JOURNAL OF EMERGING ECONOMIES AND POLICY 2024 9(2) 332-342

JOEEP

e-ISSN: 2651-5318
Journal Homepage: http://dergipark.org.tr/joeep

Araştırma Makalesi ● Research Article

Multi-Dimensional Analysis of Impact of Land Degradation on Smallholder Maize Farmers' Food Security in Kaduna State, Nigeria *

Arazi Bozulumunun Nijerya'nın Kaduna Eyaletindeki Küçük Ölçekli Mısır Çiftçilerinin Gıda Güvenliği Üzerindeki Etkisinin Çok Boyutlu Analizi

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M A K A L E B İ L G İ S İ

Makale Geçmişi:

Başvuru tarihi: 12 Eylül 2023

Düzeltme tarihi: 20 Ocak 2024

Kabul tarihi: 20 Ocak 2024

Anahtar Kelimeler:

Arazi Bozulumu

Gıda Güvenliği

Mısır Çiftçileri

Nijerya

ÖZ

Bu çalışma, toprak bozulmasının Nijerya'nın Kaduna Eyaleti'ndeki küçük ölçekli mısır çiftçilerinin gıda güvenliği üzerindeki çok boyutlu etkilerini incelemiştir. Araştırma, tarımsal arazi bozulmasının başlıca sonuçlarını ve politika eylemi önermek amacıyla katılımcıların gıda güvenliği durumunu tespit etmeyi amaçlamıştır. Birincil veriler, arazi bozulmasından etkilenen 204 mısır çiftçisinden ve etkilenmeyen 231 çiftçiden yapılandırılmış anket ve görüşme programı kullanılarak toplanmıştır. Gıda istikrar endeksi yaklaşımı, etkilenen mısır çiftçilerinin çoğunluğunun (%72,5), etkilenmeyen çiftçilerin sadece %0,9'una kıyasla zayıf gıda istikrarına sahip olduğunu ortaya koymaktadır. Ortalama olarak etkilenen mısır çiftçilerinin PSM tedavi sonuçları, etkilenen çiftçilerin arazi bozulumu zorluklarının bir sonucu olarak kalori alımlarında öğün başına -10.723 Kcal'lik bir düşüş olduğunu göstermektedir. Etkilenen çiftçilerin gıda güvenliği durumunu iyileştirmek için hükümet ve politika yapıcılar, gelişmiş tarım teknikleri, tarımsal ormancılık ve ürün çeşitlerine yatırım yapmak ve yerel toplulukların arazi yönetimi kararlarına katılımını sağlamak gibi arazi bozulumunu azaltma politikalarına öncelik vermelidir.

A R T I C L E I N F O

Article history:

Received: Sep 12, 2023

Received in revised form: Jan 20, 2024

Accepted: Jan 20, 2024

Keywords:

Land Degradation

Food Security

Maize Farmers

Nigeria

A B S T R A C T

This study examined the multidimensional effects of soil degradation on the food security of smallholder maize farmers in Kaduna State, Nigeria. The research was intended to ascertain the major consequences of agricultural land deterioration and the food security status of the respondents with the intent of proffering policy action. Primary data were collected from 204 maize farmers affected by land degradation and 231 non-affected farmers using structured questionnaire and interview schedule. The food stability index approach reveals that majority of affected maize farmers (72.5%) had poor food stability compared to non-affected farmers with only 0.9%. PSM treatment results for the Treated of the affected maize farmers on average shows that the affected farmers had a decrease of -10.723 Kcal per meal on their calorie intake as a result of land degradation challenges. To improve food security status of affected farmers, government and policymakers should prioritize land degradation mitigation policy such as investing in improved farming techniques, agroforestry, and crop varieties, and ensuring local communities are engaged in land management decisions.

* Ethics committee permission was given for the survey application of this study by Institute for Ethics Committee of Agricultural Research, Department of Agricultural Economics, Ahmadu Bello University, Zaria, Nigeria on 21.06.2021.

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Atıf/Cite as: Abdullahi, G., Usman, O. Y., Egwuma, H., Aisha, H.S., Hannat, Y. O., & Magaji, B. D. (2024). Multi-Dimensional Analysis of Impact of Land Degradation on Smallholder Maize Farmers' Food Security in Kaduna State, Nigeria. *Journal of Emerging Economies and Policy*, 9(1), 332-342.

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1. Introduction

According to Tully et al. (2015), Tilauhun and Zewide (2021), land degradation has been the biggest threat to soil productivity, causing a decline in crop productivity, and is connected to hunger and poverty. This is due to the many devastating effects of topsoil removal on soil productivity and environmental health (Utuk and Daniel, 2015). This is so because removing top soil by any means has many negative consequences on both the soil's ability to produce and the health of the environment (Oladimeji et al., 2020). Coincidentally, rapid growing population in the face of inadequate food supply is a major issue faced by many countries today especially Nigeria (Utuk and Daniel, 2015). A significant issue for many countries, especially Nigeria, insufficient food supply is a problem today due to the world's population growth (Oladimeji et al., 2020). In Northern Nigeria, particularly in the rural areas where people depend on scarce productive land resources, environmental situations such as land degradation is a driver of forced migration (Castelli, 2018).

Since the 20th century, land degradation has been a significant global concern and has continued to be a top priority on the global agenda in the twenty-first century. Degradation of the land due to human activity is referred to as land degradation (Utuk and Daniel, 2015). It is a theory that contends that the biophysical environment's worth can change as a result of many combinations of processes caused by people that till the soil (Abdulkadir et al., 2013; Gretton and Salma, 1997). Since soil is an essential part of any ecosystem, it simply means a decline in the soil's natural state (Eni, 2012; Ewetola et al., 2015).

Given that land, soil in particular, is a crucial component of farming, the effects of soil degradation and resource depletion have significant economic implications for low-income nations and impoverished rural areas around the world since the agrarian sector has a strong rural foundation (Oladimeji et al., 2020). This is especially true in Africa and of course Nigeria, where the primary sector provides the rural population's means of subsistence and agricultural production is essential to development (Oyinbo and Rekwot, 2014; Nchuchuwe and Adejuwon, 2012; Maiangwa et al., 2007).

In the past, erosion and flooding have been frequent land degradation problems in Kaduna State (Aminu and Jaiyeoba, 2015; Adewuyi, 2008). Of recent, waste and debris backlog and release on waterways and country side during flooding, usually mixed with the top soil and take quite some time before they can be degraded, have escalated land degradation. This leads to other problems, including land pollution, stumbling block to water passage, creating an environment for stationary water, which results in leaching, and as a result reducing the proportion of farmland of the rural populace or increasing their cost of production by making the land inaccessible for farming (National Agricultural Extension and Research Liaison Services NAERLS, and Federal Ministry of Agriculture and Rural Development FMARD, 2015).

Land degradation's impact on rural farmers and the environment at large is so enormous that the poor resource farmers are finding it difficult to cope with for their livelihood and sustainability. As a matter of fact, the reduction in productivity and food insecurity challenges faced by the rural populace are primarily a result of land degradation. This has discouraged some rural dwellers who still have the potential for farming to migrate to urban areas, searching for non-farm activities without thinking of going back to their inherited farming activity. This is majorly as a result of inadequate fertile farm land or the high cost of production in returning the degraded land for farming, and the implication of this as well is urbanization.

Attainment of food security is a core problem confronting global households (Manikas et al., 2023); especially rural populations due to low productivity in staple crop production as a result of land degradation caused by global warming, degrading water and land resources, and eroding biodiversity (Oldewage-Theron, 2019). This is coupled with seasonal variability in food supply as well as price fluctuations (John et al., 2013). Due to concerns about the impact of land degradation on agriculture and specifically its impact on crop yields, one of the top concerns for international development and emerging nations is now food security. Global population is projected to surpass 9 billion by 2050, with most of the extra 2 billion people living in developing countries, driven by urbanization, population and income growth (FAO, 2016). The foundation of world food security has been said to be smallholder farmers (Chappell and LaValle, 2011). This is particularly true in Nigeria where majority of people depend on agriculture for a living, and ensuring food security requires the success of small-scale farmers.

It is vital to highlight that maize is Nigeria's most significant and extensively produced crop, especially in Kaduna State among the 36 States of Nigeria, with a total cultivated area of more than 40 million ha as at 2017 (FAOSTAT, 2018). Maize production is mainly done under rainfed ecosystem; in Kaduna State, it is dominated by small farmers, who typically cultivate less than two hectares (Ameh et al., 2020; Egwuma et al., 2019; FAOSTAT, 2018; Evbuomwan and Okoye, 2017; Afolabi, 2010). Furthermore, the bulk of small-scale farmers in Kaduna State cultivate maize, being the leading state in maize production in Nigeria for several years (Makama et al., 2022; Kaduna State Agricultural Structure Survey KASS, 2017; NAERLS and FMARD, 2015).

Providing comprehensive, accurate, and pertinent information on land degradation and its severity on food security is an effective strategy to combat the threat of global food insecurity in general and in sub-Saharan Africa in particular. To do this, not a single measurement of food insecurity will suffice. An array of gauges to estimate food security are available in the literature. This could be assessed from the comprehensive and the countrywide to the household and the individual on the one hand and food consumption, livelihood, objective gauges, to subjective perception on the other hand (Maxwell, 1996). Although the agitation to synchronize food security dimensions to enhance standardization and uniformity among stakeholders remains elusive, there remains no agreement among government and non-governmental organisations (NGOs), researchers, and scientists on the gauges and approaches that are applicable for determining and tracking food security at international, regional, family, and individual levels (Carletto et al., 2013). Instead, several indices and tools have been developed, hampering which of these indices connotes the three basic food security measurements (availability, access, utilization, or stability); components (quantity, quality, safety, cultural acceptability/preferences); and levels (international, state, county, family or individual) of food security (Bawadi et al., 2012). This research adopted several of these approaches because there is a lack of consensus on which is the best for estimating, evaluating and monitoring food security (Carletto et al., 2013; Caccavale & Giuffrida, 2020). Thus, this study analyses food security using a multi-dimensional approach to determine the effects of land degradation on the food security of smallholder maize producers.

2. Research Methodology

2.1. Study Area

This study was conducted in Kaduna State of Nigeria. Using 3.2 per cent annual population growth rate of National Population Commission, the population is projected to 10,041,943 people in 2022. The State has 23 Local Government Areas (Okeshola and Sadiq, 2013). The State is located between Longitudes 60 E and 90 E of the Prime Meridian and Latitudes 900 N and 1200 N of the equator (Abdulrahman et al., 2015). Kaduna State has a total land area of 48,473.2 km2 and belongs to the savannah region, that make up a total land area of approximately 630,436 km2, about 68.44% of Nigeria's total land area of 923,769 km2; savannah region also consists of about 86% of Nigeria's total vegetation cover (Adedibu et al., 2021; National Population Commission, NPC, 2006). The annual rainfall is 1323 mm with an average temperature ranging from 28.90 C in April to 22.90 C in December (Abaje et al., 2016). Numerous crops, especially maize, are produced in large quantities because to the favourable soil and climate. (NAERLS, 2011).

Majority (80%) of the indigenous population in Kaduna State are peasant farmers who are involved in producing both cash and food crops (Kaduna Agricultural Development Project, KADP, 2007). crop rotation involving a range of different crops, including maize, ground nut, millet, guinea corn, sugar cane, tobacco, yam, cassava, cowpea is as a result of physical properties of the soil that is moderately good (NAERLS, 2011; Ameh et al., 2020). In the north of the state, there is a northern guinea savanna, while in the south, there is a southern guinea savanna. During the dry season, a substantial percentage of farming households in the state engage in irrigation farming along some major rivers and dams such as Kangimi dam, Bogoma dam, Zaria dam (KADP, 2014).

2.2. Data Collection And Sampling Technique

The primary data used for this study were collected in the 2019/2020 farming season. This was in addition to secondary data from the National Population Commission, the Central Bank of Nigeria, the National Bureau of Statistics (NPC), FAO, and USDA. The data collection tools that were employed include a structured questionnaire with the help of extension agents from Kaduna State Agricultural Development Agency (KADA) and trained enumerators working under the researcher's guidance. A checklist was also used to assess the resource availability of the selected farmers. The respondents were selected utilizing the study's multistage sampling process between the four agricultural zones

that are currently present in the State (Maigana, Samaru, Lere, and Birnin Gwari). The initial step involved the purposeful selection of two zones, namely Maigana and Samaru, where the problems of land degradation are more severe (Aminu and Jaiyeoba,2015: KADP,2014: Ajibua,2012). Secondly, two local government areas (LGAs) from Maigana zone were randomly selected, and one LGA from Samaru zone was purposively chosen, being the area most affected by land degradation. In the third stage, a list of the villages affected by land degradation in each LGA was obtained. Thereafter, 56% was used in selecting 15 out of 27 villages for this study.

The fourth stage required choosing impacted and unaffected maize producers from each of the villages using a stratified sample technique. with the assistance of Nigerian Agriculture Development Projects (NADPs) and village heads. Therefore, seventy (70) percent of the affected maize farmers were randomly selected from a sample frame of 291 affected maize farmers, resulting in a total of 204 respondents, while ten (10) percent of the non-affected maize farmers were randomly selected from a sample frame of 2,293 using ballot techniques, yielding a total of 231 non-affected maize farmers. A total of 435 affected and non-affected maize farmers were used for this study.

2.3. Analytical Techniques

In order to achieve the study's objectives, data were examined utilizing Propensity Score Matching (PSM) and a multi-index (robustness) approach to food security.

2.3.1. United State Development Agency (USDA) Food Security Approach

The United States Development Agency (USDA) method, adapted from Kazeem et al. (2020), Ibok et al. (2014), and Fakayode et al. (2009), uses a food security scale to classify homes. This scale consists of a number range from 0 to 10 on a linear scale. The scale determines the degree of a household's food insecurity in terms of a numerical value. (Ibok et al., 2014). The United States Development Agency's core food security module (USDA, 2000), which consists of a collection of 16 questions with a set of negative answers and affirmative answers, with the latter denoting better and the former denoting worse food security status, served as the foundation for the approach used to estimate the food security status of unaffected and afflicted farmers. Therefore, any factor that adversely affects the level of food security would suggest an increase, while a good factor would suggest a decrease. A continuum with a linear scale from 0 to 10 was used to scale the level of food security. The scale offers a single numerical number to indicate a household's level of hunger or food insecurity.

2.3.2. Food Security Scale

Based on their responses to a series of questions on behaviors and experiences that are known to characterize households having difficulty fulfilling their food needs, each household's position on the food security continuum is determined using the food security scale. The food security scale is calibrated as shown in Table 1 to determine the level of food security in a family.

Table 1: Household food security status, USDA Approach, 2000

0-2.32	2.33-4.56	4.57-6.53	6.54-10.0
Food security	Food insecurity		
	lack of hunger but food insecurity	hungry and insecure about food	
		"moderate"	"severe"

2.3.3. Calorie Proxy Indicator

Based on food, the calorie proxy determines the calories per person produced and consumed by a household (Cadre Harmonise Manual, 2014). Food production and purchases for consumption were first translated to kilograms and then to calories. The household size was then adjusted for adult equivalency using the equivalent male adult scale weight. The total was subsequently divided by 365 days to get the number of calories consumed daily per household, which was then compared to the FAO norm of 2400 kcal. The estimated calorie consumption of households was calculated using the calorie equivalent of regularly consumed foods in Nigeria. A household may be considered food secure if up to 2400 kcal per person per day are consumed, and below that threshold, food insecurity results.

2.3.4. Accessibility Index

The ability to acquire food is shaped by a person's economic, physical, and social access, which together make up the accessibility index. This makes it the more challenging component of food security to study. The variables selected to analyze economic access for the households were: prices of food consumed, land size under cultivation, output from maize, sales from maize output, and income from primary occupation. To construct the accessibility index, the minimum and maximum values of the variables are used, which are gotten from the data (Majumdar, 2015; 2020). Individual indices for each of the variables are first computed by the general formula:

$$Index = \frac{\text{Actual } xi \text{ value} - \text{Minimum } xi \text{ value}}{\text{Maximum } xi \text{ value} - \text{Minimum } xi \text{ value}} \quad (1)$$

Min-Max normalizes by taking away the minimum value and dividing by the range of the indicator values, the variables can be made to have an identical range (0, 100). The indexes can then be ranged and classified into high, medium and poor accessibility.

$$Accessibility\ Index = \frac{\text{PFC Index} + \text{LSC Index} + \text{OFM Index} + \text{SMO Index} + \text{IPO Index}}{5} \quad (2)$$

Where; PFC = Price of food consumed; LSC = Land size under cultivation; OFM = Output from maize; SMO = Sales from maize output; IPO = Income from primary occupation.

2.3.5. Food Consumption Score (FCS)

By adding the effects of consumption frequency for each food group and its related nutritional weight, the food consumption score for each household was calculated. The FCS is a composite indicator of dietary variety, food frequency, and the relative nutritional significance of various food groups as a result. Each household's data on these factors was gathered using a 7-day recall.

The number of days a specific food group was consumed over the course of a week was used to calculate the food frequency. The food groups are listed in Table 1, along with the weights assigned to them based on their individual nutritional values. By adding the results of the frequency of consumption for each food group and its related weight, the FCS for each household was calculated. Households with FCSs equal to or below 28 were classified as poor, those with FCSs of 29 to 42 as borderline, and those with FCSs of 42 or more as acceptable. (Butaumocho and Chitiyo, 2017). The score is calculated as follows:

$$\begin{aligned} AFCS = \; & WcerealDcereal + WlegumesDlegumes \\ & + WvegetablesDvegetables \\ & + WfruitsDfruits \\ & + WanimalproteinDanimalprotein \\ & + WdiaryproductDdairyproduct \\ & + WsugarDsugar \end{aligned} \quad (3)$$

Where, D = The number of days each food group is consumed; W = Weight assigned to the food group. The types of foods considered, the food groups they belong to, and the weight assigned to each group are displayed in Table 2 below.

Table 2: Food Groups And Weight

foods categories	Food class	Weight
rice, bread/doughnuts, pasta Maize, millet, sorghum, Cassava yams, plantains, other tubers	Cereals and tubers	2
Legumes and groundnuts (beans,	Legumes	3

cowpeas, peas, etc.)		
Veggies plus leaves	Vegetables	1
Fruits (such as mangoes, oranges, bananas, etc.)	Fruits	1
Meat, poultry, seafood, and snails, eggs	Animal proteins	4
Milk and dairy products	Dairy products	4
Sugar, honey, other goodies	Sugar	0.5
fats and oils	Oils	0.5
Condiments, spices	Condiments (*)	0

Source: Cadre Harmonise Manual (2014)

2.3.6. The HDDS (Household Dietary Diversity Score)

This indicator records how many distinct food types the household has consumed and how frequently they have done so over a specified reference period. It sometimes involves weighting these groups, with the result being a score that represents the dietary intake but not necessarily the quantity. It is similar to Food Consumption but does not offer data on how frequently the various food categories should be consumed, nor does it give weight to different food groups according to their nutritional worth. It is computed by taking a binomial variable that has two values and attaching them to the food groups. Then the binomial variables were summed to create the Household Dietary Diversity Score (HDDS). The new variable's range will be 0 through the total number of food groups gathered.

HDDS has been shown to have a strong link with indications of usage, such as birth weight, child anthropometric measurements, improved hemoglobin concentration, and a decreased tendency toward hypertension. It acknowledges the existence of concealed hunger brought about by a lack of certain micronutrients. The HDDS, which has a scale from 0 to 12, was used to determine the dietary diversity of households and to rank them into high (6–12) and low (0–5) dietary diversity groups. (FAO et al., 2022; Wineman, 2014; FAO, 2008).

2.3.7. Stability Index

In order for a home to be considered food secure, it must be guaranteed that food will always be available, that it will be accessible, and that it will be used properly—in other words, in a stable manner. The selected variable used to measure this dimension was the stock level of food items in the household. The households were asked questions on how long the various categories of food items can last, with referenced periods to choose from. This variable highlights how much a household is able to withstand food shortages through its stocks, providing an immediate image of the management of the food items' stocks. The stability index was computed similarly to the accessibility index, which involved setting the minimum and maximum values. The indicators must be changed into indices between 0 and 1. The stability indexes of the households can be classified based on the range of values into poor food stability, acceptable or moderate food stability, and stable food stability.

2.3.8. Food Security Index Classification

Table 3 provides the details of the overall food security indexes. The two most severe categories (severely and moderately food insecure) and the food insecurity rate are added to determine the percentage of food insecure households by adding the categories of food security and food insecurity.

Table 3: The Four-Food Security İndex Classification

Classification	Description	Food Secure/Food Insecure
Food Secure	At least 80% of households (0.8) are able to meet their food and non-food needs without using common coping mechanisms or turning to human aid.	Food Secure
Marginally Food Secure	At least one in five (0.2) households consume less food than is minimally adequate but are unable to pay for some necessary non-food expenses without resorting to irreversible coping mechanisms.	Food Secure
Moderately Food Insecure	Acute malnutrition affects at least one in five (0.2) households in the area at high or above-average rates. and substantial food shortages; alternatively, they are only just able to satisfy their reducing livelihood resources, which will result in meeting the bare minimum food needs and a gap in their food consumption.	Food Insecure
Severely Food Insecure	Even with humanitarian aid, at least one in five (0.2) households in the region suffers from the worse of the two scenarios: significant food consumption gaps that result in excess mortality, significant loss of livelihood resources, or extremely high acute malnutrition, both of which may result in gaps in food consumption in the near future.	Food Insecure

Source: World Food Programme (2015)

2.3.9. Propensity Score Matching (PSM)

Smallholder maize farmers' usage of degraded land has a causal relationship with their degree of food security, making it possible to analyze the causal relationship between degraded land and food security status, the matching approach was employed. This was used to achieve objective (v), which studies the effects of land degradation on maize farmers' productivity and food security. The computed propensity scores were applied to the measure of interest, the Average Treatment Effect on the Treated (ATT). The Average Treatment Effect on the Treated (ATT) is the most often used evaluation parameter of interest and is defined as:

$$ATT = E\,(Y_{1-}\,Y_0/P = 1) - (Y_1/P = 1) \quad (4)$$

If a set of X = xi features is given, the propensity score represents the likelihood that the household would continue to farm maize on degraded land.

P(X) = Pr ((P=1)/(X=xi)) (Pufahl and Weiss, 2009) (5)

The regression models used to compare these characteristics yielded the propensity scores. By calculating the differences between the two groups, the effect of treatment on the treated (the causal effect of project participation) was estimated.

$$ATT = \frac{1}{N\,1}(Y_1 - Y_0) \quad (6)$$

Where ATT = Average impact of Treatment on the treated, N1 = Number of matches (from regression model), Y1 = the productivity index by land degraded farmers, Y0 = the productivity index by non-degraded farmers. A positive (negative) value of ATT suggests that farm household land degraded farmers' outcome have higher (lower) outcome variable than non-land degraded farmers (Pufahl and Weiss, 2009).

Where Y1 is the production index for farmers whose land has been damaged, and Y0 is the productivity index for farmers whose land has not been degraded; ATT stands for Average Impact of Treatment on the Treated; N1 is the number of matches (from the regression model). According to Pufahl and Weiss (2009), a positive (negative) value of ATT indicates that farmers whose farm households have degraded land have higher (lower) outcome variables than farmers whose farms have not degraded land.

3. Results and Discussion

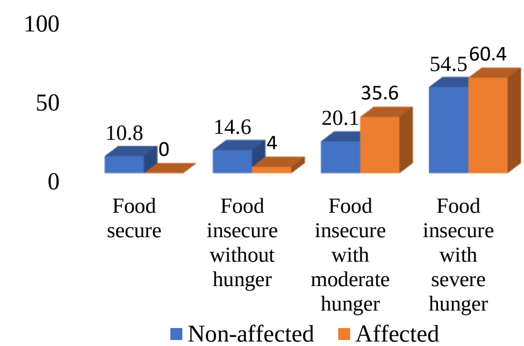
3.1. Food Security Status of Smallholder Maize Farmers in Land Degradation Areas

Various approaches including USDA, food availability and accessibility indices, FCS, and HDDS, were combined to give an overall food security classification at household and individual levels for maize farmers affected by land degradation. This is because there is a need to triangulate and combine food security indicators to understand various factors and the nexus between food security and land degradation. This is due to the fact that food security exists when every person, at all times, has physical and financial access to enough food that is wholesome, safe, and satisfies their dietary needs and food preferences for an active and healthy life. (FAO, 2000). The four pillars of food security—availability, accessibility, usage, and stability—were established using the estimated indicators (Vhurumuku, 2014).

3.1.1. USDA Approach: Household Hunger Scale

The result in Figure 2 shows the distribution of respondents based on the food security status of non-affected and affected farmers. The distribution of respondents based on the state of affected and unaffected farmers' food security is depicted in Figure 2. Maize farmers affected by land degradation were more food insecure with severe hunger (60.4%) compared with non-affected maize farmers (54.5%). Similarly, land degraded maize farmers who were food insecure with moderate hunger (35.6%) also recorded higher food insecurity status compared with non-affected maize farmers with 20.1%. It is important to emphasize that none of the affected farmers had food security, compared to 10.4% of non-affected farmers.

Fig 2: Distribution Of Farmers According To Level Of Food Security



A plausible explanation for the higher level of food insecurity among the two groups could be attributed to inflation and naira devaluation, insecurity, and land degradation that compounded and increased food insecurity among affected maize farmers. In addition, the land degradation created a level of insecurity for farmers, causing them to reduce cultivable areas, limiting their access to income and food. This outcome is consistent with Saleh and Mustafa's (2018), and Idrisa et al.'s (2008), findings who reported food insecurity in more than half of the households they examined.

Table 4: Multi-İndex (Robustness) Approach On Food Security

Classification		Non-affected		Affected	
Calorie proxy	Range	F	%	F	%
Very poor calories	800 –1600	138	59.7	137	67
Poor calories	1601–2200	58	25.3	64	31.3
High calories	2201–3200	23	10.0	3	1.7
Very high calories	3201–4000	12	5.0	0	0
Average Kcal	2240		2050		1640
	Accessibility index				
Poor accessibility	- 0.820 – 3.310	35	15.3	126	62
Medium Accessibility	3.311– 4.440	112	48.3	61	29.7
High Accessibility	4.441 – 5.550	52	22.7	17	8.3
very high Accessibility	5.551-11.576	32	13.7	0	0
Average			0.541		0.182
	Food consumption score				
Poor Consumption	2.090 - 24.700	69	30	139	68.3
Borderline Consumption	24.700 – 47.300	139	60	65	31.7
Acceptable Consumption	Above 47.300	12	10	0	0

Average			25.8		19.8
HDDS					
Low dietary score	0.0 – 3.0	76	32.9	142	69.6
Medium dietary	3.1-6.0	139	60.2	59	28.9
High dietary	6.1-12.0	16	6.9	3	1.5
mean			3.2		1.9
Food security index					
Food secure	≥0.8	19	8.2	1	0.5
Marginally food secure	≥0.2	132	57.1	97	47.6
Moderately food secure	≤0.2	79	34.2	93	45.5
Severely food insecure	0.0	1	0.4	13	6.4
Stability index					
Poor food stability	0.01-0.33	2	0.9	148	72.5
Moderate food stability	0.034-0.66	194	84.0	54	26.5
High food stability	0.67 – 1.00	35	15.1	2	1.0
Expenditure approach					
Food Expenditure t-test	1.97**				

** Significant at 5%

3.1.2. Food Availability Approach

Table 4 reveals that the majority (85%) of non-affected and 98.3% of affected households studied were not able to supply adequate calories to meet FAO's recommended daily energy levels of 2240 kilo calories per person per day. There was an average calorie intake of 2050 kcal for the non-affected compared with 1640 kcal for the affected maize farmers, which was reasonably high due to high consumption of cereal-based diets, which provided more than 80% of the energy on average, with protein from animal-sourced food being very limited. This finding is at variance with Saleh and Mustapha (2018), whose results showed that the average daily per capita calorie intake of rural households in Kaduna State, Nigeria was about 3175 calories.

3.1.3. Food Accessibility Approach

According to Table 4's findings, 85% of non-affected farmers had access to sufficient and nutritious food, compared to only about 38.0% of affected farmers. The average value for the accessibility index for affected and non-affected households was 0.182 and 0.541, respectively, indicating that non-affected households had moderate access to food in the study area. According to Ahmed et al. (2017), the issue of food insecurity is not only brought on by a lack of food supply but also by low income and already underprivileged households' lack of access to the market. The poor accessibility in the study areas can be attributed to possible factors such as price fluctuations for consumable items, inputs, and outputs, coupled with a stagnant rate of income growth and an inability to access larger expanses of land due to armed conflicts between tribes, bandits, and cattle rustlers, amongst many other economic accessibility limitations.

3.1.4. Food Utilization Approach

The outcome for the farming households is shown in Table 4. It is classified according to the food consumption groups based on the food consumption computation. The result shows that 30% of the non-affected farmers had poor food consumption, while 68.3% of the affected farmers at present had poor food consumption. The non-affected and affected households had an average food consumption score of 25.8 and 19.8, respectively. The average food consumption score of 25.8 for non-affected households' falls in the borderline food consumption group, which correlates to a diet where cereal is the main food consumed every day. As opposed to that, the average food consumption score of 19.8 for affected households falls in the poor food consumption group; this situation was worsened by the incidence of cattle rustling and banditry activities in the study area.

3.1.5. HDDS Approach

According to Table 4, the majority of unaffected families (60.2%) had dietary restrictions. A HDDS index of 3.1 to 6.0 indicates that the respondents' dietary diversity was below the medium mark. On the other hand, 69.6% of the afflicted households had low dietary score. The average HDDS score for non-affected farmers falls into the medium dietary diversity score category, while that of affected farmers (1.9) falls into the low dietary score category. Households with high dietary diversity levels have better access to food and more diverse food intake, although the different foods were consumed with varying frequencies in keeping with a 2020 study by Magaji et al. (2020), on the dietary variety score and factors influencing it in rural households in Panshekara, Kano State, Nigeria.

3.1.6. Food Security Index Approach

Using WFP's (2015), classification, the results in Table 4 indicate that only 8.2% of the non-affected farmers were food secure, compared to about 0.5% of the affected farmers. The marginally food secure households were higher (57.1%) for non-affected farmers compared with affected farmers (47.6%), and for moderately food insecure households, it was lower for the former (34.2%) compared to the latter (45.5%). About 13% of affected households were severely food insecure, compared to only 0.4% of non-affected households.

3.1.7. Stability Index Approach

The results for the stability index approach in Table 4 reveal that the majority of affected maize farmers (72.5%) had poor food stability compared to non-affected farmers with only 0.9%. Furthermore, the majority of non-affected maize farmers (84.0%) were moderately food secure, and 15.1% were also highly food stable, but only 1.0% of affected farmers were food secure (Vhurumuku, 2014).

3.2. Impact of Land Degradation on Smallholder Maize Farmer's Food Security

Table 5 displays the outcomes of the ATT estimates. The four algorithms, namely NNM, KBM, RM, and SM, were used for the analysis in order to ensure the robustness of the results. However, the PSM results show that the t-values for all four matching algorithms were negative and statistically significant at 1% level of probability, signifying a high level of effect on the food security of the affected maize farmers. The values of the estimated matching methods showed minimal differences in the outcomes from different algorithms, implying that the results were robust, although the NNM algorithm produced the least bias reduction. The choice of the NNM algorithm was also made because of the low value of the standard error, which implies a significant reduction in bias.

Table 5: ATT Estimates of Impact of Land Degradation on Food Security

Matching estimators	ATT for outcome variables	t-test
Nearest neighbor matching (NNM)	-10.723 (-0.0327982)	-12.107
Stratified matching	-10.723 (0.2214746)	-12.664
Kernel-based matching	-10.723 (-0.137559)	-14.938
Radius matching	-10.723 (0.027029)	-12.664

Therefore, the ATT of affected maize farmers was -10.723 kcal, implying that the affected farmers' calorie intake decreased by -10.723 as a result of the land degradation challenges they face. This outcome is consistent with the findings of Abdullahi (2014), who stated that 64% of the farmers in his study belong to the core poverty profile as a result of land degradation, and this is so because farmers output or productivity is translated directly or indirectly to their income.

4. Conclusion and Recommendations

The study established that maize farmers who were affected by land degradation are grossly food insecure, with the majority having very poor calorie intake below the FOA's recommended daily calorie requirement. Also, the majority of farmers affected by land degradation had limited access to enough food that is both sufficient and nutritious, poor food utilization, a low dietary diversity level, and poor food stability. Land degradation brings about low productivity, increased production costs, reduced income and, consequently, a reduction in farmers' ability to provide the basic nutritional needs of the farming households at the right amount, quality, and time. The findings also revealed that land degradation has a very high negative impact on the food security level of affected maize farmers, which was statistically significant at the 1% level of probability, leading to a reduction in calorie intake of about 10.723 kcal due to its negative effect on farmers' productivity and consequently their income.

In order to improve the food security of affected farmers, the government and policymakers should prioritize efforts to mitigate land degradation challenges. Investing in improved farming techniques such as soil conservation, agroforestry, and improved crop varieties are some of the measures that could be taken. Efficient, climate-resilient agricultural systems are particularly relevant in hedging against the potential risk arising from increasing uncertainty in agricultural production. Additionally, by ensuring that local communities are involved in land management decisions, the government and policymakers can protect important values of natural resources from destruction from land degradation. Increased technical and financial assistance is also required to help rural communities access and adopt new technologies that have the potential to improve productivity and mitigate the effects of land degradation. Furthermore, farmers should also make conscious efforts to mitigate some of the causes of land degradation like planting trees on farmland hedges, shifting cultivation and crop rotation system, using more of organic manure and avoid excessive use of chemical fertilizers and also prevent stagnant water on the farm as these will help the soil regain its nutrients. Direct food assistance for affected farmers is critical to tackling poverty and food insecurity, particularly in poor rural areas.

Possible directions for future research should pay attention to understanding the dynamics of land degradation, its effects on farmers' productivity and income, and its implications for food security. Future research should also examine the efficiency of agricultural incentives and overall agricultural development strategies in terms of minimizing land degradation and enhancing farmers' food security. Another key issue for future research is determining the influence of technological interventions, such as improved farm machinery and cutting-edge software, on reducing land degradation and improving farmers' food security. Lastly, long-term research is required for effective monitoring of land degradation as well as understanding the socio-economic and environmental conditions associated with land degradation.

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