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EVALUATING THE COST EFFECTIVENESS OF FARMING HOUSEHOLDS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN OSUN STATE

[1]AINA JOSHUA TAIWO, [2]ADEYEMI AYOTUNDE A., Ph.D. AND [3]Adewale M. E.
[1]School of Vocational and Technical Education,
Department of Technical Education,
Osun State College of Education Ila-Orangun.
[2]Department of Agricultural Education,
Osun State College of Education Ila-Orangun.
[3]Department of Biochemistry,
University of Ibadan, Ibadan.
E-mail Address: jaaina@ossceila.edu.ng

ABSTRACT

The study was undertaken to determine the Cost Effectiveness of farming households' adopted adaptation strategies to climate change In Osun State. The researchers determined the costs and returns associated with climate change adaptation strategies with a view to analysing the economics of climate change adaptation strategies employed by maize farmers in the study area. Multistage sampling procedure was employed to select 600 smallholder maize farmers in Osun Southwest, Nigeria. Both primary and secondary data were used for this study. Primary data were collected with the aid of structured questionnaire while secondary data were collected from the Nigerian Meteorological Agency (NiMet) for a period of 30 years. Data collected include socioeconomic characteristics, climate change variables, income, price and quantity of output, cost of input and soil variables. Data collected were analysed using descriptive statistics and costs and returns analysis. The research results showed the estimated net income to be ₦328,469.21. This implies that when the costs of all the fixed assets used in production are deducted from the gross margin, an average maize farmer in this category will still earn ₦328,469.21 as return per hectare of maize production. The variable inputs considered for the study included seeds, labour, agro-chemicals, fertilizer, and transportation. The average total variable costs per hectare for the cropping year were estimated to be ₦195,099.00 and the average total fixed costs was ₦47,400.37. The result also showed that benefit-cost ratio of maize production using change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies to be 2.20, which implied a benefit of ₦1.20 over every 1 naira invested. This ratio clearly indicates the benefits of maize production in a cropping year when smallholder farmers employed change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies while accounting for the costs associated their chosen strategies. Also, the net farm income ratio, which is the ratio of the gross margin to the net income, was 1.14 indicating revenue of ₦0.14 over and above every ₦1 realizable as net profit. The results also showed that benefit-cost ratio of maize production using change in planting date, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies to be 1.67, which implied a benefit of ₦0.67 over every 1 naira invested. This ratio clearly indicates the benefits of maize production in a cropping

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year when smallholder farmers employed change in planting date, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies while accounting for the costs associated their chosen strategies. Also, the net farm income ratio, which is the ratio of the gross margin to the net income, was 1.25 indicating revenue of ₦0.25 over and above every ₦1 realizable as net profit. The profit margin is a measure of profitability that is estimated as the net profit as a percentage of the total revenue. The profit margin per a hectare of maize in the study area was estimated to be 57.52 per cent. The result of the gross margin analysis which shows the difference between the total revenue (TR) and the total variable cost (TVC) was estimated to be ₦476,346.72. This implies that maize production in the study area using more than six adaptation strategies were profitable. It also suggests that an average maize farmer will earn ₦476,346.72 as a return per cropping year from cultivating a hectare of maize farm when costs of his fixed assets used in production are not taken into account. The net income/return from maize production per hectare accruable to an average maize farmer in this category was estimated as the difference between the gross margin (GM) and the total fixed costs (TFC). The result showed the estimated net income to be ₦409,116.70. Hinged on this, the study recommends' the use of multiple adaptation strategies to climate change by smallholder maize farmers.

Keywords: Cost Effectiveness, Farming Households, Adaptation Strategies and Climate Change

INTRODUCTION

Climate change is widely acknowledged as a global issue that requires concerted and coordinated adaptation and mitigation efforts from nations, communities and individuals with more consideration giving to smallholder farmers in most developing regions of the globe. Many people and most households in Nigeria depend on cereals (most especially, maize) as a contributing, if not principal, source of food and nutrition (CBN, 2005; Fadina and Barjolle, 2018). Maize is an important food security crop serving as both cash and food crop and recently replacing crops such as sorghum and millet as the most consumed cereal in Nigeria (Abdoulaye *et al*., 2012; Sertoglu *et al*., 2024). Meanwhile, maize production is found to be highly affected by climate variability and change (Abdoulaye *et al*., 2012). According to Akpalu *et al*. (2022), there is a negative impact on the yield of maize when there is a decrease in mean precipitation simultaneously with a marginal increase in mean temperature or vice versa. Given the increasing evidence for climate change in sub-Saharan Africa, there is an urgent need to analyse and explain the varying and prevailing adaptation and mitigation strategies being used to help cope with the challenges and impacts of climate change on the environment and agriculture (Trevor-Wilson and Lewis, 2015). The number of coping and adaptation strategies employed for climate variation and uncertainty are varied and location specific (FAO, 2017). Furthermore, climate change is widely acknowledged as a global issue that requires concerted and coordinated adaptation and mitigation efforts from nations, communities and individuals with more considerations giving to smallholder farmers in most developing regions of the globe. Until recently, research about adaptation has always focused on the first steps of identifying the biophysical impacts of climate change with less focus on the impact of important arable crop like maize.

Many people and most households in Nigeria depend on cereals (most especially, maize) as a contributing, if not principal, source of food and nutrition (CBN, 2005; Fadina and Barjolle, 2018). Maize is an important food security crop serving as both cash and food crop and

recently replacing crops such as sorghum and millet as the most consumed cereal in Nigeria (Abdoulaye *et al*., 2012; Sertoglu *et al*., 2017). Maize is one of the important grains in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic value. In fact, maize contribution to cereal output has also increased to 25.24 per cent between 2000 and 2010 which has also increased its contribution to Nigeria Gross Domestic Product (FAO, 2017). Meanwhile, maize production is found to be highly affected by climate variability and change (Abdoulaye *et al*., 2012). According to Akpalu *et al*. (2008), there is a negative impact on the yield of maize when there is a decrease in mean precipitation simultaneously with a marginal increase in mean temperature or vice versa.

A challenge for agricultural researchers is premised on understanding timeliness and how these adaptation measures to climate change are used by farmers and their attendant impacts (Doss, 2006). An understanding of the assessment of climate change adaptation strategies and the factors influencing the choice or combination of choices is therefore important in the process of technology development and dissemination.

Agriculture being one of the most weather-dependent of all human activities is highly vulnerable to climate change. This vulnerability to climate change is particularly felt by African countries because of their dependence on rain fed agriculture, high levels of poverty, low levels of human and physical capital, inequitable land distribution and poor infrastructure (Bamire, 2010; Tologbonse *et al.,* 2021). Climate change as defined by United Nation Framework Convention on Climate Change (UNFCC, 2001; 2007, 2015) refers to a change of climate that is attributed directly or indirectly to human activity which alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. According to Harvey *et al.* (2022), changes in climatic conditions have already presented significant challenges to smallholder maize farmers in Africa as it is being experienced in Central America.

Nigeria, like the rest of Africa, is experiencing increasing risk from climate change, including rising temperatures and heat waves, shortfalls in water supply/increasing floods arising from shortage/excessive rainfalls, sea level rise, increasing likelihood of conflict and induced environmental and vector borne diseases. These emanating conditions have compromised agricultural production (crop, livestock, forest and fishery resources), nutritional and health statutes, trading in agricultural commodities, human settlements (especially of agricultural communities), tourism and recreation among others (Adefolalu, 2007;Fadina and Barjolle, 2018). The adverse effects of climate change have negatively impacted the welfare of millions of people, most especially small holder farmers (Intergovernmental Panel on Climate Change (IPCC, 2007).

Smallholder farmers are the bed rock of Nigeria's agriculture and rural economy. They produce over 90 per cent of Nigeria's agricultural output and constituted about 60 per cent of the national population domiciling in rural areas (Akinsuyi, 2011; Federal Ministry of agriculture and Rural Development (FMARD), 2012; Adekanye, 2014). According to FMARD, (2017), smallholder farmers are those whose production capacity falls between 0.1 and 4.99 hectares holding. Clearly defined, smallholder farmers are those marginal and sub-marginal farm households that own and/or cultivate their farmlands under certain excruciating conditions (Nwankpa, 2017). Some of the myriads of challenges faced by smallholder farmers are the poor access to modern improved technologies and their general situations that fail to attract merit and tangible investments in forms of capital, labour and other inputs (FMARD, 2017; Nwankpa, 2017). These factors have led to their low efficiency

and productivity which in turn culminates to their decreasing contribution to the nation's economy (NBS, 2017). The manifestations of climate changes are diverse and far reaching. One of the resulting consequences that the increasing frequency and severity of droughts are likely to cause include crop failure, high and rising food prices, distress sale of animals, de-capitalization, impoverishment, hunger, and eventually famine (Bishwa, 2014). How much one can hold climate responsible for changes in agricultural productivity in Nigeria will, for a long time, remain a subject of research as long as other factors are at interplay in determining agricultural productivity (Collier, 2008). Therefore, building capacity against the influence of climate change requires understanding the impact of the change and effectiveness of the adaptation strategies (McCarthy, 2012). This is because different crops thrive under different climatic condition which has not been adequately explored in sub-Sahara Africa (Heltberg *et al.*, 2020).

Farmers have developed a number of coping and adaptation mechanisms in order to live with climate variation and uncertainty (Shikuku, *et al.*, 2017). Effectively adapting to climate change requires both an understanding of the causes and impacts of climate change and willingness to change behaviours: either those behaviours that contribute to greenhouse gas emissions or those that may be insolvent in the face of future climate impacts (Niles and Mueller, 2016). Such actions are predicated on recognition that climate change is happening and action is necessary (Niles and Mueller, 2016). For climate change, perceived personal experiences affect climate change belief and adoption (intended or actual) of climate adaptation and mitigation behaviours (Spence *et al.*, 2011; Broomell *et al.*, 2015). Most individuals and households employ a combination of responses to the impacts of climate on their livelihoods (Thomas *et al.*, 2005), suggesting that actions constantly change with different situations and crops.

For adaptation to be successful, it should be taken within a comprehensive and interactive process of social institutions and organizational learning and changes (Shongwe *et al.*, 2014). In many parts of sub-Sahara Africa, households rely on a combination of self-insurance and informal risk sharing arrangements (Mengistu, 2011). Many Africans cope with shocks and stresses through informal strategies that rely on family and community structures-gift exchanges, sharing food, migration, remittances, child labour, informal cash or in-kind loans, or sending children to live with relatives rather than government or market instruments (Hertberg and Siegel, 2008). Decisions made concerning the localised coping and adapting strategies is expected to have far reaching effect on the livelihood of farmers that depends on maize for survival in Nigeria (Fadina and Barjolle, 2018).

The issue of climate change is increasingly becoming a threat not only to the sustainable development of socio-economic and agricultural activities of any nation but to the totality of human existence (Adejuwon, 2004). Drastic changes in rainfall patterns and rise in temperatures have introduced unfavourable growing conditions into the cropping calendars thereby modifying growing seasons which consequently affect the crop productivity. These changes affect food prices, food security, land use (Lobell and Field, 2007) and raising uncertainty for crop managers (Pathak and Wassmann, 2009). According to Kahil *et al*. (2015), the severity of climate change impact depends on the degree of adaptation at the farm level, farmers' investment decisions and policy choices, though these factors are interrelated and negatively affects quantity of output most times.

In order to have a sustainable level of output by farmers, measures are taken by farmers to adapt to risks posed by climate change on their productive activities. Tobey *et al*. (1992) and

Adger *et al*. (2003), asserted that there are various and numerous types of adaptation and coping strategies available to different farmers and these are influenced by the level of perception of climate change which also determines the type and extent to which the strategies are employed (Ayinde *et al*., 2010).

According to Coster and Adeoti (2015), maize productivity depends on climate and nature of soil among others which are regarded as the yield potentials of a certain area. This crop survives with the mean daily temperature between 16 to 19 ^{o}C and a consistently right amount of precipitation. However, this is being threatened with persistent and erratic climate change thus affecting farming within the predominantly rain-fed systems. Climate change has induced rainfall and temperature stresses, which reduced maize yields in Nigeria. Furthermore, empirical evidence shows that there is likelihood that yield will continue to decrease by 15% and 24% by the year 2030 and 2050 respectively compared to the baseline year 2000, implying a decline of about 1.4million tons and 2.9million tons respectively using an average simulated yield of 1.3 tons per hectare (Coster and Adeoti, 2015). These changes in climate will in no small measure limit maize production, thus, prospecting lowered welfare status of farming families who solely depend directly on maize cultivation as their source of food and income.

To ensure continuous production, maize cultivators are practically taking steps to mitigate against the economic losses associated with climate change, however, it is noteworthy that these coping strategies and adaptation options utilized by various maize producers do not come without costs. The effect of climate change and its cost implications on farmers have been assessed by studies in countries like Egypt and Senegal on various crops but limited studies exist on the subject matter, most especially on maize production in some areas in Nigeria (Ayinde *et al*., 2010). Moreover, the economic loss inventories and estimation associated with maize cultivation has not been adequately documented. It is therefore imperative to estimate the economic implications and effects that are posed by climate change specifically on maize production in Osun State. This study therefore proffered answers to the following pertinent research questions;

Research Question

i. What are the costs and returns to different climate change adaptation strategies used by the farmers?
ii. What are effects of climate change on the net returns to maize farmers?

Objectives of the Study

The broad objective of this study is to analyse the economic implications of climate change adaptation strategies among smallholder farmers in Osun State.

RESEARCH METHODOLOGY

Study Area

The study was carried out in Osun State, Southwestern Nigeria, which is one of the six geographical zones in the country. The climate of Osun State, Nigeria is tropical in nature and it is characterized by wet and dry seasons. The temperature ranges between 25^{0} C and 35^{0} C while the annual rainfall ranges between 1300mm and 2500mm. The wet season is associated with the Southwest monsoon wind from the Atlantic Ocean while the dry season is associated with the Northeast trade wind from the Sahara Desert (Umar *et al.,* 2015). The ecological condition in Osun State, Nigeria is made up of fresh water swamp and mangrove forest at the belt, the low land in forest stretches inland to Ogun and part of Ondo States

while secondary forest is towards the northern boundary where derived and southern Savannah exist (Bamire *et al.,* 2010). This ecological condition encourages the cultivation of early and/or late crops such as cassava, yam, millet, rice, plantains, cocoa, palm produce, cashew and maize.

Sampling Procedure

Multistage sampling procedure was employed in selecting respondents for this study. In the first stage, Osun was purposively selected based on predominance of maize production in the region. In the second stage, six Local Government Areas (LGAs) were purposively sampled from based on the concentration of smallholder maize farmers in the study area. In the third stage, five (5) villages from each of the selected six LGAs were randomly selected to make a total of thirty (30) villages. Finally, 20 farmers per village were randomly selected to give a total number of 600 farmers:

$X_{i=(n)x}\,30$.....(1)

Where X_i = number of villages to be sampled
n= number of villages in the particular LGA
N = total number of villages in all the LGAs

Costs and Returns Analysis of Climate Change Adaptation Strategies in Maize Production

The evaluation of the cost and returns associated with climate change adaptation strategies were analysed using the budgetary technique. Various inputs that were used in the production of maize and their costs were identified and estimated. The budgetary technique was used for this study is as follows:

GM =TR-TVC.....from eqn. (6)
TR = Quantity of output (Qi) x Price(Pi) and
TVC = Quantity of Input (Xj) x Price(Pj
For this study, the gross margin is expressed as:
Where GM = gross margin (₦/ha)
Pi= average price of output i (₦/kg)
Qi= average quantity of output i (kg/ha)
Pj = average price of input j (₦/kg)
Xj = quantity of input j used (kg/ha)
Where i is the number of observations (i= 1,2,3,4,...600)

$P_iQ_i = P_{mi}Q_{mi}+P_{ci}Q_{ci}$ .....(7)

P_{mi}= average price of maize sold (₦/kg)
bQ_{mi} = average quantity of maize sold (kg/ha)

$P_jX_j= C_{mj}Q_{mj} + C_{cj}Q_{cj} + L_j + Cfj + Q_{fj}+ C_{aj} + Q_{aj} + Z_{xi}$ .....(8)

C_{mj} = average cost of maize seed used for planting (₦/kg)
Q_{mj} = average quantity of maize seed used for planting (kg/ha)
L_j = average cost of labour used for all farm operations (₦)
C_{fj} = average cost of fertilizers used in planting (₦/kg)
Q_{fj} = average quantity of fertilizer used in planting (kg/ha)
C_{aj} = average cost of agrochemicals used in planting (₦/litre)
Q_{fj} = average quantity of agrochemicals used in planting (litre/ha)
Z_{xi} = Cost of Adaptation strategy employed by maize farmers (₦/ha)
Total Revenue (TR) = Quantity Produced x Price
Gross Margin = Total Revenue – Total Variable Cost
Total Cost (TC) = Total Fixed Cost + Total Variable Cost
Net Income (NI) = Gross Margin – Total Fixed Cost

Depreciation formula that wss used for this research purpose is stated as (Cost of Farm Equipment/too – Salvage Value)/ Useful Life. The salvage value is the value of the tool/equipment after its useful life.

RESULTS AND DISCUSSION

Estimates of Costs and Returns associated with combining Change in Planting Date, Minimum Tillage, Crop Rotation, Intercropping, Change in Fertilizer Quantity and Non-Agronomic Practices

The result in Table 1 shows the costs and returns associated with combining six adaptation strategies (that is, change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices) in maize production in the study area. On the average, the farmers produced 3,884.14kg of maize per hectare of land in a year and the average price of a kilogram of maize for farmers that employed these adaptation strategies was estimated to be ₦147.00 in the study area resulting in average revenue of ₦570,968.58 per hectare. The variable inputs considered for the study included seeds, labour, agro-chemicals, fertilizer, and transportation. The average total variable costs per hectare for the cropping year were estimated to be ₦195,099.00 and the average total fixed costs was ₦47,400.37.

Table 1: Gross margin analysis of maize production per hectare (change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices)

Items	Price (₦/kg)	Quantity (Kg)	Total (₦)
(A) Revenue (₦)			
Quantity Produced	147	3884.14	570,968.58
Total Revenue (TR)		3884.14	570,968.58
(B) Variable Costs			
Maize seeds (kg)	360	25.07	9,025.20
Labour (Manday)	1200	106.19	127,428.00
Agro-chemicals (ltr)	1450	5.43	7,875.63
Fertilizer (kg)	130	294.08	38,230.40
Transportation			12,539.77
Total Variable Cost (TVC)			195,099.00
(C) Fixed Costs			
Depreciation costs on inputs...			47,400.37
Total Fixed Cost (TFC)			47,400.37
(D) Cost of Adaptation Strategies (CAS)			16,393.93
(E) Total Cost (TVC+TFC+CAS)			258,893.30
(F) Gross Margin (A - B)			375,869.58
(G) Net Income/Return (F - C)			328,469.21
(H) Profit Margin (G/A x 100/1)			57.52
(I) Operating Cash Expenses Ratio (A/B)			2.93
(J) Benefit Cost Ratio (TR/TC)			2.20
(K) Net Farm Income Ratio (F/G)			1.14

Field survey, 2026

The result of the gross margin analysis (Table 1), which shows the difference between the total revenue (TR) and the total variable cost (TVC) was estimated to be ₦375,869.58. This implies that maize production in the study area using change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies were profitable. It also suggests that an average maize farmer will earn ₦375,869.58 as a return per cropping year from cultivating a hectare of maize farm when costs of his fixed assets used in production are not taken into account. The net income/return from maize production per hectare accruable to an average maize farmer in this category was estimated as the difference between the gross margin (GM) and the total fixed costs (TFC). The result showed the estimated net income to be ₦328,469.21. This implies that when the costs of all the fixed assets used in production are deducted from the gross margin, an average maize farmer in this category will still earn ₦328,469.21 as return per hectare of maize production. The profit margin is a measure of profitability that is estimated as the net profit as a percentage of the total revenue. The profit margin per a hectare of maize in the study area was estimated to be 57.52 per cent. In other words, an average maize farmer will earn about ₦57.52 as profit per every ₦100.00 generated as revenue from cultivating one hectare of maize farm. The operating expenses ratio (OER) measures what it costs to operate a hectare of maize farm as compared to the income that accrues from the enterprise. The result from Table 7u showed the operating expenses ratio of maize production in the study area to be 2.93. This implies that about 293 per cent of the revenue generated from maize production in the study area will be needed as operating expenses.

The result on Table 1 also showed that benefit-cost ratio of maize production using change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies to be 2.20, which implied a benefit of ₦1.20 over every 1 naira invested. This ratio clearly indicates the benefits of maize production in a cropping year when smallholder farmers employed change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies while accounting for the costs associated their chosen strategies. Also, the net farm income ratio, which is the ratio of the gross margin to the net income, was 1.14 indicating revenue of ₦0.14 over and above every ₦1 realizable as net profit.

Estimates of Costs and Returns associated with combining Change in Planting Date, Crop Rotation, Intercropping, Change in Fertilizer Quantity and Non-Agronomic Practices

The result in Table 2 shows the costs and returns associated with combining five adaptation strategies (that is, change in planting date, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices) in maize production in the study area. On the average, the farmers produced 3,598.05kg of maize per hectare of land in a year and the average price of a kilogram of maize for farmers that employed these adaptation strategies was estimated to be ₦150.00 in the study area resulting in average revenue of ₦539,707.50 per hectare.

The variable inputs considered for the study included seeds, labour, agro-chemicals, fertilizer, and transportation. The average total variable costs per hectare for the cropping year were estimated to be ₦239,804.77 and the average total fixed costs was ₦60,744.39.

Table 2: Gross margin analysis of maize production per hectare (change in planting date, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices)

Items	Price (₦/kg)	Quantity (Kg)	Total (₦)
(A) Revenue (₦)			
Quantity Produced	150	3598.05	539,707.50
Total Revenue (TR)	150	3598.05	539,707.50
(B) Variable Costs			
Maize seeds (kg)	361	67.63	24,414.43
Labour (Manday)	1200	125.27	150,324.00
Agro-chemicals (ltr)	1450	5.03	7,299.45
Fertilizer (kg)	130	350.17	45,522.10
Transportation			12,244.79
Total Variable Cost (TVC)			239,804.77
(C) Fixed Costs			60,744.39
Total Fixed Cost (TFC)			60,744.39
(D) Cost of Adaptation Strategies (CAS)			22,484.03
(E) Total Cost (TVC+TFC+CAS)			323,033.19
(F) Gross Margin (A – B)			299,902.73
(G) Net Income/Return (F – C)			239,158.34
(H) Profit Margin			44.31
(I) Operating Cash Expenses Ratio			2.25
(J) Benefit Cost Ratio			1.67
(K) Net Farm Income Ratio			1.25

Field survey, 2026

The result of the gross margin analysis (Table 2), which shows the difference between the total revenue (TR) and the total variable cost (TVC) was estimated to be ₦299,902.73. This implies that maize production in the study area using change in planting date, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies were profitable. It also suggests that an average maize farmer will earn ₦299,902.73 as a return per cropping year from cultivating a hectare of maize farm when costs of his fixed assets used in production are not taken into account. The net income/return from maize production per hectare accruable to an average maize farmer in this category was estimated as the difference between the gross margin (GM) and the total fixed costs (TFC). The result showed the estimated net income to be ₦239,158.34. This implies that when the costs of all the fixed assets used in production are deducted from the gross margin, an

average maize farmer in this category will still earn ₦239,158.34 as return per hectare of maize production.

The profit margin is a measure of profitability that is estimated as the net profit as a percentage of the total revenue. The profit margin per a hectare of maize in the study area was estimated to be 44.31 per cent. In other words, an average maize farmer will earn about ₦44.31 as profit per every ₦100.00 generated as revenue from cultivating one hectare of maize farm.

The operating expenses ratio (OER) measures what it costs to operate a hectare of maize farm as compared to the income that accrues from the enterprise. The result from Table 2 showed the operating expenses ratio of maize production in the study area to be 2.25. This implies that about 225 per cent of the revenue generated from maize production in the study area will be needed as operating expenses.

The result on Table 2 also showed that benefit-cost ratio of maize production using change in planting date, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies to be 1.67, which implied a benefit of ₦0.67 over every 1 naira invested. This ratio clearly indicates the benefits of maize production in a cropping year when smallholder farmers employed change in planting date, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies while accounting for the costs associated their chosen strategies. Also, the net farm income ratio, which is the ratio of the gross margin to the net income, was 1.25 indicating revenue of ₦0.25 over and above every ₦1 realizable as net profit.

Estimates of Costs and Returns associated with combining more than Six Strategies

The result in Table 3 shows the costs and returns associated with combining more than six adaptation strategies in maize production in the study area. On the average, the farmers produced 4,678.62kg of maize per hectare of land in a year and the average price of a kilogram of maize for farmers that employed these adaptation strategies was estimated to be ₦143.00 in the study area resulting in average revenue of ₦669,042.66 per hectare.

The variable inputs considered for the study included seeds, labour, agro-chemicals, fertilizer, and transportation. The average total variable costs per hectare for the cropping year were estimated to be ₦192,695.94 and the average total fixed costs was ₦67,230.02.

Table 3: Gross margin analysis of maize production per hectare (More than 6 adaptation strategies)

Items	Price (₦/kg)	Quantity (Kg)	Total (₦)
(A) Revenue (₦)	143	4678.62	669,042.66
Quantity Produced	143	4678.62	669,042.66
Total Revenue (TR)	143	4678.62	669,042.66
(B) Variable Costs			
Maize seeds (kg)	374	37.59	14,058.66
Labour (Manday)	1200	95.86	115,032.00
Agro-chemicals (ltr)	1450	5.05	7,324.69
Fertilizer (kg)	130	349.68	45,458.40
Transportation			10,822.19
Total Variable Cost (TVC)			192,695.94
(C) Fixed Costs			67,230.02
Total Fixed Cost (TFC)			67,230.02
(D) Cost of Adaptation Strategies (CAS)			39,150.20
(E) Total Cost (TVC+TFC+CAS)			299,076.16
(F) Gross Margin (A – B)			476,346.72
(G) Net Income/Return (F – C)			409,116.70
(H) Profit Margin			61.14
(I) Operating Cash Expenses Ratio			3.47
(J) Benefit Cost Ratio			2.24
(K) Net Farm Income Ratio			1.16

The result of the gross margin analysis (Table 3), which shows the difference between the total revenue (TR) and the total variable cost (TVC) was estimated to be ₦476,346.72. This implies that maize production in the study area using more than six adaptation strategies were profitable. It also suggests that an average maize farmer will earn ₦476,346.72 as a return per cropping year from cultivating a hectare of maize farm when costs of his fixed assets used in production are not taken into account. The net income/return from maize production per hectare accruable to an average maize farmer in this category was estimated as the difference between the gross margin (GM) and the total fixed costs (TFC). The result showed the estimated net income to be ₦409,116.70. The implies that when the costs of all the fixed assets used in production are deducted from the gross margin, an average maize farmer in this category will still earn ₦409,116.70 as return per hectare of maize production.

The profit margin is a measure of profitability that is estimated as the net profit as a percentage of the total revenue. The profit margin per a hectare of maize in the study area was estimated to be 61.14 per cent. In other words, an average maize farmer will earn about ₦61.14 as profit per every ₦100.00 generated as revenue from cultivating one hectare of maize farm.

The operating expenses ratio (OER) measures what it costs to operate a hectare of maize farm as compared to the income that accrues from the enterprise. The result from Table 3 showed the operating expenses ratio of maize production in the study area to be 3.47. This implies that about 347 per cent of the revenue generated from maize production in the study area will be needed as operating expenses.

The result on Table 3 also showed that benefit-cost ratio of maize production using more than six adaptation strategies to be 2.24, which implied a benefit of ₦1.24 over every 1 naira invested. This ratio clearly indicates the benefits of maize production in a cropping year when smallholder farmers employed more than six adaptation strategies while accounting for the costs associated their chosen strategies. Also, the net farm income ratio, which is the ratio of the gross margin to the net income, was 1.16 indicating revenue of ₦0.16 over and above every ₦1 realizable as net profit.

CONCLUSION AND RECOMMENDATIONS

Thus, this research identified key stakeholder knowledge needs that will help generate the knowledge required to support cost-effective adaptation strategies because effective adaptation requires knowledge about a very wide range of information on the adopted strategies. The study identified the different adaptation strategies adopted by smallholder maize farmers that will also serve as a guide for the policy makers in making decision on climate change issues. It concludes that the result that benefit-cost ratio of maize production using change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies to be 2.20, which implied a benefit of ₦1.20 over every 1 naira invested. This ratio clearly indicates the benefits of maize production in a cropping year when smallholder farmers employed change in planting date, minimum tillage, crop rotation, intercropping, change in fertilizer quantity and non-agronomic practices as adaptation strategies while accounting for the costs associated their chosen strategies. In view of this, the study recommends the use of multiple adaptation strategies to climate change by smallholder maize farmers.

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