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# Economics of Adaptation to Climate Change among Crop Farmers in Adamawa State, Nigeria

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***Abstract:*** *This study examined the economics of adaptation to climate change among crop farmers in Adamawa state, Nigeria. Multi-stage sampling technique was used in selecting nine communities from three local government areas of zone one of Adamawa Agricultural Development Programme (AADP). Data were collected from 250 selected respondents through the use of questionnaire. Results of the study revealed that 83.83% of the respondents were aware of climate change through extension agents (44.19%), friends and neighbours (34.83%) and contact farmers (34.83%). Major adaptation strategies practiced by respondents in the study area were mixed/multiple cropping (34.71%), early planting (16.27%) and use of crop variety tolerant to new climate regime (15.62%). The result of the study also 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 depict 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 the use of cover crop/mulching (₦36,100). It is recommended that farmers should be encouraged to practice multiple adaptation strategies as they yield more return per hectare.*

***Keywords:*** *Economics, Adaptation. Crop farmers, Adamawa State, Nigeria*

## I. Introduction

Climate change constitutes a very serious threat to sustainable agricultural production and food security in many parts of the world (Adebayo *et al*. 2012). Studies such as Mendelsohn *et al.* (2000); Paavola (2006); Ozor and Cynthia (2010) indicated that temperature is rising and rainfall frequency and intensity is fluctuating. In Nigeria, analysis of long- term meteorological data (temperature, rainfall, dust haze) show discernable evidence of climate change (NIMET, 2008 cited in WEP, 2011). Anuforom (2010); Odjugo (2010) observed that within 105 years, temperatures increased by $1.2^0$ C and $2^0$C in the coastal cities of Niger Delta and northern extreme of Nigeria respectively. In Adamawa State, analysis of climate data (temperature and precipitation) over 25 years (1980-2005) reveals that temperature had increased by $0.3^o$C and rainfall fluctuated over the years (Adebayo, 2010; Sawa and Adebayo, 2010; Audu, 2013). . This leads to warmer seasons; increased frequency and intensity of weather extreme events such as drought, decline in rainfall amount by about 15-20%, increased incidence of dry spell (Adebayo, 1998; Anuforom, 2010).

Climate change impacts on agriculture include biological effect on crop yield, the resulting impact on prices, production, consumption and the impact on per capital calorie consumption and malnutrition. Climate change is increasing production risks in many farming systems and reducing the ability of farmers and rural communities to manage these risks on their own. Without appropriate responses climate change is likely to constrain economic development and poverty reduction efforts and exacerbate already pressing difficulties. Countries with economies rooted in climate sensitive sectors like agriculture, fisheries and forestry are expected to be hardest hit. Nigeria has been recognized as country in Sub Saharan Africa which is very vulnerable to climate change (IPCC, 2007; BNRCC, 2008). This is due to the fact that majority of the countries' population engage in agriculture as their primary occupation and agriculture in the country is mainly rain fed. Food production will be adversely affected by the variability in timing and amount of rainfall and heat stress and the consequence is an increase in food shortages and many farmers could lose their sources of livelihood due to climate change. Benhin (2006); Mano and Nhemachena (2006); Seo and Mendelsohn (2006) observed that climate attributes (temperature and precipitation) affect net farm revenue and such impacts can be significantly reduced through adaptation.

Adaptation is widely recognized as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agricultural sector, but with

adaptation vulnerability can largely be reduced (Easterling *et al*. 1993; Smith and Skinner, 2002) and then identify useful adaptation options and implement them (Maddison, 2006). Many adaptation strategies have been suggested in the literature and farmers have being practicing them. Little knowledge exists however, on the economic aspect of these adaptation strategies practiced by farmers particularly in the study area. This study therefore, was designed to fill in this gab in knowledge. The study is intended to answer the following research questions:

i. Are farmers aware of climate change in the study area?
ii. What are the adaptation strategies to climate change practiced by respondents in the study area?
iii. To what intensity do farmers use adaptation strategies to climate change in the study area?
iv. What are the costs and returns of crop enterprises based on adaptation strategies?

## II. Methodology Of The Study

The study was carried out in zone one of Adamawa State Agricultural Development Programme (ADADP). The area is located in the North-eastern part of the State between latitudes $10^0 21^{/}$ and $13^0 30^{/}$ North of the equator and longitude $13^0 10^{/}$ and $13^0 40^{/}$ East of the Greenwich meridian (Microsoft Student, 2009). The study area had population of about 681,353 (NPC, 2006), with 2012 projected population estimate of 823,094 based on 3.2% population growth rate. The area comprises five local government areas, namely, Madagali, Michika, Mubi North, Mubi South and Maiha. Major crops grown in the area include Maize, Sorghum, Groundnut, Cowpea and Rice (Sajo and Kadams, 1999). The Vegetation of the area is characterized of Sudan Savannah towards extreme North and Northern Guinea Savannah for the remaining part of the area (Adebayo, 1999). The area has two seasons; dry and wet seasons, the month of May to November constitute the wet season, while the dry season commences in November and ends in April. The annual rainfall range is 800mm in the extreme north to 1000mm in the remaining part of the area. Maximum temperatures can reach up to $40^{o}$C in April and minimum temperature can be as low as $18^{o}$C between December and January (Adebayo, 1999). Due to low rainfall and frequent dry spells in the study area, farmers suffer reduced crop yield, shortage of water and biomass for animals (Adebayo *et al*. 2012).

Multi-stage random sampling technique was used in selecting respondents for the study. In the first stage, three local government areas were randomly selected. The second stage involved random selection of three communities from each of the three local government areas selected giving a total of nine (9) communities used for the study. Lastly, fifteen percent (15%) of the registered farmers from the sampled communities were selected from a sampling frame that was obtained from ADADP, giving a total of 250 selected respondents for the study. Data were collected with the use of questionnaire. Descriptive statistics (frequency distribution, mean and percentages) and budgetary technique (gross margin) were used to analyse the data obtained. The empirical model of gross margin was expressed thus:

$$GM_i = \sum_{i=1} P_i Q_i - \sum_{j=1} C_j X_j \quad \text{---------- (2)}$$

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 (Kg)
$\sum$ = Summation
GM was used under the assumption that the fixed cost of production was negligible.

## III. Results And Discussion

**Awareness of Climate Change**

Result on awareness of climate change by respondents indicates that greater part (83.83%) of the respondents is aware of the menace, while 16.17% are not (Table 1). This implies that majority of the respondents noticed in one way or the other changes in the climatic variables which affect their agricultural activities. This finding concurred with the earlier studies by Idrisa *et al*. (2012); Adebayo *et al*. (2012) who observed that about 82% and 96% of farmers in the Sahel Savanna of Borno State and Adamawa State, Nigeria are aware of climate change respectively. Farmer's awareness of changes in climatic factors (temperature, precipitation, humidity) over time is important for adaptation decision making. It helps farmers reduce risk and uncertainty associated with the climate.

Table 1 *Awareness of Climate Change by Respondents (n=235)*

| | Frequency | Percentage (%) |
|---|---|---|
| Aware | 197 | 83.83 |
| Not Aware | 38 | 16.17 |

*Source: Field Survey, 2012*

**Adaptation Strategies Practiced by Respondents**

The result on adaptation strategies used by respondents reveals that 81.22% of the respondents practiced multiple cropping, 38.07% practiced early planting while 47.70% of the respondents used cover crop/mulching as an adaptation strategy. The study also reveals that 36.55% of the respondents used crop varieties tolerant to existing climate regime, 7.11% practiced irrigation supplementation, 12.69% practiced the use of intensive application of chemical/fertilizer and 11.68% practiced planting deeper than usual as adaptation strategy (Table 2).

*Table 2 Distribution of Respondents based on Adaptation Strategies Practiced (n= 197)*

| Adaptation Strategy Practiced | Frequency* | Percentage (%) |
|---|---|---|
| Multiple cropping | 160 | 81.22 |
| Early Planting | 75 | 38.07 |
| Use of Cover crop/Mulching | 92 | 46.70 |
| Use of crop variety tolerant to climate regime | 72 | 36.55 |
| Irrigation supplementation | 14 | 07.11 |
| Intensive use of Chemical/fertilizer | 25 | 12.69 |
| Planting Deeper than usual | 23 | 11.68 |

*Source: Field Survey, 2012*

**Frequency based on multiple responses*

In Nigeria, the practice of multiple cropping could have been intensified as a result of climate change. This is because different crops have different level of resilience to weather situations; hence planting many crops in the field could ensure that farmers get some output in the face of extreme climate events. Multiple cropping is also a measure of diversification by the farmers. The main trust of early planting as an adaptation strategy was to ensure that critical growth stage of crop did not coincide with very harsh conditions in the season. The frequent occurrence of dry spell is devastating to crop production; hence farmers plant early enough in order to avoid such coinciding with the most sensitive growth stage of crop. Also the excessive application of chemical and fertilizer were used to manage crops in order to avoid dry spell coinciding with sensitive growth stage of crops.

The use of cover cropping/mulching was used by respondents as a soil conservation measures. These techniques were aimed at preventing excessive moisture loss, increased soil aeration and enhance soil moisture holding capacity. It is a common knowledge that increased temperature and reduced rainfall are among the most common manifestations of climate change. The use of cover cops/mulching therefore, help farmers to conserve the little moisture they get in the face of climate change. The major trust of using crop variety tolerant to new climate regime is to use crop variety that thrives well in the face of climate change. Given the high frequency of mid-season dry spells and shortening of the rainy season in the study area, farmers used short season and drought resistant crop varieties. Instead of using local crop variety, respondents opted for hybrid that takes short period to mature and yield more than traditional varieties.

**Intensity of Use of Adaptation Strategies**

Intensity of use of adaptation strategies was measured by the number of adaptation strategy (ies) practiced by respondents. Result reveals that majority (49.24%) of respondents practiced three adaptation measures on their farms, 25.89% practiced two strategies and 21.83% practiced only one adaptation strategy. A dismal (3.05%) of the respondents practiced four adaptation strategies on their farms at a go (Table 3).

Table 3 *Distribution of Respondents based on Intensity of use of Adaptation Strategies (n= 197)*

| Intensity of Use | Frequency | Percentage (%) |
|---|---|---|
| 1 | 43 | 21.83 |
| 2 | 51 | 25.89 |
| 3 | 97 | 49.24 |
| 4 | 06 | 03.05 |

*Source: Field Survey, 2012*

It can be deduced from the above result that overwhelming majority (77.35%) of the respondents practiced more than one adaptation strategies on the same farm with the aim of reducing the effect of extreme climatic conditions. This result corroborated the previous findings of Eileen (2009); Oyerinde and Osanyande

(2010) who observed that farmers practiced adaptation strategies in complementary way rather than taking them as an independent strategy.

Assessment of respondents based on practice of one adaptation strategy reveals that 41.86% of respondents used multiple cropping, 34.88% practiced crop variety that are tolerant to new climate regime, 18.60% practiced the use of cover crop/mulching and only 4.65% practiced early planting as sole adaptation strategy. The higher percentage of respondents that practiced multiple cropping solely could be attributed to the fact that it was regarded as a tradition. It was however, intensified as a result of climate change.

Table 4 *Distribution of Respondents based on practice of one Adaptation Strategy (n=43)*

| Adaptation Strategy | Frequency | Percentage (%) |
|---|---|---|
| Multiple cropping | 18 | 41.86 |
| Early Planting | 2 | 4.65 |
| Use of cover crop/mulching | 8 | 18.60 |
| Use of crop variety tolerant to new climate regime | 15 | 34.88 |

*Source: Field Survey, 2012*

**Cost and Return of Crop Enterprises based on Intensity of Use of Adaptation Strategies**

Table 5 reveals that respondents who practiced only one adaptation strategy had average gross margin of ₦37,283.00/ha while those who practiced two adaptation strategies had gross margin of ₦43,800.00/ha. Respondents that practice three adaptation strategies had average gross margin of ₦50, 950.00/ha and those practiced four adaptation strategies had gross margin of ₦52,650.00/ha. From the foregoing, it can be deduced that the higher the intensity of adaptation practices by respondents, the higher the gross margin of crop enterprise. This could be attributed to the fact that practicing more than one adaptation strategy could enable farmers cope many climatic variables. This led to the higher output, hence higher gross margin per hectare. Almost all the respondents of the study practiced multiple cropping perhaps, the reason of the high gross margin for respondents that practiced two or more adaptation strategies on their farms.

*Table 5 Costs and Returns of Climate Change Adaptation Strategies based on Intensity of practice*

*Intensity/Cost per ha*

| | 1(₦/ha) | 2(₦/ha) | 3(₦/ha) | 4(₦/ha) |
|---|---|---|---|---|
| **Gross Revenue (GR)** | **69890** | **78200** | **81200** | **85200** |
| **Variable Costs** | | | | |
| Seed | 1935(5.93) | 2750(7.99) | 2500(8.26) | 3100 (9.52) |
| Fertilizer | 6969(21.37) | 8250(23.98) | 7250(23.97) | 7950 (24.42) |
| Chemical | 3530(10.83) | 6500(18.89) | 5500(18.18) | 4800(14.75) |
| Labour | 20173(62.48) | 16900(49.13) | 15000(49.59) | 16700(51.30) |
| **TVC** | **32607** | **34400** | **30250** | **32550** |
| **GM (GR- TVC)** | **37283** | **43800** | **50950** | **52650** |

*Source: Field Survey, 2012*

*Figures in parenthesis are the percentage contribution of the variable inputs to TVC*

Result on the gross margin of crop enterprise (s) based on the use of one adaptation strategies reveals that multiple cropping had the highest gross margin (₦43,450/ha) among the four adaptation strategies that were practiced solely. This was followed by the use of crop variety tolerant to new climate regime (₦38,800/ha) and use of cover crop/mulching (₦36,100/ha). The gross margin that accrued from the use of early planting was ₦30,750/ha (Table 4.9). Impliedly, multiple cropping and use of crop variety tolerant to new climate regime had the highest gross margin per hectare respectively as revealed by the study. The result of this study was in line with that of Enete *et al*. (2011) who observed that multiple/intercropping had the highest Profitability Index (PI) i.e return per unit investment among the adaptation strategies considered. John (2009) also reported that mixed cropping had the highest gross margin among the drought coping strategies practiced by crop farmers in Borno State, Nigeria.

Looking at the cost components of the adaptation strategies revealed that labour account for 68.03% of the total cost of crop enterprise in multiple cropping, followed by use of cover crop/mulching (63.27%) and use of crop variety tolerant to new climate regime (58.63%). It is obvious that much labour is required in mixed cropping especially in planting, harvesting and processing. The cost of seed was higher (24.43%) of the total cost of crop enterprise in the use of crop varieties tolerant to new climate regime, because respondents used hybrid seeds that are costly.

Table 6 *Costs and Returns of crop enterprises based on practice of one Adaptation Strategy*

*Adaptation Strategy/Cost per hectare*

| | MC(₦/ha) | EP(₦/ha) | UCCM(₦/ha) | UNCV(₦/ha) |
|---|---|---|---|---|
| **Gross Revenue (GR)** | **80200** | **59850** | **68500** | **69500** |
| **Variable cost** | | | | |
| Seed | 1750 (4.76) | 2000(6.87) | 1600 (4.94) | 2500 (8.14) |
| Fertilizer | 6500(17.69) | 6000 (20.62) | 7000 (21.60) | 7500 (24.43) |
| Chemical | 3500 (9.53) | 4600 (15.81) | 3300 (10.19) | 2700 (8.79) |
| Labour | 25000 (68.03) | 16500 (56.70) | 20500 (63.27) | 18000 (58.63) |
| **TVC** | **36750** | **29100** | **32400** | **30700** |
| **GM** | **43450** | **30750** | **36100** | **38800** |

*Source: Field Survey, 2012*

*Figures in parenthesis are the percentage contribution of the variable inputs to TVC*

MMC= Multiple Cropping EP= Early Planting UCCM = Use of Cover Crop/Mulching UNCV= Use of Crop Variety Tolerant to new Climate Regime TVC = Total Variable Cost GR= Gross Revenue GM= Gross Margin

## IV. Conclusion and Recommendations

The study analysed the economics of adaptation to climate change in Adamawa State, Nigeria. The study concludes that majority of the respondents is aware of climate change. Major adaptation strategies practiced by respondent in the study area were multiple cropping, cover crop/mulching, early planting and the use of new crop variety tolerant to new climate regime. The study revealed that greater part (77.35%) of respondents practiced multiple adaptation strategies of 2, 3 and 4. The higher the intensity of adaptation strategies practiced by respondents, the more the profit of crop enterprises. Multiple cropping had the highest returns/ha among the adaptation strategies practiced solely. This was followed by the use of crop variety tolerant to climate regime and the use of cover crop/mulching.

Based on the findings of the study, the following recommendations are proffered:

i. Farmers should be encouraged to practice multiple adaptation strategies because the resulting crop enterprises yield high profit per hectare, and
ii. Farmers should also be encouraged to go into irrigation agriculture with support from governments and non-governmental organisations (NGOs).

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