ANALYSIS OF COST AND RETURNS AND COST- EFFECTIVENESS OF CLIMATE CHANGE ADAPTATION STRATEGIES AMONG CROP FARMERS IN BORNO STATE, NIGERIA

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Abstract
The study analyzed cost and returns and cost effectiveness of climate change adaptation strategies among smallholder crop farmers in Borno State, Nigeria. The study was conducted in Sudan savannah and Guinea savannah Agro-Ecological Zones (AEZ) of the State. Data for the study were obtained using structured questionnaire with the aid of oral interview schedule. Multi-stage sampling procedure was used in selecting 360 smallholder farmers for the study. Both descriptive statistics (percentages; frequencies, means); inferential statistics (simple regression) and budgetary technique (gross margin) were used to analyze the data. Findings on the Gross Margin (GM) analysis indicated that application of chemical had the highest gross margin (₦89, 880), this was followed by increased application of fertilizer (₦88,015) and use of improved crop varieties tolerant to new climate regime (₦81,626). Application of chemical had the least marginal cost (0.192), therefore, was the most cost-effective adaptation strategy. Result on the F-test of hypothesis revealed that null hypothesis was rejected and the alternative which states that there is significance difference between cost and returns of the component crops used in adaptation strategies to climate change was accepted. The study concludes that applications of chemical, increased application of fertilizer and use of improved crop varieties had the highest gross margin per hectare. Application of chemical had the least MC, therefore is the most cost-effective adaptation strategy. The study recommends among others that adaptation materials should be provided to farmers at subsidized rate. This will increase farmers' capacity to adapt the most profitable and cost-effective adaptations options; and advocacy and awareness creation on the cost- effective climate change adaptation strategies should be carried out among farmers.

Keywords: Cost and Return; Cost- effectiveness, Climate Change, Adaptation Strategies, Borno State, Nigeria

INTRODUCTION
Climate change poses environmental, social and economic challenges on a global scale (Mendelsohn *et al*., 2006; Scholze*et al*., 2006). Without gainsaying, climate change is a serious challenge facing the entire world today. The impacts of climate change are being felt by both developed and developing countries. These impacts are likely to be felt more by developing countries not necessarily because they are the lowest contributors to climate variations but because they lack economic, social and political infrastructures to respond adequately to the effects of climate change (Farauta*et al*., 2011).

Studies indicate that Africa's agriculture is negatively affected by climate change (Pearce *et al*. 1996; Mertz *et al*., 2009); particularly sub-Saharan Africa is likely to face the most severe challenges on food security due to climate change and other pushing factors of global change (Easterling *et al*., 2007). Fischer *et al*. (2005) estimated that as a result of climate change, agricultural GDP in Africa is expected to fall between 2 to 8 percent. Many farmers in Africa are likely to experience net revenue losses as a result of climate change, particularly as a result of increased variability and extreme events. Dry land farmers, especially the poorest ones, are expected to be severely affected. Kurukulasuriya and Mendelsohn (2006a)

estimated that a 10 percent rise in temperature will lead to visible loss net incomes that could be gained per hectare; that is on average 8.2 percent for rain fed production. On the other hand, irrigated farmers are likely to have better gains in productivity (as higher temperatures support yield increment in most of Africa as long as sufficient water is available). This suggests that irrigation might be an effective adaptation strategy.

Adaptation to climate change is the adjustment of practices, processes and structures to reduce the negative effects particularly, the unavoidable ones, and takes advantage of any opportunities associated with climate change (IPCC, 2007). Although, African farmers have a low capacity to adapt to changing climate, however, have survived and coped in various ways over time. Better understanding the financial implications of how they have done this is essential for designing incentives to enhance private adaptation. There is need to support farmers' coping strategies through appropriate public policy and investment. Deressa (2008) posited that farmers adapted to climate change in order to maximize profit by changing crop mix, planting and harvesting dates, and a host of agronomic practices. The coping strategies adopted by arable crop farmers, which are mainly initiated at the farm and village-level, are expected to enhance their farm productivities, and improve their profit as a producing unit.

Many studies have been conducted on adaptation to climate change in Nigeria(Apata*et al.,* 2009; Oyerinde and Osanyede 2010; Nzeadibe*et al*., 2011; WEP, 2011; Idrisa*et al*., 2012; Adebayo *et al*., 2012; Adebayo *et al*., 2013). These studies identified adaptation responses by farmers, determinants of likelihood of adaptation, factors affecting intensity of adaptation and constraints to adaptation to climate change, limited knowledge however, exist on the cost and returns and cost effective climate change adaptation option of smallholder farmers to climate change owing to the fact that smallholder farmers are resource poor and depend so much on traditional technologies. This study was designed to fill this gab in knowledge and specifically provides information on the following research questions:

I. What are the cost and returns of climate change adaptation strategies practiced by respondents?
ii. What is the most cost-effective climate change adaptation option available to farmers?

In addition, the study tested the following null hypothesis:

iii. There is no significant difference between costs and returns of adaptation strategies been practice by respondents in the study area.

Literature Review

Profitability of Climate Change Adaptation Strategies Literature on profitability of adaptation practices by farmers is scanty as a result of the limited research on the subject. This study explored and provided the available literature. Mohammed *et al*. (2013) explored the economics of adaptation to climate change among crop farmers in Adamawa State, Nigeria among 250 sample respondents. The result of the study revealed that 77.35% of the respondents practiced multiple adaptation strategies of two, three and four. Costs/ha of crop enterprises based on one, two, three and four adaptation practices were ₦32,607, ₦34,400. ₦30,250 and ₦32,550 while their corresponding gross margin/ha were ₦37,283, ₦43,800, ₦50,950 and ₦52,650 respectively. The result depicts that the higher the extent of adaptation practiced by respondents, the more the profit of crop enterprises. Mixed/multiple cropping had the highest returns/ha (₦43,450) among the adaptation strategies practiced solely. This was followed by the use of crop variety tolerant to new climate regime (₦38,800) and use of cover crop/mulching (₦36,100).

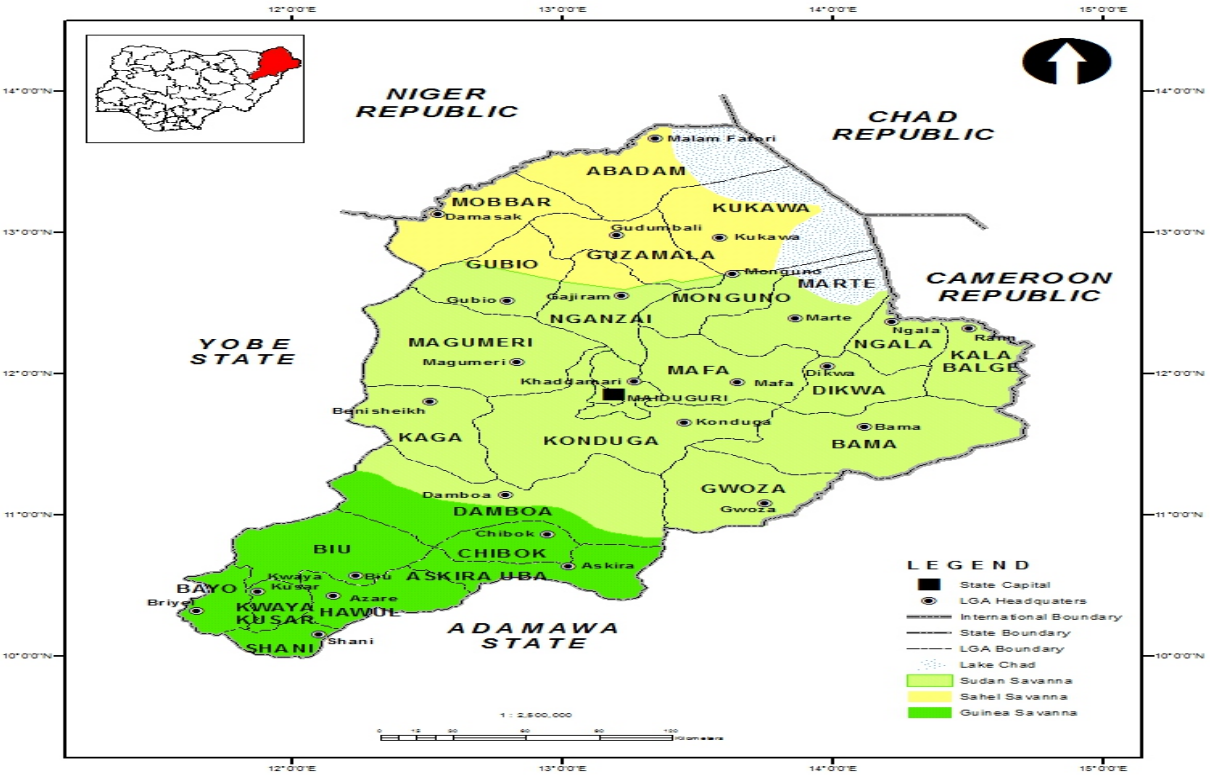
John (2010) examined economic analysis of drought coping strategies among food crop farmers in Borno State, Nigeria using 240 sample respondents. Results revealed that the average cost of production for dry planting, early planting and mixed cropping coping strategies were ₦6,823.4, ₦14,246.7 and ₦7,377.4 per hectare respectively. The analysis reveals that the production cost of the early planting coping strategies was the highest, followed by mixed cropping and dry planting coping strategies. The higher production cost for the early planting coping strategy could be as a result of the use of more labour. Planting of crops may be done several times if the rainfall is irregular. Also, at the on-set of rainfall, labour supply is

scarce because every farmer is busy on his/her farm. Mixed cropping strategy had the highest gross margin per hectare of ₦78,448.22. This was followed by early planting and dries planting copping strategies with gross margin of ₦61,096.28 and ₦11,507.31 per hectare respectively. The least gross margin per hectare from dry planting could be attributed to the fact that it is only millet that is dry planted solely, though sometimes intercropped with cowpea. In addition, the low price of millet also contributed to the low total revenue obtained by farmers during the production year.

Shongwe (2013) determined the cost benefits of climate change adaptation strategies on crop production systems: a case of Mpolonjeni Area Development in Swaziland using 350 respondents. Result on cost benefits analysis reveals that households (6.6 %) have reported that they have adapted to climate change by shifting to drought tolerant crops. These are sorghum, cotton and beans. However, they still do not grow these crops at larger scales and so maize still dominates. The Net Present Value (NPV) was computed based on per hectare average returns. The crop that has the highest NPV is cotton and this shows that when planted cotton, the benefits would be more than the costs by E1864.40 for each household while maize will give E14.40 on average. Compare with maize all the other crops had higher net present values. This shows that households should consider switching maize for drought tolerant crops based on the value of the NPV calculated. However, the results have to be compared with the NPV for the other adaptation strategies. The sensitivity analysis shows that even if the discounts rate can change to 5 % or 15 % the NPV for the different crops still be positive.

Ifeanyi (2016) assessed adaptation strategies to climate change among smallholder crop farmers in Enugu State, Nigeria using 320 sample respondents. Results revealed that respondents used eleven adaptation strategies. Multiple cropping had the highest average gross margin of (₦39,509.92) per hectare while adjusting the dates of planting had the least of (₦12,900.42). Multiple/intercropping a tradition for smallholder farming in Nigeria may have been intensified as a result of climate change effects. This high gross margin associated with multiple cropping was because planting many crops in the farm would ensure that farmers get some guaranteed output in the face of extreme climate events. This translates to more farm output from different crops thus, more farm income per hectare.**Methodology**The study was conducted in Borno State. The State has a land area of 69, 435 square km (Amaza*et al*., 2007). The area lies between latitudes 12^{o} - 00N and 14^{0}, 00N and Longitude 10^{o} - 00E and 14^{0}- 00E of north eastern Nigeria (Fig. 1). There are 27 Local Government Areas (LGAs) in the state spread over three agro-ecological zones viz, the Sahel (S), Guinea Savanna (GS) and the Sudan Savanna (SS) (Amaza*et al*., 2007).

The State has population of 4,151,193 (NPC, 2006) with a projected 2017 estimates of 6,001,901 based on 3.2 population growth rate. It has climatic peculiarities characterized by erratic and un-reliable rainfall patterns. The rains are of short duration followed by a long dry spell. Temperatures are high all year round, with hot season mean temperatures ranging between 39^{o} and 40^{o}C in the northern part of the State. The annual precipitation ranges from less than 600 mm in the north to 1500 mm in the south. Rainfall, however, varies from year to year but has tended to decrease over the last two decades (Amaza*et al*., 2007). Droughts are endemic. Borno State is one of the Desert front line States of Nigeria (WEP, 2011). The main livelihood activity of the people is agriculture producing variety of crops, livestock and fish.



Source :Department of Geography,University of Maiduguri (2019)

Figure 1 : Map of Borno State showing Ecological Zones.

Data for the study were mainly from primary sources, obtained through household survey. Multi-stage sampling technique was used in selecting respondents in the two AEZs selected for the study.In the first stage, three (3) LGAs were purposively selected from each AEZ based on the intensity of agricultural production practices and accessibility to communities. The second stage involved random selection of three (3) communities from each LGA, giving a total of eighteen (18) communities. Lastly, from the lists of registered farmers obtained from Borno State Agricultural Development Programme (BOSADP), farmers associations and community leaders, farmers were proportionately selected from each community, making a total of 360 respondents for the study. Both descriptive (mean, frequency and percentages) and inferential statistics (multinomial logit regression) were used in analyzing data obtained.

Gross Margin (GM) Analysis

GM was used to assess cost and returns of the main climate change adaptation strategies used by smallholder crop farmers. The cost of the main climate change adaptation strategies were considered while other costs incurred in the farm were ignored. These include the costs of both hired and family labour (for planning, implementation, clearing of the farm land, fertilizer application, and harvesting), transaction cost (transportation), cost of improved seed varieties, and cost of fertilizer. The returns of the adaptation strategies to climate change at farm level was the benefit from sale of crop yields, crop yields consumed by farm family and yields given as gifts. Gross margin is the difference between the total farm revenue and total farm variable costs per hectare (Olukosi and Ernabor, 2012). The GM model is empirically presented thus:

$$GMi = \sum_{i=1}^{n} PiQi - \sum_{j=1}^{n} CjX_j \quad \text{---------- (i)}$$

Where;

GM_i= Gross Margin of enterprise i (₦/ha)
P_i = Unit price of product i (₦)
Q_i = Quantity of product i produced (Kg)
C_j= Unit cost of variable input j (₦)
X_j = Quantity of variable input j used
$\sum$ = Summation
GM was used under the assumption that the fixed cost of production is negligible.

Simple Regression Technique

This technique was used to determine the statistical relationship between the total cost of production and output of smallholder farmers for each adaptation strategy practiced by farmers. This shows the cost effectiveness of each adaptation strategy by estimating the marginal cost (MC). The model is explicitly expressed thus:

$$Y_i = a + bX_i + u_i \quad \text{---------- (ii)}$$

Where,
Y_i = Total Output of each adaptation strategies to be measured in Grain Equivalent Weight (GEW)
a = Constant
b = parameter to be estimated
X_i = Total Cost of each adaptation strategy (₦)
u = Error term
i = 1, 2-----n

This method of computing the relationship between cost and output was used by Iheanacho (2005). The adaptation strategy with the least marginal cost is the most cost- effective. In other words, the lower the marginal cost the more cost effective of the strategy and vice versa.

Results and Discussion

Cost and Returns

Table 1 presents the gross margin of the component crops in the main adaptation strategies practiced by farmers.

Table 1: Costs and Returns of component crop based on the practice of the main Adaptation Strategies to climate change

Adaptation Strategy/Cost per hectare						
	AH(₦/ha)	**EP(₦/ha)**	**IAF(₦/ha)**	**MUCC(₦/ha)**	**UICV(₦/ha)**	**AOM(₦/ha**
Gross Revenue (GR) 130000	**84656136786**	**66274**	**122554**	**50120**		
Variable cost						
Seed	3413 (8.86)	2767(8.85)	3044 (7.23)	2356(9.50)	4132(9.90)	1520(8.17)
Fertilizer	7613 (17.36)	5365 (15.53)	10643(19.58)	3129(13.36)	8148(18.00)	3050(14.05)
Chemical	8625 (23.93)	1727 (14.35)	6870 (18.44)	2500(18.53)	1250 (11.71)	2500(9.74)
Labour	20469 (49.85)	22985 (61.26)	28214(54.77)	16877(58.60)	27398(60.39)	15000(58.05)
TVC	**40120**	**32844**	**48771**	**24862**	**40928**	**22070**
GM	**89880**	**51812**	**88015**	**41412**	**81626**	**28050**

Source: Field Survey, 2018
Figures in parenthesis are the percentage contribution of the variable inputs to TVC

AH= Application of Herbicides EP= Early Planting IAF= Increased Application of Chemical MUCC = Mulching and Use of Cover Crop UICV= Use of new Crop Variety AOM= Application of Organic Manure TVC = Total Variable Cost GR= Gross Revenue GM= Gross Margin

The result revealed that application of herbicides had the highest margin (89,880/ha). This was followed by increased application of fertilizer (88,015/ha) and use of crop variety tolerant to new climate regime (81,626/ha). Early planting,

mulching/use of cover crops and application of organic manure had the least gross margin of 51,812/ha, 41,412/ha and 28,050/ha respectively. It can be deduced from the foregoing that application of herbicides, increased application of fertilizer and the use of improved crop varieties tolerant to new climate regime had the highest gross margin of components crops among the main adaptation strategies employed by farmers in the study area. These are technology- based adaptation options practiced by farmers. For example, the high yielding and fast-growing crops are known to easily escape the vagaries of climate change by completing theirgrowth cycle before storm and dry spells, thereby checking the impact of climate change. Downing *et al*. (1997) noted that the use of heat tolerant and drought resistance cropsare effective adaptation practices. Enete*et al*. (2011) also noted a profitability index of1.77 for the use of resistant varieties as adaptation option to changing climate effects in Southeast Nigeria. According to Enete*et al*. (2011), farmers noted the declining soil fertility as one of the sources of land degradation which is overwhelmingly on the increase. Hence, increased fertilizer application as an adaptation practice is expected in order to maintain soil fertility.

The cultural- based adaptation options (early planting, mulching/use of cover crops and application of organic manure) had the least gross margin per hectare. This is perhaps because of the dependence of farmers on traditional practices and inputs such as seeds, manure, weeding etc. The predominance of dry periods, accompanied with heat waves,erratic rainfall, and wind erosion observed in the study area explained the use of mulching asadaptation option to climate change. According to Downing *et al*. (1997), increasing the useof organic matter such as mulch could prevent excessive soil moisture loss, increased soilaeration and soil moisture holding capacity. This finding agrees with Enete*et al*. (2011) andMohammed *et al*. (2013) who noted profitability index of 1.89 and gross margin of N36,100associated with mulching as adaptation strategy in Southeast Nigeria and Adamawa Stateserspectively. This means that culturally- based strategies play an important role towards adaptation to climate change by farmers.

Considering the cost component of crop production based on different adaptation strategies practice revealed that labour account for the highest cost of crop production under all the adaptation strategies considered.Early planting had the highest cost of labour (61.26%) and application of chemical had the lowest cost of labour (49.85%). The reason for the labour intensive early planting could be as a result of labour requirement during re-planting. Rainfall is usually not sufficient at the beginning of rainy season and farmers opt to plant crops early to avoid dry spell and early cessation of rainfall. As a result, 100% crop establishment is not possible, therefore, re-planting is necessary. Application of herbicides had the lowest labour cost among the adaptation strategies practiced by farmers. This is because herbicides application such is a substitute to labour in weeding as revealed by the study. Least labour was recorded under this strategy. Application of herbicides however,had the highest cost of herbicides component of crop production (23.93%). Use of improved crop varieties tolerant to new climate regime had the highest cost of seeds (9.90%) among the main adaptation strategies practice by farmers in the study area. This is obvious considering the fact that improved seeds varieties (hybrid) are costly compared to local seeds varieties which could be planted under other adaptation options. Cost of fertilizer was highest under increased application of fertilizer (19.55%). This is obvious considering the cost of fertilizer.

Cost- effective Climate Change Adaptation Strategy Marginal Cost Analysis

Simple regression analysis was used to estimation of marginal costs of production of component crops under different adaptation strategies to climate change based on the value of R^2.The result is shown in Table 3. The result indicated 65.2%, 49.2%, 50.7%, 83.0%, 54.8% and 48.2% of the variation in returns of components crops of application of herbicides, use of improved crop varieties, increased fertilizer application, mulching/use of cover crops and application of organic manure adaptation strategies were explained by their costs of production as revealed by R^2. All the adaptation strategies were significant at 1% level.

Table 3. Marginal Cost of Production per Kg of the Component Crops based on the main Adaptation Strategies

Adaptation Strategy		Constant	MC	T-ratio	R^2	Sig
AH24464.72	0.192	13.047*65.2	0.000			
EP		8750.63	0.206	8.300*	49.2	0.000
IFA		14749.27	0.266	5.168*	50.7	0.000
MUCC		14989.97	0.256	12.099*	83.0	0.000
UICV		8680.16	0.240	12.655*	54.8	0.000
AOM		16425.03	0.234	11.042* 48.2	0.000	

Source: Field Survey Data, 2018 * Significant at 1%
AH= Application of Herbicides EP= Early Planting IAF= Increased Application of Fertilizer MUCC = Mulching and Use of Cover Crop UICV= Use of new Crop Variety AOM= Application of Organic Manure

The Marginal Cost (MC) of application of herbicides, early planting, increased fertilizer application, mulching/use of cover crops, use of improved crop varieties and application of organic manure were 0.192, 0.206, 0.266, 0.256, 0.240 and 0.234 respectively. Application of herbicides had the lowest marginal cost. This was followed by early planting and application of manure. Application of herbicides was therefore, the most cost-effective adaptation strategy. Any rational farmer would like to produce at a least cost to be able to maximize output and profit. Under application of herbicides adaptation strategy, an additional ₦1 return of component crop could be accrued with 19 kobo. The reason for application of herbicides been the most cost-effective adaptation strategy could be because chemical application such as herbicides is a substitute to labour. The strategy reduces the labour cost of crop production, hence yielding higher returns.

The hypothesis that there is no significance difference between cost and returns of the component crops used in adaptation strategies to climate change was tested using F-test and the P-value of 0.000 was recorded as presented in Table 2. The P-value showed that the null hypothesis was rejected and the alternative which states that there is significance difference between cost and returns of the component crops used in adaptation strategies to climate change was accep

Table 25: F-test of the difference between cost and returns of component crops used in adaptation strategies to climate change

Adaptation Strategy	Sum of Squares	df	Mean Square	F	Sig.
AH					
Regression	32890587488.029	1	32890587488.029	146.392	.000
Residual	6740247511.971	30	224674917.066		
Total	39630835000.000	31			
UICV					
Regression	28023208084.112	1	28023208084.112	160.152	.000
Residual	23097262065.142	132	174979258.069		
Total	51120470149.254	133			
IAF					
Regression	12395167859.176	1	12395167859.176	26.704	.000
Residual	12068533212.252	26	464174354.317		
Total	24463701071.429	27			
EP					
Regression	4895947384.095	1	4895947384.095	68.895	.000
Residual	5045532889.878	71	71063843.519		
Total	9941480273.973	72			
MUCC					
Regression	30060533359.937	1	30060533359.937	151.508	.000
Residual	16071163629.311	81	198409427.522		
Total	46131696989.247	82			
AOM					
Regression	24567812561.241	1	24567812561.241	27.469	.000
Total	37089062713.253	15			

Source: Regression extract, 2018

Conclusion and Recommendations

The study concludes that applications of herbicides, increased application of fertilizer and use of improved crop varieties have the highest gross margin per hectare. Application of herbicides had the least MC, therefore is the most cost-effective adaptation strategy.Any rational farmer would like to produce at a least cost to be able to maximize output and profit. The reason for application of chemical being the most cost-effective adaptation strategy could be because herbicides application is a substitute to labour. The strategy reduces the labour cost of crop production, hence yielding higher returns. The following recommendations are therefore, proffered:

I. Adaptation materials should be provided to farmers at subsidized rate. These include improved crop varieties, fertilizers and herbicides. This will increase farmers' capacity to adapt the most profitable and cost-effective adaptations options.

ii. Advocacy and awareness creation on the cost-effective climate change adaptation strategies should be carried out among farmers.

iii. Government and non-governmental organization should support farmers towards climate change adaptation particularly on the use of the cost- effective strategy.

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