and farm size/cropped area were the major factors affecting output. Major activities of the farmers that exacerbate climate change were bush burning, clean land clearing soil excavation and continuous cropping. Major problems of climate change experienced by farmers based on their perception were drought, heat stress, flooding and reduced crop yield. Also, socio-economic factors influencing adoption of adaptation strategies were age of the farmer, education, farming experience, income and farm size. It was recommended that in order to mitigate the vagaries of climate change, policies that strengthen educating the farmer, especially agricultural education should be put in place. This should involve educating the youths who are the future farmers and informal education of the current farmers. Also, policies aimed at mitigating the effects of climate change should harness the experience and practical knowledge of the farmers for increased production. In addition, it is important to also increase farmers' access to credit facilities in order to increase incentives for the adoption of climate change adaptation strategies.

Key words: Climate · Farm · Nigeria

INTRODUCTION

It is now clear that most adverse climatic and environmental impacts that occur today are manifestations of man's inadvertent modifications to climate on local and to a limited extent, regional scale in some activities of the distant past. Natural and human induced global environmental change belongs to the class of risk with high probability of occurrence and damage potentials that for the time being no one is willing to perceive the threat. Although the probability of occurrence and damage potentials are well known and clear, there is always a time lag between trigger and consequence which create a fallacious impression of security [1]. Most disasters (including floods, drought, desertification, land degradation, subsidence etc) are not random events occurring without underlying causes; they are sudden manifestations of slow but continuous degradation processes [2].

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. Until recently, the effects of man's activities on climate variations were perceived as negligible and so climate was generally taken

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for granted and there was little thought that climate could be a problem with severe impacts [3]. But today, because climate and environmental changes affect the very basis of arable crop production, the connection between climate variability and food security has became very strong.

Climate change and variability, led by global warming is occurring essentially because human activity is bringing about a rapid increase, beyond natural limits of the concentration of green house gases and in severe cases bringing about the depletion of the Ozone layer include: carbon dioxide (CO_2), Methane (CH_4), Nitrogen oxide (N_2O) and halocarbons. They are a resultant effect of fossil fuel combustion; break down of organic matter and chemical breakdown. They are retained in the atmosphere for longer periods of time [3].

Over the years there has been variability in the proportion of arable land used for cultivation of crops. Studies have shown that the changing climate also comes with it resultant change in land-use and land cover, leading to the decline in crop output [4]. Climate change and variability has the potential to affect all natural and human systems and survival.

Global climate change may impact food production across a range of pathways by changing overall growing conditions (general rainfall distribution, temperature regime and carbon); by inducing more extreme weather such as floods, drought and storms; and by increasing extent, type and frequency of infestations, including that of invasive alien species [5-9].

Current results concluded that while crops would respond positively to elevated CO_2 in the absence of climate change, the associated impacts of high temperatures, altered patterns of precipitation and possible increased frequency of extreme events such as droughts and floods, will likely combine to depress yields and increase production risks in many world regions [10].

Furthermore, projected changes in the frequency and severity of extreme climate events are predicted to have more serious consequences for food and food security than changes in projected mean temperatures and precipitation [3]. Also, regional differences will grow stronger with time [11], with potentially large negative impacts in developing regions but only small changes in developed regions [3,10]. Developing countries are more vulnerable because of the dominance of agriculture in their economies, the scarcity of capital for adaptation measures, their warmer baseline climates and heightened exposure to extreme events [10,13]. This will aggravate inequalities in food production among regions [11].

The two major climatic variables that affect crop yield/ productivity are: reduced amount of rainfall/ drought and increased temperature (°C) (IPCC, 2007). Climate variability can be said to be responsible for limitations in farm size availability for cultivation of crops through landslides and severe erosions caused by wind and water, reduction in its fertility, etc. But the reduction in vulnerability of farm size to climate variability is achieved through farm diversity, that is diversity in farming activities (e.g. differences in crops grown, fertilizer and biocide use, irrigation, use of cross bars, diversity in management) which would in turn reduce vulnerability of crop productivity [14].

Given the fundamental role of agricultural productivity in human welfare, concern has been expressed by federal Agencies and others regarding the potential effects of climate change on Agricultural crop productivity. Interest in this issue has motivated this research on climate change and arable crop production. The specific objectives were therefore to (i) examine the pattern of climate variability in Abia state; (ii) identify the factors affecting arable crop output; (iii) identify the activities of farmers which exacerbate climate change; (iv) ascertain the problems associated with climate change based on the perception of farmers; and (v) identify socio economic factors influencing the adoption of strategies to mitigating the problems of climate change and variability.

This project is set to provide a better understanding about the factors affecting arable crop output alongside climate variability and farm size. It will provide knowledge on adaptation strategies and possible ways of mitigating the problem of climate change and variability by the farmers. This is would alleviate the problem of food insecurity through crop and farm management practices for the farming communities and teeming population.

Methodology: This study was conducted in Abia state of Nigeria. It consists of seventeen (17) Local Government Areas and three (3) Agricultural Zones namely. The major occupation of the people is farming and they are known to produce arable crops such as:-yams, maize, potatoes and rice, etc.

Located in the south eastern Region of Nigeria, Abia state lies within approximately latitude 4°40’ and 6°14’ North and longitudes 7°10 and 8° east. It covers an area of about 5,243.75 Sq km and 2,833, 999 million people [15,16]. The State is low-lying with a heavy rainfall of about 2,400mm year especially intense between the months of April through October.

In carrying out this research work, multi-stage sampling technique was used to select the respondents as they had to come from different locations. In the first stage, Umuahia Agricultural Zone was randomly selected from the three Agricultural Zones of Abia state. In the second stage, Umuahia South Local Government and Ikwuano Local Government Areas were randomly selected from the five Local Government Areas that make up Umuahia Agricultural Zone. In the third stage, four communities each were randomly selected from the two Local Government Areas listed above. In the fourth stage, ten arable crop farmers, each from the eight selected communities were purposively selected as the study demands. This gives a sample size of eighty (80) arable crop farmers. The sampling frame is the list of arable crop farmers in each chosen community.

Both primary and secondary data were employed for the study. Primary data were generated through the administration of a structured questionnaire and interview schedules. Secondary data were sourced from research institutes, Abia State Agricultural Development Programme, published journals and other relevant literature.

Data analysis involved the use of descriptive statistics, Trend Analysis and Regression Analysis. Objective I was analyzed using trend analysis. Objectives II and V were realized using Multiple Regression Model. Objectives III and IV were realized using descriptive statistics such as means, percentages and frequency distribution. For objective II; the implicit form of the model analyzed is given as:

$$Y_1 = f(X_1, X_2, X_3, X_4) \quad (1)$$

Where Y_1 is arable crop output in kg (converted using grain equivalent table); X_1 is precipitation (mm); X_2 is temperature (°C); X_3 is cropped area (ha); and X_4 is time trend

For objective V, the model analyzed is given as:

$$Y_2 = f(X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}) \quad (2)$$

Where:
Y_2 is adoption index, derived as:

$$A = U/V \text{ x}100) \quad (3)$$

U is number of measures adopted by each farmer, V is the total number of measures available, X_5 is age of the farmer (years), X_6 is years of formal education, X_7 is farming experience (years), X_8 is income (Naira), X_9 is sex of the farmer (if male =1, female = O), X_{10} is access to extension facilities (if yes = 1 otherwise = O) and X_{11} is farm size (hectares).

RESULTS AND DISCUSSION

Pattern of Climate Variability in Abia State: Trend analysis was used to note the variations in the pattern of precipitation and temperature for the period, 1992-2007 in Abia state and is presented in Fig. 1. The result of the analysis of the precipitation pattern from 1992-2007 showed fluctuations in the amount of precipitation. There was low rainfall, corresponding to drought in 1992 and 1995 which was about 120mm and the State experienced high levels of rainfall in 2002 and 2007 as revealed by Figure 1.

This therefore accounts for the increasing rate of erosion, flooding; washing away plant nutrients, destroying germinating and sprouting/ growing crops. Flooding affects the amount of oxygen in the soil adversely, causing an increase in the soil temperature, leading to poor growth of crops. This is consistent with the report of the Intergovernmental Panel on Climate Change, IPCC, [17].

Also, the result of the analysis of the temperature pattern from 1992-2007 (Fig. 2) showed that there's been a steady rate of increase in temperature, with a faster rate between 2003 to 2007.This explains the increased rate of drought. This affects the yield of crops negatively due to water shortage [3].

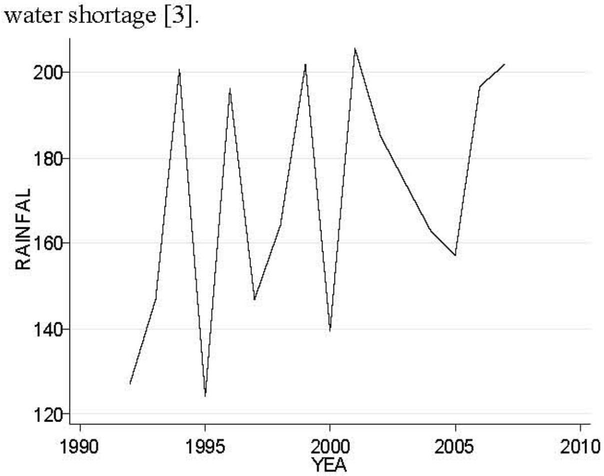

Fig. 4.1: Rainfall Variability

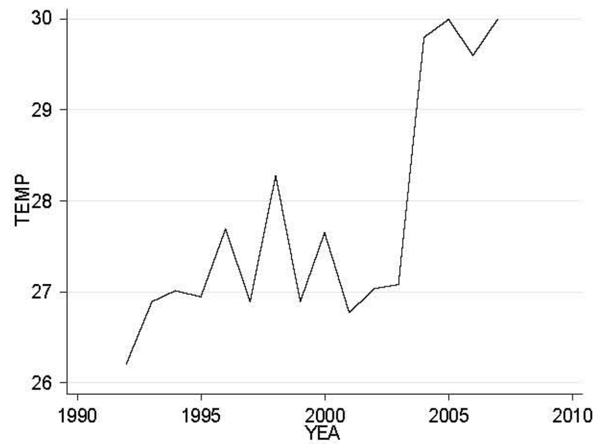

Fig. 2: Temperature Variability

Factors Affecting Arable Crop Output: The regression result of the factors affecting arable crop output is presented in Table 1. The double log functional form was chosen as the lead equation as it is the best fit model. The choice of the lead equation was based on the value of the co-efficient of multiple determinations (R^2 Value), the number of significant variables and the conformity of the signs borne by the estimated coefficients of the variables to *a prior* expectation. The F-ratio which indicates the goodness-of-fit of the model is significant at 1 percent with the highest value. The co-efficient of multiple determination was 0.6529 which implies that 65.3 percent of the variations in output were explained by the variables included in the model.

The significant factors affecting output were temperature, cropped area and time trend. Temperature is negatively related to output and significant at one percent. This implies that as temperature increases by one unit, output will decrease by 0.325kg. This is as result of drought which is a major cause of crop failure in rain fed dependent agrarian communities prevalent in the study area. It conforms to priori expectation. This explains the negative relationship between temperature and output.

Crop area is significant at 5 percent and related positively to output. This implies that as more lands are put into cultivation, more output would be realized, *ceteris paribus*. This conforms to a prior expectation. Positive and significant relationships between cropped area and output have been reported by other researchers such as Iheke and Nto [18], Iheke and Nwaru [19], among others.

Also, time trend is positively related to output and significant at one percent. As the years go by, efforts are intensified to boost food production to feed the additional mouths. This accounts for the positive relationship between time trend and output. The positive relationship also could have resulted from adoption improved farming techniques and other innovations such as use improved and resistant varieties of crops, sustainable agricultural intensification, etc.

Activities of Farmers Which Exacerbate Climate Change: The result of the activities of the farmers which exacerbate climate change were shown in Table 2 below. The Table revealed that the largest percentage of the farmers (83.75 percent) practice bush burning on their farms. This accounts for the rapid increase in the global warming and the consequent gradual depletion of the ozone layer. Burning releases methane (CH_4) and halocarbons, which are retained in the atmosphere for longer periods of time [3].

Table 4.1: Factors Affecting Arable Crop Output

Variable	Linear	Exponential	Double log+	semi-log
Constant	218.205	5.532***	4.053***	-409.991
	(1.10)	(14.82)	(2.30)	(-0.41)
Rainfall	0.574	.004**	0.133	52.633
	(0.53)	(2.28)	(0.41)	(0.29)
Temperature	-0.237	-0.001	-0.325***	-6.119***
	(-0.26)	(-0.34)	(-2.75)	(-2.70)
Cropped area	0.225	0.001	0.490**	87.103
	(0.26)	(0.38)	(2.03)	(0.63)
Time trend	19.485***	0.039***	0.255***	119.797***
	(2.92)	(3.13)	(3.53)	(2.92)
R^2	0.5462	0.5945	0.6529	0.5585
Adj. R^2	0.3812	0.4471	0.5266	0.3980

Source: computed from survey data, 2010
***, **,* = statistical significance at 1 percent, 5 percent and 10 percent respectively
+ = lead equation
Figures in parenthesis are the t-ratios

Table 4.2: Activities of Farmers which Exacerbate Climate Change

Activities	Frequency	Percentage
Bush burning	67	83.75
Clean land clearing	58	72.5
Accumulation of residues	45	56.25
Soil excavation	29	36.25
Continuous cropping	49	61.25
Mono-cropping	19	23.75

Source: Field survey data
*multiple responses

Table 4.13: Problems Associated With Climate Change

Problems	Frequency	Percentage
Erosion	71	88.75
Flooding	56	70.00
Heat stress	71	88.75
Delay in coming of rains	52	65.00
Dryness and sandiness of soil	58	72.50
Pests and diseases on crop land	57	71.25
Reduced crop yield	68	85.00
Less clearly defined seasons	52	65.00

Source: field survey data, 2010
*multiple responses

Table 4: Socio Economic Factors Influencing Adoption Strategies

Variable	Linear	Exponential	Double log	Sem-log
Constant	40.947** (2.38)	3.470*** (3.08)	-0.735 (-0.18)	-17.689 (-0.28)
Age (X5)	0.349* (1.56)	-0.057*** (-3.86)	1.241* (1.79)	-17.920** (-2.08)
Education (X6)	-1.016 (-1.17)	0.78*** (2.91)	0.939** (2.20)	11.118***(3.58)
Farming experience (X7)	-1.072** (-2.43)	1.045** (2.45)	-0.368 (-1.39)	9.461** (2.35)
Income (X8)	0.000 (0.81)	0.240*** (3.69)	0.557** (2.23)	2.328 (0.63)
Sex (X9)	3.533 (0.63)	0.172 (0.47)	0.095 (0.26)	2.283 (0.41)
Access to extension (X10)	-1.304 (-0.19)	-0.244 (-0.53)	-0.412 (-0.92)	-3.925 (0.57)
Farm size (X11)	-18.176* (-1.78)	-1.509** (-2.25)	-0.333** (-2.08)	-3.787*(-1.55)
R^2	0.5972	0.7522	0.5398	0.4646
Adj R^2	0.5343	0.6698	0.4661	0.4155
F-Ratio	6.73***	8.96***	3.87***	2.89***

Source:-Survey data, 2010
***, ** and * = statistical significance at percent, 5 percent and 10 percent respectively
+ = Lead equation.
Value in parenthesis = t-ratio

In the same vein, continuous cropping was practiced by 61.25 percent of the farmers. Continuous cropping decreases the productive potential of the soil with a consequent decrease in crop yield. This is further explained by the law of diminishing returns, which states that "if increasing quantities of one factor of production are used in conjunction with a fixed quantity (e.g. land), after a certain point, each successive unit of the variable factor will make smaller and smaller addition to the total output".

Clean land clearing, practiced by 21.72 percent of the population exposes the soil to flooding and erosion, leading to loss in growing crops, thereby reducing the level of yield per hectare. Soil nutrients are consequently gradually being washed away, decreasing soil fertility level. Other factors exacerbating climate change as revealed by the Table were accumulation of residues, soil excavation and mono-cropping.

Problems Associated with Climate Change on the Basis of Farmers' Perception: The problem associated with climate on the basis of farmers' perception is presented in Table 3. Of the 80 respondents, 71 respondents (88.75 percent) identified erosion and heat stress as the major problems associated with climate change. About 68 respondents identified reduced crop yield.

The farmers indicated that their growing crops were devastated by torrential rains and heat stress which results in drought, hampering crop productivity. Farmers explained that rainfall patterns has been quite unpredictable and that when the rains finally come, they come with heavy down pours, washing away top yoils and growing crops. This results in reduced crop yields. Other problems associated with climate change based on the farmers' perceptions include delay in coming of rains, dryness and sandiness of soil, pests and diseases on crop land and less clearly defined seasons.

Socio-economic Factors Influencing Adoption of Strategies: The regression result of socio economic factors influencing the adoption of strategies is presented in Table 4. The exponential functional form was chosen as the lead equation. This was based on the value of the co-efficient of multiple determinations (R^2 Value), the number of significant variables and the conformity of the signs borne by the estimated coefficients of the variables to *a prior* expectation. The F-ratio which indicates the goodness-of-fit of the model is significant at 1 percent with the highest value. The co-efficient of multiple determination was 0.7522 which implies that 75.22 percent of the variations in adoption mitigating strategies were explained by the variables included in the model. The significant socio-economic factors affecting adoption include age, education, farming experience, income and farm size.

Age of the farmer was significant at 1 percent and negatively related to the adoption of climate change mitigating strategies. This implies that the older the farmer becomes, the lower the probability of adopting farm management and crop diversification strategies. For every unit increase in age, adoption index reduces by 0.057. It has been noted that older people are more risk averse and hence adoption of innovations decreases with age.

Farmers' education was significant at 1 percent and positively related to adoption index. Education is the bedrock of knowledge and as farmers level of education increases, there would be an increased awareness of available adaptation strategies to climate change. Obasi [20] stated that the level of education of a farmer not only increases his farm productivity but also enhances his ability to understand and evaluate new production techniques. Therefore, efforts at mitigating the vagaries of climate change should involve policies that strengthen educating the farmer, especially agricultural education. This should involve educating the youths who are the future farmers and informal education of the current farmers.

Farmers' farming experience was significant at 5 percent and positively related to the adoption of climate change mitigating strategies. This implies that the probability of adoption would increase with increase in farming experience. Highly experienced farmers are likely to have more information and knowledge on changes on climatic conditions and crop and livestock management practices. This result has some positive implications for increased crop productivity and reduction in the negative effects of climate change because according to Nwaru [21] and Iheke [22], the number of years a farmer has spent in the business of farming may give an indication of the practical knowledge he has acquired on how to overcome certain inherent farm production problems. Therefore, policies aimed at mitigating the effects of climate change should harness the experience and practical knowledge of the farmers for increased production.

Farmers' income has a positive relationship with adoption and is significant at 1 percent significant level. The result implies that for every unit of increase in the farmers' income, there would be a 0.24 increase in adaptation to strategies. It has been noted that lack of fund constrains the adoption and risk bearing abilities of farmers.

Farm size is negatively related to adoption index and was significant at 5 percent. This implies that as the size of the area to be cultivated is increased, there would be decrease in the level of adaptation to strategies due to cost implications. That is because the farmers incur greater cost in the adoption of strategies when he has very large hectarage of land.

CONCLUSION

From the foregoing, it is evident that temperature, cropped area and time trend are important determinants affecting arable crop output in Abia state. While in increase in temperature would cause drought, leading to reduced yield, increased crop area will increase output. Similarly, age of farmers, education, farm size, farming experience and income are amongst the socio-economic characteristics of the farmers that influence the adoption of strategies to mitigating the problems of climate change. It was recommended that in order to mitigate the vagaries of climate change, policies that strengthen educating the farmer, especially agricultural education should be put in place. This should involve educating the youths who are the future farmers and informal education of the current farmers. Also, policies aimed at mitigating the effects of climate change should harness the experience and practical knowledge of the farmers for increased production.

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