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# ESTIMATING THE TREATMENT EFFECT OF LAND DEGRADATION ON SMALLHOLDER ARABLE CROP FARMERS' FOOD SECURITY AND PRODUCTIVITY IN KWARA STATE, NIGERIA

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## ABSTRACT
The study was conducted to estimate the treatment effect of land degradation on smallholder arable crop farmers' food security and productivity in Kwara State, Nigeria. A multi stage random farming household survey resulted in four (4) Local Government Areas (LGAs), eight (8) villages, and 240 farmers were filtered to 92 and 148 land graded and non-degraded farmers, respectively. The t-statistics, propensity score matching (PSM) and local average treatment effect (LATE) models were used as analytical tools for the study. The result showed that the t-test value of 2.3 was statistically significant at P≤0.05 signifying difference between the income of farmers whose land was degraded and non-degraded. The results of the impact of land degradation on food security and productivity of the smallholder farmers revealed that the average food security index and productivity was 0.297 and 1.17 units, respectively. The average impact estimation disclosed that degraded land had a significant and negative impact on food security status and productivity of arable crop farmers. The treatment effect on the treated (ATT) on the average had a negative impact and reduced food security index and productivity of farmers whose land was degraded by -0.419 (60.55 %) and 0.120 (9.3 %). The average effect of the treatment (ATE) for arable crop farmers also had negative difference of -0.200 and -0.090 units, respectively. The study recommended that farmers should take advantage of their cooperative membership and collaborate with relevant agencies such as extension personnel, ministry of environment and others relevant stakeholders for training and workshop on how to prevent and combat land degradation problems.

**Keywords:** Arable crop, Extension contact, Food security, Land degradation, Treatment effect.

## INTRODUCTION
Increased pressure on land as a result of rapid growing world population has led to intensification in global environmental problems. Land degradation is a complex and global phenomenon, influenced by natural, cultural, institutional, technological and socio-economic factors. The extent of degraded and marginal lands suitable for dedicated biomass production is highly uncertain and cannot be established without due consideration of current land use and land tenure. Worldwide, it is estimated that nearly two billion hectares (ha) of biologically productive land have been rendered unproductive due to irreversible degradation (Vilanculos, 1994) and of recent, the total area of degraded lands has been estimated at 10–60 million km$^2$ or about two billion ha (FAO, 2018, and Olsson *et al.*, 2019). The present rate of land degradation is estimated at 5 to 7 million ha per year, suggesting that 0.3 to 0.5 % of the world's arable land is lost annually due to land degradation affecting 1.5 million people (Dudal, 1975; Vilanculos, 1994, and FAO, 2018). According to Abdelfattah (2009), the world is losing 10 ha of arable land each minute - 5 ha to soil erosion, 3 ha from salinity, and 2 ha by other degradation processes.

Land degradation is the temporary or permanent lowering of the productive capacity of land in terms of reduction or loss of biological or economic productivity including processes arising from human activities and habitation patterns (UNEP, 1992). It thus covers the various forms of soil degradation, adverse human impacts on water resources such as waterlogging, deforestation, and lowering of the productive capacity of rangelands. It refers to the reduction in the capacity of the land to provide ecosystem goods and services and assure its functions over a period of time for its beneficiaries (Abdullahi, 2014).

The land degradation process appears particularly severe in developing countries, which has significant implications for food security, crop productivity, climate change mitigation and adaptation. Food security is directly linked to the ability of the land to support populations (Scherr and Yadav, 1996). Low agricultural production, food insecurity, low income of the rural population and poverty are consequences of land degradation (Junge *et al.*, 2008). According to Agcaoili *et al.* (1995), estimated increasing degradation would lead to as much as 10% decline in productivity in the developing countries and could lead to worsening malnutrition in the developing world. Land degradation occurs globally but its negative impacts are most felt in regions which depend solely on agriculture for its income (Swift and Shepherd, 2007).

Due to rapid population growth, land use is being intensified in Nigeria with severe consequences on land resources. In Nigeria where the population has increased to about 200 million in 2019 (FAO, 2020) human-induced land degradation has intensified, due mainly to expansion of agricultural lands into marginal areas. It is pertinent to note that poor rural households in Nigeria are often found in the marginal agricultural lands where land productivity and income are stagnant or declining due to continual cultivation. There is, however, very limited data on the assessment of land degradation in Nigeria particularly Kwara State where majority of rural areas depend largely on agriculture and where agricultural production is key to livelihood and development of the rural populace.

Furthermore, given that land is an essential input in farming, the impacts of land degradation and the depletion of soil resources have profound economic implications for Nigeria as a nation particularly rural area since agrarian sector has a strong rural foundation. Majority (85%) of rural farming households are smallholding whose production capacity falls between 0.1 and 4.99 ha (Federal Office of Statistics [FOS], 1999). According to Awoke and Okorji (2004), smallholder farmers are those farmers who produce on small scale, not involved in commercial agriculture but produce on subsistence level, and cultivate less than five ha of land annually on the average. Production of arable crops by smallholder farmers in Kwara State is achieved through sole or mostly intercropping crops such as maize (*Zea mays*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), groundnut (*Arachis hypogea*), cassava (M*anihot esculentus*) and yam (*Discorea* Spp).

A number of biotic and abiotic yield-limiting factors due to land degradation have resulted in a steady decline in cultivated area and grain production over the years. A study of effects and economic implications of land degradation on farmers' food security and productivity can be used to identify measures and mitigate, and provide an accurate diagnosis or solutions to land degradation issues (Fairhead and Leach, 1995). The information may also be useful for large and smallholder agricultural development projects, enabling farmers ability to have high production in a given land use. To sustain the land resources of Nigeria, land degradation must be accorded greater significance on the environmental agenda. There is need to incorporate the local knowledge, land use suitable and land mitigating strategies to control land degradation in the study area. Lack of knowledge on the crop production practices that can mitigate degradation by smallholder arable crop production farmers in the study area has made the study imperative.

Land degradation is a complex issue and sometimes representative samples from degraded soils needs to be analyzed by selecting parameters relevant to specific indicators (Abdelfattah, 2009). However, indicators generally simplify reality to make complex processes quantifiable so that the information obtained can be useful (EEA 2005). This study used local farmers' knowledge otherwise called physical indicators such as erosion, overgrazing, water logging, soil colour,, nutrient deficiency, and flooding among others. Majority of the farmers practiced maize-based production systems in the selected villages. Hence, crops output were converted to maize grain equivalent weight (GEW) as adopted from Clark and Haswell 1970 cited in Iheanacho (2000).

In addition, past empirical studies on impacts of land degradation failed to examine the causal effect using propensity score matching (PSM) and local average treatment effect (LATE) models and duo established an appropriate counterfactual situation that could facilitate the true identification of the causes of effect and eliminate prejudice of pseudo impact or at worst overestimated or underestimated change. Hence, the objective of the study was to estimate the effect of land degradation on smallholder arable farmers' food security and productivity in Kwara State, Nigeria.

## MATERIALS AND METHODS

### The Study Area

Kwara State is located between 70° 45' and 90° 30' N Latitude and 20° 30' E and 60° 25' Longitude at the north central Nigeria with Ilorin as capital occupying a land mass covering about 32,500 square km, a total land size of 3,682,500 ha with majority living in rural areas. The State major ecosystems comprise nearly 90 % of southern guinea and derived savanna zones with scanty of deciduous trees. With an estimated population of about 2.4 million people (National Population Commission [NPC], 2006), the State's population and farm families were projected in 2020 to be about 3,624,094 and 358,880, respectively, representing 3.2 % annual growth rate, an average density of 112 persons and agricultural density of 10 persons per sq. km. The mean annual rainfall is 1,524 mm which spreads within 7 to 9 months in a year with an annual temperature ranges between 14.6°C and 36 °C and average humidity range from 85 % in July to 21 % in January. The vegetation consists largely of a great expanse of arable land and rich fertile soil (Ajao *et al.*, 2014).

### Sampling Procedure and Sample Size

A multi stage random farming household survey was conducted in four (4) Local Government Areas (LGAs): Asa, Lafiagi, Moro and Patigi in 2018/2019 farming season. The choice of four (4) LGAs out of existing sixteen LGAs was because land degradation issues were more predisposed to and pronounced in those areas and has multitudes of tributaries of river Niger overflowing their boundaries with resultant effects of flooding, erosion and waterlogging on farm lands. In the same vein, two (2) villages each were purposefully selected from each of the four (4) LGAs being area deeply affected by land degradation. Subsequently, 30 farmers were randomly selected from each of the village to make a total of 240. The last stage involved a stratified sampling method in selecting affected and non-affected arable crop farmers from each of the villages. These farmers were filtered to 92 and 148 land graded and non-degraded farmers, respectively.

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**Method of Data Collection**

Primary data was used for the study. Structured questionnaire with the help of trained enumerators under the supervision of the researcher was employed to collect the relevant data. Information collected includes socio-economic and demographic characteristics of farming households, land degradation indicators to include erosion, deforestation, and topography. An assessment checklist was also used to assess the farm output before land was degraded and after, mitigating strategies adopt by the farmers and land degradation indicators perceived by the arable crop farmers.

**Analytical Techniques**

Descriptive statistics, land degradation perception index, t-test statistics and propensity score matching (PSM) and the local average treatment effect (LATE) models were used to achieve the aims of the study. Household's perception rating of plot level land degradation parameters was used for the construction of land degradation perception index.

The perception index adopted from Genene and Wagayehu (2010) and Abdullahi *et al. (*2014) was used in the study and is specified as:

$$PI = \frac{\sum PWPS}{AWPP} \quad \ldots (1)$$

where;
PI = perception index,
PWPS = parameter weighted perception score,
AWPP = aggregate weighted point of parameter descriptors.

The index was ranged from 1.0 to 4.99, thus, index: 1.0 - 1.99 = slightly degraded; 2.0 – 2.99 = moderately degraded; 3.0 – 3.99 = severely degraded 4.0 – 4.99 = extremely degraded.

The propensity score matching (PSM) was used to examine this causal effect of land degradation on food security status and productivity by smallholder arable crop farmers. The estimated propensity scores were then used to estimate the average treatment effect on the treated (ATT) which is the parameter of interest adopted from Idi *et al.* (2019) and specified as:

$$\delta \equiv E\{Y_i^1 - Y_i^o / D_i = 1\} = E\{E\{Y_i^1 / D_i = 1, P(Z_i)\} - E\{Y_i^o / D_i = 0, P(Z_1)\} / D_i = 1\} \ldots (2)$$

where; = P-score,
$Y_i$ and $Y_i$ = the potential outcomes (food security status and productivity) in the two counterfactual situations of receiving treatment and no treatment.

Furthermore, Heckman and Hotz (1989), Hunermund and Czarnitzki (2016) adopted from Imbens and Angrist (1994), opined that local average treatment effect (LATE) estimator could be used to remedied the noncompliance problems experienced in estimation of the average treatment effect (ATE) for the population. LATE estimation was achieved using equ. 3 as specified below:

$$E\lfloor Y^1 - Y^0 \mid T = C \rfloor = \frac{E\lfloor Y \mid Z=1 \rfloor - E\lfloor Y \mid ,, Z=0 \rfloor}{E\lfloor D \mid Z=1 \rfloor - E\lfloor D \mid Z=0 \rfloor} \quad \ldots (3)$$

T-statistics adopted from Oladimeji *et al.* (2016) was used to determine the hypotheses that state that land degraded had no impact on food security and productivity of farmers. The formula is given as:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad \ldots (4)$$

where; $\overline{X}_1$ = food expenditure in ₦ (a proxy for food security)/average output kg(a proxy for productivity) from arable crop farmers affected by land degradation, $X_2$ = average output (kg)/food expenditure (₦) from arable crop farmers not affected by land degradation, $\sigma_1^2$ = variance from $X_1$, $\sigma_2^2$ = variance for $X_2$, $n_1$ and $n_2$ = sample size of $X_1$ and $X_2$.

The PSM and LATE models was used to measure the total factor productivity and food security. The food security status of arable crop farmers was measured using total expenditure incurred on food items by each farmer. Thereafter, a threshold of 0.5 and above is assumed as food secured and otherwise. The food expenditure ($y_i$) index adopted and modified from Mamoon (2017) and Fashina (2019) is specified as:

$$\text{Food Security Index} = \frac{\text{Actual } yi \text{ value} - \text{Minimum } yi \text{ value}}{\text{Maximum } yi \text{ value} - \text{Minimum } yi \text{ value}} \quad \ldots (5)$$

The productivity of arable crop farmers was estimated using the total factor productivity (TFP) model. It was used examine this causal effect of land degradation on productivity of arable crops. It was adopted from Osanyinlusi and Adenegan (2016) and specified as:

$$TFP = \frac{Gross\ value\ of\ output}{Gross\ value\ of\ inputs\ use} \quad \ldots (6)$$

## RESULTS AND DISCUSSION

### Socio-economic Characteristics of Arable Crop Farmers

Table 1 revealed that the sampled farmers are in their productive age with mean of 47 years and 95% were male with household size of 6. The estimated mean years of schooling of sampled farmers were 9.30 years, largely skewed towards junior secondary certificate. The mean area devoted to farming of 2.25 ha confirmed the assertion of FOS (1999); and Awoke and Okorji (2004) of farmers' smallholding. The average farming experience (13.70 years), years of cooperative membership (11.62) and land ownership index (0.88) indicate that the respondents are inherent to farming occupation. The results also showed that the skewness values of most socio-economic characteristics were located around their mean. The findings are comparable with studies of Oladimeji *et al.* (2019) on sweet potato farmers in north central and western Nigeria.

**Table 1:** Socio-economic Characteristics of Arable Crop Farmers

| Variables | Mean | Std. dev. | Minimum | Maximum | Skewness |
|---|---|---|---|---|---|
| Age (years) | 47.1 | 4.07 | 19 | 73 | 0.7 |
| Sex (dummy) | 0.95 | 0.07 | 1 | 240 | 1 |
| Education level (years) | 9.30 | 0.50 | 0 | 16 | 1.56 |
| Farming experience (years) | 13.70 | 3.8 | 2 | 56 | 1.20 |
| Extension contact (Number) | 0.69 | 0.26 | 0 | 2 | 0.10 |
| Area devoted Farm (ha) | 2.25 | 0.98 | 0.3 | 27 | 0.98 |
| Cooperative membership (years) | 11.62 | 0.27 | 0 | 31 | 1.17 |
| Family labour (man-days) | 34.00 | 2.05 | 14 | 51 | 0.3 |
| Hired labour (man-days) | 20.04 | 1.07 | 7.0 | 39 | 0.5 |
| Household size (number) | 6.04 | 0.52 | 2 | 19 | 0.74 |
| Land ownership (dummy) | 0.88 | 0.09 | | | |
| Access to credit ('000₦) | 47.5 | 13.8 | 0 | 250,000 | 2.18 |

**Farmers' Knowledge and Perception of Degraded Land**

Table 2 depicts the farmers' knowledge and perception of land degradation. The results revealed that 81.25% of the sampled arable crop farmers identified erosion as the causes of land degradation and with perception index (4.3) to cause extremely severity on degraded land. Nutrient deficiency (60.42%), Soil colour change, (55.0%) and water logging (44.58%) were also critical indicators of land degraded with perception indices of 3.9, 2.25, and 2.01 respectively. Kosmas *et al.* (2015) opined that there is always a possibility for inaccuracy associated with indicators but this can be taken into account sometimes as degree of risk. However, it is usually more meaningful to use indicators than try and interpret huge numbers of individual pieces of data. The most useful indicators, however, are those which indicate the potential risk of land degrading while there is still time and scope for remedial action.

**Table 2:** Farmers' Knowledge and Perception of Degraded Land (n = 240)

| Degraded indicators | Frequency* | % | Perception index | Degraded remarks |
|---|---|---|---|---|
| Erosion | 195 | 81.25 | 4.3 | Extremely |
| Nutrient deficiency | 145 | 60.42 | 3.9 | Severely |
| Soil colour changes | 132 | 55 | 2.25 | Moderately |
| Water logging | 107 | 44.58333 | 2.01 | Moderately |
| Loss of vegetation | 51 | 21.25 | 1.37 | Slightly degraded |
| Others | 33 | 13.75 | 1.07 | Not /slightly |

*Multiple responses allowed

**Impact of Land Degradation on Arable Crop Farmers' Income**

The t-test of the impact of land degradation on income of the arable farmers is presented in Table 3. The result showed that the mean income of farmers whose land were degraded (₦115,650.9 per ha) was less than counterfactual (₦187,700.5). The t-test value of 2.3 was statistically significant at 5%. This implies that there is a significance difference between the income of farmers whose land was degraded and non-degraded. This is in line with the study of Sonneveld *et al*. (2016) on the impact of land degradation on millet productivity which state that there was significance difference in millet production in landed degraded and non-degraded plot.

**Table 3:** t-test of the Impact of Land Degradation on Arable Crop Farmers' Income

| Variables /ha | Non-degraded land | Degraded land |
|---|---|---|
| Mean (₦) | 187,700.5 | 115,650.9 |
| Variance | 7,500.8 | 18,960,7 |
| Observation | 148 | 92 |
| Hypothesized mean difference | 0 | |
| Df | 238 | |
| t-statistics | 2.300765** | |
| P(T≤ t) one tail | 0.500741E-06 | |
| t critical one tail | 1.723006 | |
| P(T≤T) two tail | 0.200945E-07 | |
| t critical two tail | 1.960271 | |

Significant at 5 %

**Impact of Land Degradation on Farmers' Food Security Status and Productivity**

This was achieved through propensity score matching (PSM) and local average treatment effect (LATE) model. For propensity score, nearest neighbor (NN) matching algorithm had the best fit and was used to match the socio-economic characteristics between land degraded and non-degraded farmers. This was selected based on the three diagnostic statistics, higher t-value, lower Rubin B and Rubin R (Rubin, 1974, 1978) compared to the other two algorithms, radius and kernel in Table 4. NN also uses the propensity score of individuals alike in the treated and control group to construct the counterfactual outcome with its major advantage of having lower variance which is achieved because more information is used. However, according to the results of the three algorithms, the difference in means of the socio-economic characteristics between the degraded and non-degraded land is completely eliminated based on the diagnostic statistics. The Rubin's B criterion estimate for the NN matching (21.00%) is less than 25% which implies that only the NNM is effective in balancing the covariates across land degraded and non-degraded farmers. But in terms the Rubin's R, all the three algorithms were effective in balancing the covariates across the degraded and non-degraded groups. Overall, it can be concluded that the NNM is the best algorithm for the estimation of the impact of land degradation on food security status and productivity of the farmers. The result is in line with Idi *et al.* (2019) that examine the impact of microcredit utilization on maize output and food security in Kaduna State, Nigeria.

Propensity scores were obtained through Logit regression model and non-land degraded farmers were matched on the basis of the proximity of their propensity scores of degraded farmers in the counterfactual using individual socio-economic characteristics to form matched pairs of observational similar individual characteristics. The propensity score is a probability, so the average probability in the treatment of was 0.592 (Table 4). The probability that a particular arable crop farm land will be degraded (treatment assignment) is 59.2%. All other farmers whose propensity scores for not degraded were different from the range of scores for the degraded farmers were dropped from the analysis.

**Table 4:** Comparison between NN, R and K algorithms

| Algorithms by matching | T-value | Rubin's B | Rubin's R |
|---|---|---|---|
| Nearest neighbor (NN) | 9.01 | 21.00 | 1.02 |
| Radius (R) | 7.42 | 37.29 | 1.18 |
| Kernel (K) | 7.39 | 35.53 | 1.27 |
| **PSM Diagnostic statistics** | | | |
| Observation | 240 | | |
| Mean | 0.592 | | |
| Standard deviation | 0.170 | | |
| Minimum | 0.0038 | | |
| Maximum | 1.0000 | | |

Note: Note: NN = nearest neighbour; R = Radius; K = Kernel

**Propensity Score of the Arable Crop Farmers**

To identify the factors that affect land degradation among arable crop farmers in the study area, the Logit model was used to generate propensity scores for the matching algorithm. The diagnostic statistics in Table 5 indicates that the overall model is well fitted and the explanatory variables used in the model were collectively able to explain the factors influencing land degradation in the study area. The significant variables that determine the land degradation include age, level of education and farm size of the farmers and extension contact.

The result of Logit model was interpreted using the odds ratio. The odds values represent the odds of Y is equal to one when a significant independent variables increases by one unit. These are the exponential, logit coefficient. There are two conditions: If the odds ratio is greater than 1 then the odds of Y is equal to one increases and vice versa. More specifically, the model revealed a statistically significant (P<0.01) and negative relationship between education and the probability of land degradation. This is suggesting that number of years spent in school by farmers will reduce the probability of land degradation by -1.206 units. This may be attributed to the fact that education create awareness on land degradation issues and enhance adoption of new innovation and techniques on land management practices. Awotide *et al.* (2015), Oladimeji *et al.* (2016), and Ogunniyi *et al.* (2018), have shown that education plays systematic role in adoption of technology.

**Table 5:** Maximum Likelihood Estimates of the Propensity Score of the Arable Crop Farmers

| Variable | Odds ratio | SE | T-value | P > /Z/ |
|---|---|---|---|---|
| Constant | 1.029*** | 0.019 | 2.79 | 0.001 |
| Age | 0.596 | 0.187 | 1.12 | 0.725 |
| Level of education | -1.206*** | 0.026 | -3.12 | 0.000 |
| Farm size | 1.521*** | 0.001 | 4.00 | 0.000 |
| Cooperative membership | 4.106 | 0.129 | 0.81 | 0.833 |
| Amount of credit | -2.305*** | 0.116 | -4.16 | 0.000 |
| Extension contact | -0.632*** | 0.001 | -5.00 | 0.000 |
| Household size | 3.329*** | 0.096 | 3.43 | 0.000 |
| Diagnostic statistics | | | | |
| LR $Chi^2$ (7) | 162.00 | | | |
| Prob > $chi^2$ | 0.000 | | | |
| Pseudo $R^2$ | 0.19 | | | |
| Log likelihood | 89.75 | | | |
| Observations | 240 | | | |

*** P<0.01 and **<0.05 levels of probability

The coefficient of farm size holdings was positive and statistically significant at 1% level of probability. This signifies that a unit increase in the coefficient of farm size will lead to corresponding increase of 1.521 units in land degradation. Access to production credit was also statistically significant at 1% level with negative coefficient, suggesting that access to credit could reduce land degradation. The implication is that land degradation would be decreased by -2.305 units with access to credit and respondents that utilized production credit. This confirmed the empirical and theoretical expectations that the judicious utilization of production credit will enhance opportunities to increased land management practices and apparently increase output level, *ceteris paribus*.

The number of extension visits made to the farmers by extension agents had a regression coefficient of -0.632 and statistically significant at 1%. This indicates that the more the number of extension visits made, the higher the likelihood that land degradation level will be reduced. This is because during such visits, farmers that are predisposed to or has problem of land degradation will be train on land management practices and feedbacks will be received on the innovation and adaptation techniques passed to the respondents during the previous visit. This allowed for positive interaction and hence the likelihood that the interaction will assist the farmers to benefit more on the land management practices being passed. This could be supported with the work of Genene and Wagayehu, (2010) that studied farmers` perceptions of land degradation and determinants of food security at Bilate watershed, southern Ethiopia.

The household size was statistically significant, and it is negatively associated with the probability of land degradation with coefficient of -3.329 units. The possible reason is that farmers with larger family size may not be able to adopt management practices that involved huge financial expenses because of other essential needs. On the other hand, if large percentage of the farmer's household is actively involved in the farming activities, they could be involved in cultural practices that could enhance control of degraded land.

**Impact of Land Degradation on Food Security Status and Productivity of the Farmers**

The results of the impact of land degradation on food security and productivity of farmers are presented in Table 6. The result revealed that the average food security index and out-input ratio (productivity) was 0.297 and 1.17 units, respectively. This implies a unit increase in land degradation will lead to 0.297 and1.17 units' decrease in food security index and productivity, respectively. The average impact estimation shows that degraded land had a significant and negative impact on food security status and productivity of arable crop farmers.

The treatment effect on the treated (ATT) on the average had a negative impact and reduce food security index and productivity of farmers whose land was degraded by -0.419 (60.55%) and 0.120 (9.3%). This implies that land degradation negatively impacted on the affected farmers in the two parameters considered. In other words, if any crop farmers' farm size in the population are degraded the food security and productivity indices of the farmers will be decreased by -0.419 and 0.120 units, respectively.

The Treatment effect on the untreated (ATU) was estimated by matching similar treated arable crop farmers to each non-treated respondents. The results showed that ATU had a significant and negative coefficients of -0.205 and -0.160 impact on food security and productivity indices, this is the counter factual outcome of the treated had it been they were not treated. The average effect of the treatment (ATE) for arable crop farmers also have a negative difference of -0.200 and -0.090 units, respectively compared to the treated category.

**Table 6:** Impact of Land Degradation on Food Security Status and Productivity of Farmers

| Estimation by | Sample | Treated | Control | β | SE | T-statistics |
|---|---|---|---|---|---|---|
| (i) Food security | Unmatched | 0.297 | 0.511 | 0.214 | 0.097 | 2.206186 |
| Index | ATT | 0.273 | 0.692 | 0.419 | 0.051 | 8.215686 |
| | ATU | 0.205 | 0.437 | 0.232 | | |
| | ATE | | | 0.200 | | |
| WALD Chi$^2$ test | | | | 0.318 | 0.103 | 3.09 |
| Degraded versus | | | | 0.511 | 0.0976 | 5.235656 |
| Non-degraded | | | | 0.297 | 0.096 | 3.09375 |
| Observed diff. | | | | 0.214 | 0.03 | 7.133333 |
| (ii) Output-input | Unmatched | 1.170 | 1.290 | 0.120 | 0.05 | 2.4 |
| Ratio | ATT | 1.260 | 1.540 | 0.280 | 0.09 | 3.11 |
| | ATU | 0.850 | 1.010 | 0.160 | | |
| | ATE | | | 0.090 | | |
| WALD Chi$^2$ test | | | | 0.408 | 0.118 | 3.46 |
| degraded versus | | | | 1.170 | 0.654 | 1.97 |
| non-degraded | | | | 1.290 | 0.708 | 1.65 |
| Observed diff. | | | | 0.121 | 0.040 | 3.01 |

Note: treated = degraded and control = non-degraded; Treatment Effect on the Treated (ATT), Treatment Effect on the Untreated (ATU)

The LATE estimate was carried out for food security and productivity indices using WALD chi square estimator proposed by Imbens and Angrist (1994) and adopted by Nwahia (2020). The result of its (LATE) mean difference as shown in Table 6 is that there was a significant difference of 0.318 and 0.408 units in food security and productivity indices respectively between the land degraded and non-degraded arable crop farmers. This implies that the indices of land degraded farmers were 0.318 and 0.408 units lower when compare with the non-degraded counterpart. This is the average change in the indices brought about by the land degradation. LATE model does not over-estimate or under-estimate the impact of a project because of its ability to estimate the impact of project in a situation of non-compliance and ability to bring out the actual impact of the degradation irrespective of other factors that might influence the outcome of interest.

**Land Mitigating Strategies adopt by the Farmers**

Table 7 depicts the distribution of strategies adopt by the farmers in mitigating land degradation. The result revealed that intercropping and mixed cropping are the most common strategy adopted by farmers in mitigating land degradation as 162 respondents (67.5%) of sampled respondents and 28.62% of total responses acceded to it. This was followed by plant trees (54.17%) of total respondents and 22.97% of total responses employed planting trees such as *Jatropha curcas*, *Melinea arboria*, grasses among others at the edge or boundary of their farm to prevent rill and possible gully which usually occur on a sloping surface and where runoff is prevalent because of land use and lack of vegetation. About 18% of total responses add organic manure to their farm land to mitigate land degradation.

**Table 7:** Strategies Adopt by the Farmers in Mitigating Land Degradation (n = 240)

| Strategies | Frequency* | Percentage | Ranking |
|---|---|---|---|
| Inter/mixed cropping/crop rotation | 162 | 67.50 | 1st |
| Plant edging/tree planting | 130 | 54.17 | 2nd |
| Organic manure | 98 | 40.83 | 3rd |
| Cover cropping | 84 | 35.00 | 4th |
| Tillage practices | 51 | 21.25 | 5th |
| Others: waterways, contour , mulching | 41 | 17.08 | 6th |
| Total | 566 | 235.83 | |

* = Multiple responses existed

**CONCLUSION AND RECOMMENDATIONS**

The study examined impact of land degradation on food security and productivity of arable crop farmers in Kwara State, Nigeria. The study established that there was negative effect of land degradation on arable crop output, hence, food security status and productivity of sampled farmers. The study recommended as follows:

1. Farmers should take advantage of their cooperative membership and collaborate with relevant agencies such as extension personnel, ministry of environment and others relevant stakeholders for training and workshop on how to prevent and combat land degradation problems.
2. Arable crop farmers should use their local knowledge to mitigate land degradation issues to restore, sustain and enhance productivity functions of the land in the study area.
3. Soil productivity restorations approaches was recommended with acronym ARMUPCO; where; A = application of organic manure, R = recommended inorganic fertilizer

application, M = mixed cropping, U = use of vegetative (trees) barrier to control erosion, P = planting of leguminous creeping as cover crops which can provide useful ground cover to control soil and water erosion, C = crop rotation and O = others effective stakeholders participating in land use planning and mitigating strategies.

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