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## ORIGINAL ARTICLE

# Exploratory analysis of Economics of Soil erosion Management practices by Crop farmers in Anambra State, Nigeria

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**ABSTRACT**
*A better knowledge of soil erosion management practices used by rural farmers can help to design more powerful strategies for soil restoration and consequently improve the economic benefits of adopting cost effective soil erosion management practices. It is on the bases, this study has explored the economic analysis of soil erosion management practices by crop farmers in Anambra State in Nigeria. The study adopted both purposive and random sampling techniques in collecting primary data from 160 crop farmers with the aid of well-structured questionnaire guided by interview schedule. Both descriptive and inferential statistics were employed in data analysis. The findings indicated that majority of the crop farmers engaged restoration of soil fertility, terracing, intercropping amongst others as the major soil erosion control measures practiced in the study area. The result of the binary logistic regression analysis showed that about 86.5 percent of the total variation observed in use of soil erosion management practices was sufficiently explained by the independent variables included in the regression model. Meaning that the socio-economic characteristics of the crop farmers exert significant effect on their use of soil erosion management practices in the study area. Similarly, the findings also showed that the result of the benefit cost ratio of (1.72) after adoption of soil erosion management practices is greater than the benefit cost ratio of (1.01) before adoption of soil erosion management practices in the study area showing that crop farming is very profitable venture when appropriate soil erosion management practice is adopted. Finally, the result also showed inadequate credit to obtain technology; Soil conservation require high management skills; Non- availability of suitable implements amongst others as the constraints to crop farmers' adoption of soil erosion management practices in the study area. The study therefore recommends that Extension agents should encourage crop farmers to form cooperative society to enable them access credit for procurement of soil erosion management practices; Government should engage more in public enlightenment and educational program majored on anti-erosion measures to eliminate the anthropogenic factors that causes soil erosion; extension agents should intensify their training of farmers on required information for proper soil erosion management techniques in their farms and also inform and encourage them on the need to adopt such practices to increase their output and income, amongst others.*
***KEYWORDS:*** *Constraints; Erosion menace; Management practices; Soil erosion.*

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## INTRODUCTION

Soils play an essential role for mankind because they provide the fundamental ecosystem services required for human life primarily for the production of food by providing the environment for plant growth [37]. Soils provide the pathways through which water and nutrients move to the roots of plants, they are the matrix for nutrient transformations and environment for micro-organisms and fauna [35]. According to Dominati *et al.* [16] the most important provisioning service for human life is supplied by soils through food production. Though soils are a non-renewable resource its capacity to meet required outputs, agricultural productivity and sustenance of food security is threatened as a result of continuous human exploitation thus causing soils to be degraded and deteriorated with all the natural

species/ecosystem being endangered to destruction. Soil degradation which is a decline in the quality of soils to meet up with expected demands is greatly caused by problems like soil erosion. Erosion menace is the bane of most farmers, particularly those who farm in erosion-intensive environmental conditions. Aside from the relatively minor inconveniences of erosion such as fields collapsing and drainage systems getting clogged up, erosion actually results in a lot of financial loss to farmers. This is based on the fact that livelihoods of most of the rural households in Nigeria are dependent on agricultural land. The land resource has been employed in varied proportions to meet both subsistence needs and/or cash needs, thereby making it vulnerable to erosion menace. In general, soil erosion, world over, is becoming a serious problem because of considerable economic damage it causes to the society at large. It is widely recognized as a major environmental and agricultural problem affecting many parts of the world. Soil erosion can be defined as the steady process of soil particles and sediments, especially topsoil, being moved by wind and water to other areas [20]. Similarly, Jimoh [22], defined soil erosion as the removal of soil materials and/or soil nutrients by surface run-off from different points of origin to other locations. According to Ofomata [28], soil erosion is a systematic removal of soil, including plant nutrients, from the land surface. Consequently, soil erosion occurs in several parts of Nigeria under different geological, climatic and soil conditions, but the degree of occurrence varies considerably from one part of the country to the other. Thus, while it is true to observe that soil erosion is one of the most striking features on the land surface of Southeastern Nigeria, especially in Anambra state, only rare occurrences of the phenomenon are recorded in some other States of the Federation. Equally varied are the factors responsible for the inception and development of erosion, as well as the types that exist in several parts of the country [21]. The problem of erosion continues to beset Nigerian farmers thereby jeopardizing their farming activities. These farmers have therefore experienced a decline in productivity necessitating some actions on their part. These problems are evident in terms of general decrease in soil fertility, increased labour cost and diminution of cultivable land as a result of the occurrence and expansion of gullies [5]. According to Okin [31], over 65 percent of the soil on earth is said to have displayed degradation phenomena as a result of soil erosion, salinity and desertification. Estimates suggest that, each year, as much as 75 billion ton of soil are removed from the land by wind and soil erosion, with most of it coming from agricultural land [34]. While the rates at which soil erosion occurs vary over time between different locations, it has intensified in recent years, causing great concern in developing countries. In Nigeria, about 850,000 hectares (ha) of land are badly affected annually or rendered useless for agricultural purposes and human settlement [18]. Accordingly, World Bank [40] in Mbaya (2013), recognized three main environmental problems facing Nigeria: soil degradation and loss, water contamination and deforestation. In similar way, Ofomata [28], indicated that gully erosion types are the most visible forms of soil erosion in Nigeria contributing to each of the three main problems, and causes damage with an annual cost to the nation, estimated at $100 million. Unfortunately, the situation has not significantly changed. As at 1997, there were 5,700 gully erosion sites nationwide [3]. This figure has certainly increased. For example in 2009, the World Bank report on Nigeria still listed gully erosion as one of the top five major hazards threatening the Nigerian environment. Numerous new gullies have emerged and many of the old gullies have grown rapidly to disaster levels. In the same vein, Igwe [21], remarked that more than 1.6% of the entire land area of south eastern Nigeria is occupied by gullies. This is very significant for an area that has a high population density of 500 persons per $km^2$ in Nigeria. Urban soil erosion according to Titilola and Jeje [38], affects only 18,517km, representing only 2% of the total area of Nigeria and so tends to be ignored in the literature. However, the area of land affected by soil erosion is not the sole criterion for estimating the damage they inflict on the national economy [24]. The value of the lands they destroy, the cost of protective measures, and the effects of soil degradation on the farmers' socio-economic situation should also be considered. Evidence of soil erosion menace abounds in southeastern Nigeria. The Nanka erosion for instance become famous and legendary in its devastating effects on the agricultural and other socio-economic lives of the people of the communities in the area because its devastation has attracted the attention of the international community notably: Nanka, Agulu, Oko and many other contiguous towns who groan under the enormous and increasing danger of this phenomenon [21]. At the Agulu-Nanka gully complex, over 1,000 hectares of land have been lost to the gullies and the modest estimate for the expansion of the gullies is at least 1% per annum [21]. At present, it is the single most important environmental degradation problem in the developing world, especially the tropics [8]. Hanyona [19] opines that soil erosion automatically results in reduction or loss of the biological and economic productivity and complexity of terrestrial ecosystems, including soil nutrients, vegetation, other biota, and the ecological processes that operate therein. In another dimension, Scherr and Yadav [36], argue that by the year 2020, soil erosion may pose a serious threat to food production and rural as well as urban livelihoods particularly in poor and densely populated areas of the developing

world. They further advocated for policies that would encourage soil retention strategies, land improving investments and better land management if developing countries are to sustainably meet the food needs of their populations, preserve nonrenewable natural resources and hand over their soils to future generations. Significant in this is that when soil gives away its fertility, human beings lose their fundamental living source they rely on. This is why soil erosion has been identified as the direct cause of environmental deterioration and poverty in many parts of the world [10]. The above therefore necessitates the need for soil erosion management**-** which refers to measures taken to successfully prevent or control soil erosion. Anambra State is adjudged to be the most erosion prone and erosion devastated landscape in Southeastern Nigeria, and there are about one thousand erosion sites with varying degrees and dimensions in Anambra state [9]. Severe and devastating incidences of erosion have been recorded in the state since the 20th century. Despite this fact, there seems to be no empirical evidence on the economics of soil erosion management practices from the farmers' point of view in the study area. This has necessitated the need to assess farmers' view of soil erosion management for agricultural decision making and insulation of the rural farmers from adverse impacts of soil erosion. This study seeks to contribute to a better understanding of soil erosion by exploring local farmers' knowledge through an exploratory analysis of economics of soil erosion management practices by crop farmers in south-east, Nigeria. Specifically, the study seek to: describe the socioeconomic characteristics of farmers in relation to the use of soil erosion management practices; characterize the soil erosion management practices adopted by the farmers; determine the socioeconomic characteristics of farmers affecting the use of soil erosion management practices; determine the costs-benefits of selected soil erosion management responses; identify farmers' constraints in the use of soil erosion management practices. This study has been carried out in Anambra State of Nigeria in 2018.

## MATERIALS AND METHODS

Area of the performed study is located between latitudes $6^0\ 45^1$ and $5^0\ 44^1$ N and longitudes $6^0\ 36^1$ and $7^0\ 20^1$ E of the Greenwich Meridian; with a land mass of 4,844 $km^2$ and a population of 4,055,048 (NPC, 2006). It has tropical rain forest vegetation, humid climate with a temperature of about $30^0$C and a rainfall of between 152 mm-203 mm [12]. The state has a weak soil that is easily eroded (C-GIDD, 2008), hence vulnerable to the menace of erosion. Three soil types can be recognized in Anambra State. They are: alluvial soils, hydromorphic soils, and ferallitic soils [17]. Well-structured questionnaires, augmented with an interview schedule were used to collect primary data for the study. The study adopted a combination of purposive and multistage random sampling techniques to select the farmer respondents. Purposively, Two Agricultural zones (Aguata and Awka) and two local government areas each from a zone were selected because they are more involved in erosion menace in the study area [30]. From the two LGAs selected, two communities from each LGA and two villages from each community were purposively selected based on the intensity of erosion menace in the area, giving a total of eight communities and 16 villages. From the selected villages, 10 contact farmers were randomly selected from the list of registered farmers acquired from ANADEP (Anambra State Agricultural Development Program) and cooperative society based on the demography of farmers in the sampled area. This gave a total of one hundred and sixty (160) contact farmers that were used in the study.

Both descriptive and inferential statistical tools were employed in data analysis. Specifically, Objectives (i), (ii) and (v) were achieved using descriptive statistics such as averages, percentages and factor analysis Objective (iii) was realized using binary logistic regression analysis, while Objective (iv) was realized using cost-benefit and gross margin analysis

*Model specification*

The binary logistic regression model on effects of the socioeconomic characteristics of the farmers on the use of soil erosion management practices in the study area was stated as Eq. 1.

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_8 X_8 + e_i \qquad \text{eq.1}$$

Where, Yi = use of ith soil management practice which is tillage, vegetative cover, contour planting, contour bunds, crop rotation, soak away pits, control grazing, reforestation, terracing, use of manure and ridging (use =1, 0 otherwise). $\alpha$ = intercept, $\beta_1 \ldots \beta_8$ = parameters to be estimated, $e_i$ = error terms, $X_1 \ldots X_8$ = vector of explanatory variables

Where, X1 = Age of farm household head (years); X2= Gender; X3 = Education level (years); X4 = Household size; X5 = Farming experience (years); X6 = Farm size (ha); X7 = Farm income (naira); X8 = Distance of farm from residence; e = Error term.

Cost-benefit analysis was employed to estimate the costs and benefits of selected protective measures against soil erosion, so as to determine the economic benefits of practicing conservation measures against soil erosion. The formula was stated as Eq. 2.

GM = TR – TVC eq.2
Where, GM = Gross margin; TR = Total revenue; TVC = Total variable costs;
Discounting flow = $X/(1+R)^n$

Where, X = Cost/Revenue to be discounted; R = Interest Rate; n = Time/Year as Eq. 3.

$$BCR = \sum_{t=1}^{n=1} \frac{\frac{Bt}{(1+r)t}}{\frac{ct}{(1+r)t}} = \frac{\text{Discounted revenue}}{\text{Discounted cost}} \quad \text{eq.3}$$

Where, Bt = benefit per ha in each year; Ct = cost of production per ha in each year; t = 1, 2, 3, . . .n; n = number of years; r = interest rate; ∑ = summation sign;
Decision rules:For BCR, Project is viable if BCR is greater than one.
*Decision rule for a priori expectation*
If GM > 0 (greater than 0), then it is profitable; If GM < 0 (less than 0),then it is not profitable
If GM = 0 (equal to 0), then it breaks even.

**RESULTS AND DISCUSSION**
The results obtained were presented and discussed based on the data collected from the responses of 160 farmers.
*Socioeconomic characteristics of the respondents*
Averages, frequency and percentages were used to determine the socioeconomic characteristics of the farmers in the study area. Data on them were collected, analyzed and presented in Table 1.

Table 1: Percentage distribution of respondents by socioeconomic characteristics

| **Variable** | **Anambra State, N = 160** | | |
|---|---|---|---|
| | **Frequency** | **Percentage** | **Mean** |
| *Age (y)* | | | |
| 21-30 | 6 | 3.8 | |
| 31-40 | 28 | 17.5 | |
| 41-50 | 49 | 30.6 | |
| 51-60 | 45 | 28.1 | |
| Above 60 | 32 | 20.0 | 50.3 |
| *Gender* | | | |
| Male | 75 | 46.9 | |
| Female | 85 | 53.1 | |
| *Educational level* | | | |
| Not educated | - | - | |
| Primary school | 24 | 15.0 | |
| Secondary school | 98 | 61.3 | |
| Tertiary school | 38 | 23.8 | |
| *Marital status* | | | |
| Single | 6 | 3.8 | |
| Married | 123 | 76.9 | |
| Divorced | 9 | 5.6 | |
| Widowed | 22 | 13.8 | |
| *Farming experience (y)* | | | |
| 1-10 | 11 | 6.9 | |
| 11-20 | 105 | 65.6 | |
| 21-30 | 31 | 19.4 | |
| 31-40 | 6 | 3.8 | |
| Above 40 | 7 | 4.4 | 21.75 |
| *Household size (Number)* | | | |
| 1-5 | 36 | 22.5 | |
| 6-10 | 123 | 76.9 | |
| Above 10 | 1 | 0.6 | 6 |
| *Occupation* | | | |

| | | | |
|---|---|---|---|
| Farming | 29 | 18.1 | |
| Civil servant | 38 | 23.8 | |
| Public servant | 2 | 1.3 | |
| Business/petty trading | 91 | 56.9 | |
| *Farm size (ha)* | | | |
| 0.1-1.0 | 65 | 40.6 | |
| 1.50 | 18 | 11.3 | |
| 1.1-2.0 | 64 | 40.0 | |
| 2.1-3.0 | 10 | 6.3 | |
| 3.1-4.0 | 3 | 1.9 | |
| *Annual Income ($)* | | | |
| | | | |
| 0-553.36 | 90 | 56.3 | |
| 556.13-1106.72 | 26 | 16.3 | 895.42 |
| 1109.49-1660.08 | 18 | 11.3 | |
| 1662.85-2213.44 | 15 | 9.4 | |
| Above 2213.44 | 11 | 6.9 | |
| *Distance of household from farm (km)* | | | |
| 0.1-1 | 142 | 88.8 | 1.1 |
| 1-1.2 | 11 | 6.9 | |
| 2.1-3 | 4 | 2.5 | |
| Above 3.1 | 3 | 1.9 | |
| *Types of crop grown* | | | |
| Arable crops | 38 | 23.8 | |
| Cash crops | 1 | 0.6 | |
| Both | 121 | 75.2 | |
| *Household experiencing soil erosion* | | | |
| No | 2 | 1.3 | |
| Yes | 158 | 98.8 | |
| Total | 160 | 100.00 | |

The result of the age of the farmers indicates an average age of 50 years, with very small percentage (4%) of the sampled households within the age group of 21-30 years and greater percentage (31%) in the age group of 41-50 years. The pooled data revealed that approximately 80% of the farmers were in their active and productive age which has a direct and positive influence on their choice of soil erosion management practices. This is in line with the findings of Adeola, [2] which showed that the predominance of active and productive ages has a direct influence over the adoption of soil erosion management practice. Also, this is in agreement with the study of Young and Shortle, 1984 which states that with age, a farmer may get experience about his/her farm and can react in favour of retention of soil conservation structures. Therefore, age influence farmers' adoption of erosion management practices. The result on gender of the farmers showed that female farmers (53.1%) were higher in number than male farmers (46.9%), implying that farming was dominated by female in the study area. This could be attributed to the fact that in the study area, men are more preoccupied with more advanced commercial businesses that generate higher income than farming. The result on marital status showed that 77% of the respondents are married with majority (61%) of the farmers as secondary school graduate and an average farming experience of 22 years. While greater percentage of the farmers (65.6%) had 11-20 years of farming experience, very few (4.4%) had an experience of above 40 years. This result suggests that the average farming household head had a considerable experience and is very much aware of the incidence of soil erosion and its effects on agricultural production, hence the need to tackle the problem. This is in line with the study of Ogundele and Okoruwa [29], which stated that to be competent enough to handle all the vagaries of agriculture, farmers need farm experience through the years to increase farm output. This is not in tandem with the study of Amaza *et al.,* [6] that up to a certain number of years, farming experience would have positive effect, after that the effect may become negative due to ageing or reluctance to change.

The result on household size indicated an average household of six persons with greater percentage of the farmers (76.9%) having a household size of 6 – 10 members and 0.6% of the farmers had above 10 members in their household size. Thus a typical farming household in the study area is large, which would influence the adoption of soil erosion management practice, and hence provide a high supply of labour for the soil erosion management practices. The result on occupation of the farmers shows that only 18.1% of the respondents are involved in farming as their major occupation; while greater percentage 56.9% combined business/petty trading and agriculture as their occupation. This result could be as a result of predominance of erosion menace in the study area, which caused them to diversify and seek for a more sustainable means of lively hood. The result on farm size showed that 40.6% and 40% of the respondents owned 1 and 2 ha of land respectively. Just an insignificant number of respondents 1.9% owned 3-4 ha of land. This proves that there is pressure on agricultural land in the study area due to urban housing development and other related activities. But at the same time, this did not deter the decision of the farmers towards adoption of soil erosion measures. The result on annual income showed an average annual income of *$* 895.42 per household, while only 6.9% had an income above *$*2213.44 from farming only. This result implies that civil servants and business/traders who combine farming with their trade, earn higher than those who have farming as their major source of income and could fund their farm projects without seeking for financial assistance. Furthermore, the average distance of household to farm was 1.1kms while very few of the farmers 1.9% had their homes above 3kms distance from the farm and 75.2% grew both arable crops and cash crops in the study area.

*Characterizing the soil erosion control practices adopted by the farmers*

The major contributing factor towards the improvement of farming, have been the best practices used by the farmers over the years to sustain agriculture in the study area especially terracing, inter-cropping, contours and mulching. These practices are encouraged for areas that are experiencing soil erosion problems especially from hill slopes farmlands. There are different forms of soil erosion management practices adopted by farmers to regulate the incidence of soil erosion on their farms in the study area as stated in Table 2.

Table 2: Percentage distribution of respondents based on soil erosion control measures

| S/N | Variables | Frequency | Percentages |
|---|---|---|---|
| 1 | Tillage | 100 | 62.5 |
| 2 | Stubble mulching | 133 | 83.1 |
| 3 | Control grazing | 9 | 5.6 |
| 4 | Contour planting | 150 | 93.8 |
| 5 | Contour bunds | 131 | 81.9 |
| 6 | Terracing | 152 | 95.0 |
| 7 | Crop rotation | 8 | 5.0 |
| 8 | Soak away pit | 100 | 62.5 |
| 9 | Restoring soil fertility | 157 | 98.1 |
| 10 | Intercropping | 152 | 95.0 |

The result showed that the significant agronomic soil erosion conservation practices among the farmers were: tillage (62.5%), stubble mulching (83.1%), contour planting (93.8%), contour bonds (81.9%), terracing (95.0%), soak away pit (62.5%), restoring soil fertility (98.1%) and intercropping (95.0%). The findings supported the report of FAO (2007) which identified mulching, contour bunds, intercropping and terracing as common agronomic soil conservation practices among farmers in Sub-Saharan African. In addition, Junge *et al.,* [23] enumerated agronomic soil erosion conservation measures commonly practiced among farmers to include: mulching and crop management practices which consist of cover cropping, contour planting, multiple cropping, intercropping, planting pattern/time and crop rotation. These practices according to Morgan [27], use the effect of surface covers to reduce erosion by water and wind in order to conserve the soil.

*Socioeconomic characteristics of farmers affecting the use of soil erosion management practices*

The result of the binary logistic regression showing the socioeconomic factors affecting the use of soil erosion management practices are presented in Table 3.

Table 3 Binary logistic regression result for socioeconomic characteristics of farmers affecting the use of soil erosion management practices

| Explanatory variables | Co-efficient | Standard error | Z-value |
|---|---|---|---|
| Age | .029971 | .0582043 | 0.51 |
| Education qualification | 4.601399 | 1.045439 | 4.40*** |
| Years of farming experience. | .4655961 | .1238121 | 3.76*** |
| Household size | -1.263477 | .5058391 | -2.50** |
| Farm size | 3.325346 | 1.764562 | 1.88* |
| Annual income | 4.38e-06 | .0054879 | 3.86*** |
| Distance | -16.45247 | 4.224187 | -3.89*** |
| Constant | 18.53637 | 12.33464 | 1.50 |
| Log likelihood ratio | -7.9703778 | | |
| Chi-square | 13.86 | | |
| $R^2$ | 0.8651 | | |

***=significant at 1%; **=significant at 5%; * = significant at 10% levels respectively

The result on age was found to be non-significant and positively related to the use of soil erosion management practices in the study area. This implies that an increase in age will increase the use of soil erosion management practices in the study area but not to a significant level. Education was positive and significant at 1% level of probability. This implies that education influences ones decision to use soil erosion management practices positively. This means that the farmers with higher level of education positively showed greater interest in the use of soil erosion management practices. This agreed with the findings of Ahmad *et al.,* [4]; Okoye [32], who both agreed that education, be it specific or general, commonly correlates positively with the adoption of soil erosion conservation practices. Farming experience was also positive and significant at 1% as a factor influencing soil erosion management practice. This is because the more experienced a farmer is, the more exposed he is to the dangers of soil erosion, and therefore the need to use soil erosion management practices. But this is in contrast with the findings of Adeola, [2] who opined stated that an increase in farming experience will significantly reduce the level of adoption of conservation measures. However, it conforms to the findings of Onuoha [33], that farming experience is positively correlated with intensity of the use of soil erosion conservation measures. The more experienced a farmer is, the more likely the farmer would be consistent in using soil erosion management practices more especially those practices that could be considered as part of traditional system [13]. Household size was significant at 1% level of probability and inversely related to the use of soil erosion management practices. This means that the probability of using soil erosion management practices decreases if household size increases. This is because as the size of the household increases, consumption and household demand increases living little or nothing for investment in soil erosion control practice, hence its reduced use. This agrees with Onuoha [33], that household size is significant but has a negative value; meaning that a decrease in the number of household size will lead to an increase in the level of adoption of soil erosion management practices because there will be less family expenses required and more available finance for adoption of soil erosion management practices. Farm size was positive. This implies that an increase in the farm size increases the level of adoption of soil erosion control measures. While the smaller the farm size, the lesser the farmer's willingness to use soil erosion management practice, since physical conservation structures occupy some portions of the farmland and then compete for the scarce productive land. But when a farmer has a big farmland he will want to invest in soil erosion management practice thereby preserving the land. This agrees with the findings of Adeola [2], who stated that owners of large farms are likely to accept land consuming soil erosion conservation measures than small holders. Annual income was positive and significant at 1% level of probability. This implies that higher income for the farmers increases the probability to invest and use soil erosion management practice. This is true because with higher income a farmer can fund his farm projects and still afford a good standard of living. This corroborates with the findings of Claassen [13], that farmers with higher income adopt more conservation practices. Distance from farm was found to be negative and inversely related to the use of soil erosion management practice. This means that the probability of using soil erosion management practice decreases if the distance from the house to the farm increases and vice versa. This is because structures are retained more on farms closer to the house and more attention is given to it contrary to when it is further away from the house. The co-efficient of determination $R^2$ was found to be 86%. This indicates that the included socioeconomic factors excluding age accounted for about 86% of the total variations in the farmers' use of soil erosion conservation practices. The result also showed that the binary logistic regression model had age as the only non-

significant variable, implying that age was not a significant determinant in the use of soil erosion management practice in the study area. This was justified based on the fact that both young and old farmers in the study area felt the effect of soil erosion and saw the need to invest in soil erosion conservation, hence their full commitment to solving the problem.

*The cost-benefit of soil erosion management practices*

BCR was used to assess the economic effects of soil erosion management practices by farmers, by analyzing and comparing the total costs and revenues before adoption and after adoption of soil erosion management practices for three years. The costs and benefits were discounted for a period of three years, at the rate of 14% which is the current interest rate of the Central Bank of Nigeria. Table 4 (before adoption) and Table 5 (after adoption) below shows the discounted streams of average total costs and average total revenues (benefits) of soil erosion management practices for one hundred and sixty farmers.

Table 4: Streams of discounted average costs and benefits of soil erosion management practices before adoption

| Project year | Total average cost | Discount rate (14%) | Discounted average cost | Total average revenue (benefit) | Discount rate (14%) | Discounted average revenue (benefit) |
|---|---|---|---|---|---|---|
| T1 | 14951.51 | $(1.14)^1$ | 13115.34 | 16480.91 | $(1.14)^1$ | 14456.88 |
| T2 | 14951.51 | $(1.14)^2$ | 11505.19 | 16480.91 | $(1.14)^2$ | 12681.52 |
| T3 | 14951.51 | $(1.14)^3$ | 3647470 | 16480.91 | $(1.14)^3$ | 11124.12 |
| Total | 44854.53 | | 3672090.53 | 49442.73 | | 38262.52 |

Table 5: Streams of discounted average costs and benefits of soil erosion management practices after adoption

| Project year | Total cost | Discount rate (14%) | Discounted cost | Total revenue (benefit) | Discount rate (12%) | Discounted revenue (benefit) |
|---|---|---|---|---|---|---|
| T1 | 15779.89 | $(1.14)^1$ | 13842.01 | 28792.24 | $(1.14)^1$ | 25256.35 |
| T2 | 15779.89 | $(1.14)^2$ | 4388504 | 28792.24 | $(1.14)^2$ | 22154.70 |
| T3 | 15779.89 | $(1.14)^3$ | 10650.98 | 28792.24 | $(1.14)^3$ | 19433.94 |
| Total | 47339.67 | | 36635.10 | 86376.73 | | 66844.98 |

Table 6 shows a summary of the above tables for the total average cost, total average revenue (benefits), gross margin and benefit cost ratio (BCR) of soil erosion management practices for one hundred and sixty respondents.

Table 6: Cost benefits of soil erosion management practices before and after adoption

| Indices | Before Adoption | After Adoption |
|---|---|---|
| Number of farmers | 160 | 160 |
| Total fixed cost (₦) | 20626.49 | 20626.49 |
| Total variable cost (₦) | 24228.04 | 26713.18 |
| Total Cost (₦) | 44854.53 | 47339.67 |
| Total revenue (₦) | 49442.72 | 86376.73 |
| Total discounted costs (₦) | 34712.35 | 36635.10 |
| Amount received from sales (₦) | 49442.72 | 86376.73 |
| Total discounted revenue(₦) | 38262.52 | 66844.99 |
| Gross margin (₦) | 22732.03 | 62981.50 |
| BCR @ 14% CBN rate | 1.01 | 1.72 |

Computation of Gross Margin and Benefit Cost Ratio before adoption of soil erosion management practices, using 14% interest rate which is the prevailing Central Bank interest rate in Nigeria.

*Gross margin before adoption of soil erosion management practices*

(GM) = Total Revenue – Total variable cost

(GM) = 49442.72 – 24228.04

(GM) = 25214.68

Gross margin was estimated here as total revenue less total variable cost. Findings of the study in Table 6 above showed that the total revenue generated before adoption of soil erosion management practices was $49442.72. On the other hand, the total variable cost incurred before adoption of soil erosion management practices was $24228.04. From these, the gross margin was calculated to give$25214.68.

*Benefit cost ratio before adoption of soil erosion management practices*
In evaluating the BCR before adoption of soil erosion management practices, the following relationship was used;

$$BCR = \frac{\text{Discounted revenue}}{\text{Discounted cost}}$$

$$BCR = \frac{\$38262.52}{\$34712.35}$$

BCR = $1.10

The benefit cost ratio before adoption of soil erosion management practices was realized by discounting for a period of three years, the revenue generated and cost incurred from the enterprise at an interest rate of 14%. From the result of the study in Table 4 above, the discounted revenue before adoption of soil erosion management practices was $38262.52, while the discounted cost was $34762.15. From this information, the BCR was calculated which further showed a BCR of $1.10.
Computation of GM and BCR after adoption of soil erosion management practices, using 14% interest rate which is the prevailing Central Bank interest rate in Nigeria.
*Gross margin after adoption of soil erosion management practices*
(GM) = Total Revenue – Total Variable Cost
(GM) = $86376.73 – $26713.18
(GM) = $59663.55

Gross margin was estimated here as total revenue less total variable cost. Findings of the study in Table 5 above showed that the total revenue generated after adoption of soil erosion management practices was $86376.73. On the other hand, the total variable cost incurred after adoption of soil erosion management practices was $26713.18. From these, the Gross Margin was calculated to give $59663.55.

*Benefit cost ratio after adoption of soil erosion management practices*
In evaluating the BCR after adoption of soil erosion management practices, the following relationship was used;

$$BCR = \frac{\text{Discounted revenue}}{\text{Discounted cost}}$$

$$BCR = \frac{\$66844.99}{\$36635.10}$$

BCR = $1.82

The Benefit-Cost Ratio after adoption of soil erosion management practices was realized by discounting for a period of 3 years, the revenue generated and cost incurred from the enterprise, at an interest rate of 14%. Findings showed that the discounted revenue after adoption of soil erosion management practices was $66844.99 while the discounted cost was $36635.10. From this information, BCR was calculated, which showed a BCR of $1.82.
Following the decision rule, the economic indicators (BCR and GM), it is obvious that both revenues generated before and after adoption of soil erosion management practices showed viability of the practice but the revenue generated after adoption showed a higher viability with large significant differences in the values of the BCR and the GM. This might be as a result of the adoption of a better soil erosion management practices (terracing, soak away pits, tillage, etc) by farmers in the study area to check the problems of soil erosion which has been affecting their productivity/output. Since the GM and BCR after adoption was greater than the GM and BCR before adoption of the soil erosion management practices, it implies that adoption of soil erosion management practices was viable to the farmers and should be considered for the sustainability of agriculture in the study area. This is in line with the findings of Onuoha [33], who reported that for every ₦1 investment, there is a return of ₦ 2.18k benefits from investment, where the farmers made a benefit-cost ratio of ₦ 1.93 on investments of soil erosion control measures. Also, Uri [39] provided a detailed evaluation of the costs and benefits of soil erosion conservation tillage, including the production costs and yield return, which showed that farmers made a benefit cost ratio of ₦1.74 on investments of soil erosion control practices. These findings further implied that soil erosion management practices should be encouraged because it will go a long way in rehabilitating the already damaged agricultural land, curb soil erosion associated loss of productivity thereby increasing productivity/output, promoting agricultural development and increasing the per

capita income and food supply of the farmers. This will further generate more employment and income for those engaging in other sectors of agriculture (transportation, processing, storage, contract farming etc) as agriculture expands, promotes food security, cuts the vicious circle of poverty and generates revenue and foreign exchange for the government through taxes and export of agricultural produce thereby building a strong and diversified economy.

*Farmers' constraints in the use of soil erosion management practices*

Soil erosion hazard in the study area has been the major problem farmers are faced with. Also, the initiatives and efforts taken to tackle the problem have been confronted with major constraints.

These constraints were analyzed with a four-point Likert type rating scale with a decision rule of 2.50 as Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) =2 and Strongly Disagree (SD) = 1.

Table 7: Mean distribution of respondents based on constraints to the use of soil erosion management practices

| Constraints | Mean score | Ranking | Remarks |
|---|---|---|---|
| Lack of awareness | 2.8188 | 9th | A |
| Insufficient information about proper use | 2.3813 | 10th | D |
| Small farm size | 2.2000 | 12th | D |
| Lack of interest | 1.9750 | 13th | D |
| Insecure land tenure system | 2.8813 | 8th | A |
| Inefficiency of information transfer | 2.3313 | 11th | D |
| Technologies are costly to use and sustain | 3.2250 | 5th | A |
| Lack of manpower | 3.1063 | 6th | A |
| Inadequate credit to obtain technology | 3.6375 | 1st | SA |
| Lack of training for farmers wishing to use technology | 2.9000 | 7th | A |
| Non- availability of suitable implements | 3.4063 | 3rd | SA |
| Inadequate and high cost of labour | 3.3438 | 4th | A |
| Soil conservation require high management skills | 3.3938 | 2nd | SA |
| Our culture forbids its use | 0.9813 | 14th | SD |

Any mean score, greater than the decision rule-DR of 2.50 shows that the constraint significantly affects the selection of soil erosion management practice in the study area. The major constraint that significantly affected the use of soil erosion management practice as revealed by the respondents was inadequate credit to obtain technology with a mean score of 3.6375. Insufficient credit availability has been a major challenge for farmers wishing to engage in soil erosion management and this has caused most farmers to shy away from this necessary and important practice resulting in hunger and reduced income/productivity. Poor rural households in developing countries lack adequate access to credit. This in turn impinges a significant negative impact on the adoption of soil erosion management practice, agricultural productivity, nutrition, health, and overall household welfare [15]. In the study area, it was found that majority of the respondents reported having difficulty in obtaining credit from formal sources for over ten years. Further revelations showed that the following constraints with their mean scores were equally significant and hindered the use of soil erosion management practices: high cost of labour (3.3938), lack of man-power (3.1063), high management skills (3.4063), non-availability of suitable implements (3.3438) and inadequate and high cost of technologies (3.2250). In our literature review, we indicated that inadequate consideration of labour and man-power in soil erosion management activity might result in failure.

The other problems mentioned by the respondents (farmers) were; lack of training of farmers wishing to use technology, insecure land tenure and lack of awareness with mean scores of 2.9000, 2.8813 and 2.8188 respectively. The issue of land tenure is among the strongly contested aspect of agricultural policy. In the study area, insecure land tenure was prevalent and affected the farmers' full commitment towards the use of soil erosion management practices. Majority of the respondents in the study area revealed that the tenure arrangement influenced their decision and caused delays towards the use of soil erosion management practices. Cramb [14], in emphasizing farmers rationality pointed out that farmers who own their own farmland will not knowingly allow their soil to be eroded so long as the benefits from the efforts in conservation investment exceeds the cost. Adekunle [1], also reported that some farmers are not willing to engage in soil erosion conservation schemes due to non-availability of land, problems of land tenure, lack of technical expertise, lack of incentive and poor government policies among others. In

addition, insufficient information and training facilities are some of the institutional challenges facing farmers. Training is an important aspect of sharing new technologies. It is a recognized fact that the diffusion of information on improved technological alternatives is an important element that contributes positively to adoption and sustained use of soil erosion management practices. Most of the respondents in the study area lamented that they do not get training as required for soil erosion management practices. Unless there is an adequate mechanism for training and raising the awareness of farmers, the use of any new practice would not be successful. Lack of awareness and training can prevent widespread use of soil erosion management practices. In the study area, widely used means of raising awareness is through poor communication with relatives, neighbors and community leaders, with unhealthy commitment of public extension services and development agents assigned to farmers to provide extension services. This has greatly affected the use of new soil erosion management practices in the area. The constraints highlighted above by the farmers were their major limitations towards the use of soil erosion management practices and if not tackled could result to shortage of the already scarce land resource for cultivation which will lead to poverty, hunger and food insecurity. The findings of this study agreed with that of Amusa *et al.,* [7] who found that high cost of farm input and inadequate access to inputs constitute major challenges of farmers. Also Madukwe [25], noted that ineffective transfer of agricultural technology through extension agents; inadequate credit facility and land tenure insecurity are major problems facing agricultural development in Nigeria. These findings also agree with Blosser [11], who further identified that rough topography of the farmland, is a major challenge of farmers engaged in soil erosion conservation practices.

## CONCLUSION

The study therefore concludes that Soil erosion is a continuous natural phenomenon which cannot be stopped entirely but can be managed and minimized to retain soil nutrient level, fertility and ensure continued cultivation to sustain agricultural productivity; that the major soil control measures practiced in the area includes terracing; intercropping; stubble mulching; Contour bunds amongst otherss, that the use of soil erosion management practices by farmers has significantly improved their productivity and revenue thus improving the welfare of their household. Finally that the major factors that hinder conservation practices were inadequate credit, lack of manpower, high management skills, high cost of labour and lack of training.

## RECOMMENDATIONS

In line with the result of this research, the study therefore recommends that extension agents should intensify their training of farmers on required information on proper soil erosion management techniques in their farms and also inform and encourage them on the need to adopt such practices to increase their output and income; governments should provide solution to soil erosion problem through adequate funding since lack of access to credit is one of the major constraints to adoption of soil erosion management practices. Government should engage more in public enlightenment and educational program majored on anti-erosion measures to eliminate the anthropogenic impacts that generate soil erosion; researchers who want to work on soil erosion should be encouraged by the government through grants and loans since their research will be of tremendous benefit to environmental sustainability; Extension agents should encourage crop farmers to form cooperative society to enable them access credit for procurement of soil erosion management practices.

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## CONFLICT OF INTEREST

No conflict of interests

## ABBREVIATIONS

| | |
|---|---|
| *ha* | Hectares |
| *KM* | Kilometer |
| *LGA* | Local government area |
| *mm* | Millimeter |
| *₦* | Naira sign (Nigeria's Currency) |
| *%* | Percentage |
| *KM²* | Square kilometers |
| *N* | North |
| *E* | East |
| *NPC* | National |

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