INCOME EFFECT OF CLIMATE CHANGE ADAPTATION TECHNOLOGIES AMONG CROP FARMERS IN DELTA STATE, NIGERIA.

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ABSTRACT
Adaptation technologies include practices carried out by crop farmers to cope with the adverse consequences of extreme weather events on household welfare such as income shocks, poverty and hunger. This study thus investigated the capacity of adaptation technologies adoption to improve the income of adapting crop farmers in Delta state, Nigeria. Primary data elicited from randomly selected 122 crop farmers with structured questionnaire, were analyzed with parametric and non- parametric statistical tools (mean, standard deviation and percentage). The result shows that average farm income increased from ₦21,639 to ₦34,050.That is ₦12,411(57.4%) increase in net farm income was attributed to the practice of relevant adaptation technologies. The increase in adaptation-based income of the surveyed farmers was significantly ($P<0.05$) influenced by soil conservation (0.624), irrigation (0.415) and crop diversification (0.359).When farmers substituted crop diversification for new varieties technology their income increased by 6% (₦2,043). The 57.4% increase in adaptation-based farm income has implications for poverty alleviation among vulnerable farm families. Further result of the analysis shows that individual crop farmer's food consumption expenditure (food security) increased by 52% after adaptation technology adoption. We recommended that crop farmers should concentrate adaptation efforts and resources on the relevant adaptation technologies such as soil conservation, irrigation and crop diversification technologies. Extension workers should convey this information to potential adapters in order to improve their welfare.
KEY WORDS: welfare, income effect, climate adaptation,technology substitution, crop farmers.

INTRODUCTION
Climate change is characterized by changes in precipitation patterns, windstorms and hailstorms (Manyatsi,*et. al*, 2010).The effect of human-induced climate change threatens the means of livelihood and welfare of vulnerable people through extensive destruction of agricultural lands, properties and reduction in human lifespan. Farm land degradation, decreasing agricultural output and consequent poverty trap, are critical climate related problems facing farmers in the Nigerian flood belt.

Extreme climate events has multiple adverse effects on human welfare and the society. These effects can only be reduced through relevant adaptation technologies. It is important to investigate the multiple effects of adaptation technologies. Adaptation to climate change can translate to multiple economic and financial benefits among small scale crop farmers. The multiple economic benefits of adaptation include: sustained and increased agricultural production, higher household incomes, enhanced environmental quality, protection of assets base, food security and resilient to extreme weather events.

In crop production, adaptation involves changes in management practices such as shifting planting dates, increasing fertilizer use, introduction of new plant varieties and use of irrigation systems to offset the effects of reduced precipitation and higher temperature on yields. These strategies can be short or long term, private or public (Sathaye and Christensen, 1998; Callway, 2003; Schipper, 2007; Bruin, 2011).

Climate adaptation by small scale farmers is an essential and valuable part of global efforts, towards to the achievements of many human development goals such as food security and eradication of hunger.

Adaptation practices to climate change as a ladder out of climate stress, has merely been mentioned at many fora and professional reports of climate change experts (IPCC, 2007), but has not received adequate research attention.

Arable crop sector is one of the highly vulnerable sector to climate change in Nigeria. Nigeria, therefore, has focused its research attention on adaptation technologies to climate change. With the aim of contributing to the National objective of research on adaptation to climate change, this study was conceived to investigate the income effects, substitution effects and overall welfare effects of adaptation measures on households, communities and the society at large.

Whereas the primary goal of adaptation technologies is anchored on improving the welfare of the individual farmer; the secondary goal of adaptation is directed at the welfare of the farmer's immediate households; while the tertiary goal hinges on the community or societal benefits. These three domains of benefit or welfare effects of adaptation technologies have not been fully investigated, especially, how adaptation technologies translate to welfare upgrading, food security and poverty alleviation of individual,

household and the society. The essence is to have a wholistic view of the benefits of adaptation technologies in the study area.

Farming in Nigeria has been one of the most popular enterprises in rural and urban areas. With the substantial number of people engaged in Agricultural production, its contribution to individual, household, community and national welfare, is expected to improve but climate change extremes has the potential to erode the individual, household, community and national welfare status of these farmers.

It is vital to investigate the adaptation technologies that have been adopted by the arable crop farmers in order to build resilience to climate change and improve their welfare. This include soil conservation/management techniques like mixed cropping, crop rotation, planting cover crop, mulching, changing planting dates among others to adapt to climate change.

Previous research works have focused on regional assessment of the potential effects of climate change on agricultural sector. Fischer *et al*, (2002) was among the earliest studies on the effects of climate change on agriculture, followed by (Hassan and Nhemachem, 2008;Apata, *et. al*, 2009). Though some works have been done on the effects of climate change on crop production and adaptation measures in rainforest zone of Nigeria (Nwajuiba, *et. al*, 2008), although their findings were clear, their arguments were not directed at income effect of adaptation practices among crop farmers. This has created a gap or lacuna in knowledge with respect to efforts required to improve the welfare of vulnerable crop farmers.

What is already known about adaptation to climate change in the study area includes awareness of the farmers to climate change and various adaptation technologies (Obi, 2015) but the income, substitution effect and welfare effect (primary, secondary and tertiary impact) of adaptation technologies were yet to be known in the study area. This study was therefore intended to reveal how the right adaptation practices has improved the income of the crop farmers, justified the investment in adaptation practices and reduce their poverty status.

Some pertinent questions that this research was designed to answer were;What is the income effect of adaptation technologies on crop farmers? What is the effect of adaptation practices poverty status of crop farmers? What is the joint effect of identified adaptation technologies on the income of adapters?

The main objective of the study was to determine the income effects of climate change adaptation technologies among arable crop farmers in Delta state, Nigeria.

The specific objectives were to: (1) ascertain the income effect of adaptation technologies of arable crop farmers in the study area. (2) determine the effect of climate change adaptation practices on the individual farmer's poverty status (marginal propensity to consume) in the study area. (3) evaluate the joint effect of the identified climate change adaptation technologies on the income of the adapter in the study area.

The following hypotheses were formulated and tested to guide the study:

.**HO_1**: There is no significant difference between the welfare of adapters before and after adaptation practices to climate change in the study area.

HO_2: There is no significant difference between the welfare of adapters' household before and after adaptation practices in the study area.

HO_3: The identified adaptation technologies have no joint significant effect on the income of the adapter

CONCEPTUAL FRAMEWORK

Income /Welfare Concept

Welfare means well-being in terms of health, happiness and prosperity. In traditional economic research welfare has often been measured by price index. The real income and expenditure of the adapter is used as an indicator or measure of individual, household and community welfare.

Micro-economists have studied consumption expenditure andbehavior, using consumption data to measure poverty.The income effect of the arable farmer, assuming all other factors contributing to his income remains constant, the income effect of adaptation technology is the changes in income that occur as a result of adoption of climate change adaptation practices . If the income of the consumer increases, the budget line will shift outward to the right. On the contrary, a fall in income will shift the budget line inward to the left.Anindifference curveand the budget line explain the changes in farmers income and the associated welfare level. That is, if the farmer uses adaptation technologies, he will have a great output thus leading to increase in income, but if no adaptation technology is put in place, there would be a decrease in the farmers income.

MATERIALS AND METHODS

The Study Area, Sampling Techniques and Sample Size

The study was carried out in Delta State. The Ukwani-speaking people of the Niger Delta occupies the area lying approximately between longitude $6^0 6^1$ West and $6^0\ 42^1$ East, and latitude $6^0\ 31^1$ South and $5^0\ 25^1$ North. The Ukwani comprises one of the major ethnic groups in Delta State, the others being the Igbo(Asaba), Itsekiri, Ijaw, Isoko, Ika and Urhobo.The geographical boundaries of the territory are as follows: on the North by Edo speaking people; on the south by Ijaw; on the East by Bight of Benin; on the West by Urhobo and

Isoko speaking people, on the North-East by Ika and Aniocha people; and on the South-East by Ahoada Local Government of the Rivers State. Nine towns make up the Ukwani Local Government Area namely: Akoku, Amai, Ebedei, Eziokpor, Ezionum, Obiaruku, Umuebu, Umukwata and Umutu with a population of about 120,390 going by the 2006 census.

For this study a two - stage sampling procedure was used to select the sample for the study in the following manner; Out of the nine (9) communities in Ukwani Local Government Area, five (5) communities were randomly selected.In each community, twenty-five (25) arable crop farmers were randomly selected by picking one out of five households in a community since a sampling frame is not available making it a total of one hundred and twenty five (125) respondents in Delta state, Nigeria.

Data collection and Methods of Data Analysis

The study was based on the use of primary data. Primary data for the study were collected using wellstructured questionnaire. The questionnaire was subjected to the test of validity and reliability. The questionnaire contained questions relating to different sections such as the arable farmers socio-economic characteristics, income effect, substitution effect, as well as welfare effect of adaptation (i.e. welfare level of individual adaptors and household adapters). The copies of the questionnaire were personally administered to the sampled arable crop farmers in the study area.

The income effect of the arable farmer, assuming all other factors contributing to his/her income remains constant. Given the adaptation technologies such as alternating planting dates, soil conservation and so on, if the income of the farmer/producer changes, the effect it will have on his/her income is known as income effect. (Jhingan,1994).

Income effect of adaptation technology was evaluated on the basis of counter factual, that is farm income of the farmer before adaptation practices and after adaptation practices. The mean income difference was subjected to t-test analysis as follows;

$$T = \frac{FINCa - FINCb}{SDa/na + SDb/nb}$$

Where:

FINCa = Farm income after adaptation, FINCb = Farm income before adaptation, SDa = Standard deviation after adaptation, SDb = Standard deviation before adaptation, na =number of cases after, nb = no of cases before.

The multiple regression model was used to determine adaptation based income effect of the farmer. This is presented in the model below:

Model specification on the relationship between farm income and adaptation technologies.

$$FINC = \beta_0 + \beta_1(APD) + \beta_2(SC) + \beta_3(PT) + \beta_4(NV) + \beta_5(IRG) + \beta_6(CD) + ei$$

Where;

FINC = Farm Income, APD = Alternating Planting Dates, SC = Soil Conservation, PT = Planting Trees, NV = New Varieties, IRG = Irrigation, CD = Crop diversification, β_0-β_6 = Coefficient or estimate, ei = stochastic disturbance term. Farm income was measured in Naira. The explanatory variables were measured on binary scale of yes =1 if farmer adopted the technology, 0 otherwise.

Evaluation of the effect of climate change adaptation practices on adapters' household welfare (food security) level in the study area.

This was achieved using Food Security Index.It is assumed that poverty level of the individual and food security status of the farmer before adapting to climate change will fall as a result of climate change hazards, but after adopting climate change technologies, their status was appreciated. Thus, household food security was used to analyze the objective.

$$P = G/N$$

Where $G = L - X/L$

Where P = Food security status

L = Expected Food security level

X1 = Actual food security level of adapting households

N = Number of households

RESULTS AND DISCUSSION

The income and consumption effects of adaptation technologies is presented in Table 1.0.

Effect of Adaptation Technologies on the Farm Income of Arable Crop Farmers

The result shows that the mean net farm income of arable crop farmers before adaptation technologies adoption is ₦21,639.34 while the mean net farm income after adaptation is ₦34,050.00. An increase in farm income of ₦13,611.66 is attributed to adoption of climate adaptation technologies by crop farmers in the study area (Table 1.0 and Table 2.0).

Table 1.0: Descriptive statistics of Farm Income and Consumption Expenditure

Variables	N	minimum	maximum	mean	std. deviation
Net farm income after adaptation	122	100.00	60000.00	34050.00	20227.95
Net farm income before adaptation	122	.00	50000.00	21639.34	11380.76
Individual consumption before adaptation	122	5000.00	20000.00	13524.59	7348.70
Individual consumption after adaptation	122	2000.00	75000.00	28073.77	14343.58
Household consumption before adaptation	122	10000.00	180000.00	87622.95	48944.28
Household consumption after adaptation	122	200.00	450000.00	137744.26	105928.51

Table 2.0 Statistical Test ofIncome Effect of Adaptation Technologies

Variables	Mean	Df	SD	t.cal	t.crit	Remarks
net farm income before adaptation	₦21,639.34	122	2027.95	28.00	1.96	significant
net farm income after adaptation	₦34,050.00.	122	1138.76			

Effect of Adaptation Technologies on Food Security (food consumption) status of Adapters and Household members

Individual consumption expenditure before adaptation was ₦13,524.59 while the mean individual consumption after adaptation increased to ₦28,073.05.

$$\%\ difference = \frac{IFCEa - IFCEb}{IFCEa}\ X\ 100/1$$

IFCEa = Individual food consumption expenditure after adaptation practices

IFCEb = Individual food consumption expenditure before adaptation practices

$$\%\ difference = \frac{₦28,073.05 - ₦13,524.59}{₦28,073.05}\ X\ 100/1$$

= 52%.

The result of the analysis shows that individual crop farmer's food consumption expenditure (food security) increased by 52% after adaptation technology adoption. This is an indication of increase in the food security/ welfare level of individual adapting farmer in the study area.

$$\%\ difference = \frac{HFCEa - HFCEb}{HFCEb}\ X\ 100/1$$

HFCEa = Household food consumption expenditure after adaptation practices

HFCEb = Household food consumption expenditure before adaptation practices

$$\%\ difference = \frac{₦87,622.95 - ₦13,744.26}{₦13,744.26}\ X\ 100/1$$

= 54%.

The result of the analysis shows that crop farmer's household food consumption expenditure (food security) increased by 54% after adaptation technology adoption. This is a clear demonstration of increase in the welfare level of adapting farmer's household in the study area. This result is possibly due to the fact that adaptation technology adoption leads to an increase in farm output and corresponding increase in net farm income. It follows that the adapting crop farmer acquires more financial resources to purchase more food for himself and family.

Effect of Adaptation Technology–related Factors on Arable Crop Farmer's Income.

The linear function outperformed the semi-log and double-log function on the basis of R^2 value (93%) and the number of significant variables. T- statistics was used to test the significance of the parameter coefficients. The t-test indicates that three out of the adaptation technologies were significant (P <0.05). These factors are soil conservation, irrigation and crop diversification.

Soil conservation: The result of the study shows that soil conservation practices exerted a positive and significant effecton the post - adaptation income of the crop farmers. Soil conservation is the prevention of soil and water loss or reduced fertility caused by over usage and exposure. Where soil conservation practices are carried out by the crop farmers, the crops are

protected from the effect of extreme dry weather conditions as a result crop output and income would increase. Obi, (2015), had a similar finding in an earlier study. Techniques for improved soil conservation include crop rotation, cover crop, conservation tillage and planted windbreaks and affects both erosion and fertility. This variable is considered to be important in curbing climate change extremes.

Irrigation: The result of the study shows that irrigation has a positive and significant relationship with the adaptation-based-income of the farmer. Irrigation is the method in which water is supplied to plants at regular interval for crops to do well. It is used to assist the growing of crops, maintenance of landscape and re-vegetation of disturbed soils in dry areas and during period of inadequate rainfall.

Crop diversification: This variable entered the model with a positive sign according to a priori expectation. It is intended to give a wider choice in the production of a variety o crops in a given area or farmland. Crop diversification reduces the risk that the farmer might encounter due to climate change, natural disasters, fire outbreaks or failure of one particular crop to produce well, the farmer. Crop farmers who diversified into the production of other crops, particularly, weather resistant crops will fall back on those crops for survival.

Table 3.0: Effect of Adaptation Technology–related Factors on Arable Crop Farmer's Income.
Depended Variable: Net farm Income

Variables	Standard Error	Coefficient	T. Value	P. Value
Constant	.375		-2.212	.054
Alternating planting dates	.117	.143	1.438	.184
Soil conservation	.140	.624	4.700**	.001
Planting trees	.151	-.167	-1.438	.184
New varieties	.200	-.099	-.947	.368
Irrigation	.135	.462	3.842**	.004
Crop diversification	.121	.359	3.048**	.014

* = 5% significant level
** = 1% significant level
R^2 = 93%
F. cal = 22.537

CONCLUSION AND RECOMMENDATIONS

The income effect of climate change adaptation technologies was investigated in this study. Income differential before and adaptation practices was used as a measure of income effect of adaptation practices in the study. Percentage difference in food consumption expenditure before and after adaptation practices was employed as a measure of effect of adaptation technologies on food security status of the adapter. The results of the study show that adopting the relevant adaptation technologies such as soil conservation, irrigation and diversification, significantly improved the income and food security status (welfare) of crop farmers in the midst of climate extremes. The investment in adaptation technologies pays off in the form of income improvement among crop farmers.The increase in adaptation–based income enhanced the household's ability or propensity to consume food and enjoy better welfare. Adaptation technologies are therefore, strong tools for improving the welfare (poverty alleviation and food security) of vulnerable farmers .The result of this study has contributed to the existing body of literature on the subject matter and has also provided information for adaptation policy formulation and implementation.

Based on the research findings the following recommendations were made;

1. Adaptation policy and programs of the Government should encapsulate crop diversification, irrigation and soil conservation technologies in the study area, since they significantly contributed to crop based income of the farmer.
2. Climate change adaptation technologies should form an important part of Government food security and poverty reduction programs for vulnerable crop farmers in the study area..

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